European Conference on Visual Perception 2017

Abstract Book

Welcome Address

The 40th European Conference on Visual Perception (ECVP) took place in Berlin (Germany), from August 27th to 31st, 2017. With about 1200 fellow vision scientists coming to the Hauptstadt, this has been the biggest ECVP yet. As organizers of this meeting, we were impressed by the large number of contributions that allowed us to put together an amazing program. In three parallel tracks and across four days, we hosted over 200 talks in 12 symposia and 24 talk sessions, and more than 750 posters in 7 poster sessions. We also consider ourselves lucky that we could win Nava Rubin and Shin'ya Nishida for inspiring Perception and Rank Prize lectures, respectively. In addition, we used the opportunity to create a new format that we hope will catch on in the years to come — the Keynote Dialogue, in which two speakers present their opposing views on a fundamental question in vision science. This year, we enjoyed a stimulating and entertaining session in which Brian Scholl and Merav Ahissar discussed the question "Does cognition penetrate perception?"

In this abstract book, you will find the summary of each of these contributions. We hope that the ECVP 2017 in Berlin stays with you for a long time. We certainly keep a fond memory of this meeting.

The organizing team: *Niko Busch, Guido Hesselmann, Marianne Maertens, Florian Ostendorf, Martin Rolfs, & Philipp Sterzer.*

Contents

Monday August 28th Poster presentations

Pupil dilation during perception of the Necker cube reflects the viewing-from-above bias

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'Necker Cube' is a well known bistable figure. Previous studies showed that downward viewing is preferred than upward viewing (viewing-from-above bias). Although such a bias has been examined with psychophysical experiments, its neural basis still remains unclear. The neurocognitive aspects of bistable perception could be clarified by use of pupillometry, since this measure can index the intensity of cognitive processing, attention, and noradrenergic activity in the brain. Specifically, this study investigated pupillary changes while participants viewed a 'Necker cube' stimulus, which was made of corners that could be either dark or bright. When participants attended to surface that consisted of dark dots, it was expected that pupils dilated than when attending to a surface that consisted white dots. Moreover, the perceived direction was manipulated by cueing one surface of the cube (by temporarily filling the surface with white before the classic stimulus presentation). From the key press of participants it was clear that the onset appearance of the Necker cube changed significantly due to the effect of the cue. As in previous studies, the likelihood of the downward appearance appeared to be stronger than the appearance of an upward cube. However, the effects of the corners' luminance on the pupil diameter were small and non-significant. Since trials with the upward cue resulted in greater pupil diameter dilation than the downward cue, we surmise that the upward perspective requires more attentional effort than the downward perspective, consistent with the view-from-above assumption in perception of bistable figures.

Visual working memory load reduces the perceptual orientation bias of the Necker cube

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Introduction: During observation of the ambiguous Necker cube our perception becomes unstable and alternates spontaneously between 'front-side-down' and 'front-side-up' 3D-interpretations, with typically longer stability durations for 'front-side-down' (orientation bias). We studied the influence of working memory load on perceptual dynamics of the Necker cube. Methods: In two different experiments participants first memorized either cubic objects (Exp. 1) or Chinese characters (Exp. 2) as memory primes for 3 seconds. Easy, medium and hard memory load conditions differed in the number of memory primes. After the memory task participants observed a Necker cube for 15 seconds and indicated perceptual reversals. Finally, we presented a memory probe and participants indicated whether this probe had been present in the memory primes. We analyzed reversal rates and the perceptual bias as a function of prime identity and load level. Results: Increase of visual working memory load significantly reduced the perceptual 'front-side-down' interpretation bias of the Necker cube. We further observed a tendency for fewer Necker cube reversals with higher memory load. Discussion: Our perceptual system deduces causes in the world that produce the sensory signals by matching the sensory evidence with memory contents from previous perceptual experiences. The perceptual result will then be biased to the most probable solution(s). We hypothesize, that when working memory is loaded, its contribution to the resolution of the ambiguity is reduced and thus the perceptual orientation bias is reduced.

Direct comparison of eye patch and virtual occlusion during computer-aided treatment of amblyopia in children

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Some recent investigations evidenced that, in treating amblyopia, virtual occlusion (VO) could have significant advantages over traditional occlusion with eye patches (PO). However, the data available are mostly obtained in adults and still seem to be preliminary but not comprehensive. In order to compare the effectiveness of using PO and VO in children directly, we employed PO in some training sessions and VO (realized by means of 3D technique) in others. The same sets of visual stimuli and identical training procedures were used in the courses of treating amblyopia (10 sessions by 5 minutes) in two groups of children aged 7-14 years. The groups had 15/15 and 15/14 patients with disbinocular/refractive amblyopia and similar characteristics as concerned distributions of age and initial visual acuity. The first group underwent treatment with PO sessions then VO sessions (PO/VO), the second one – in inverse order (VO/PO). For the amblyopic eyes designed to treatment, the training procedures PO/VO and VO/PO produced increase in visual acuity 35%/20% and 38%/10%, respectively. In the case of VO, significant improvement in visual acuity was also registered in the paired eyes (by 25%/11% after first/second course), while in the case of PO, visual acuity in these eyes remained unchanged. In addition, employment of VO results in significant increase of binocular visual acuity (by 33%/12% after first/second course). Supported by the Program III.3 of DNIT Russ Acad Sci, 2017.

Investigating binocular oculomotor learning in adults with impaired stereopsis by means of stereoscopic stimulation and eye-tracking

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We investigate whether binocular fusion in strabismic stereoanomalous adults can be restored, if the positions of binocular stimuli are adjusted to their individual gaze positions, by providing the optimal image disparity for each person, using a stereoscope combined with an eye-tracking

system. We suppose that in this case, binocular fusion and stereopsis occurs with less effort. This visual experience is expected to aid oculomotor learning: once the 3D scene is perceived, it can serve as a cue to keep the necessary convergence, as normal image disparity is approached gradually by adjusting the positions of the binocular stimuli during the perceptual and oculomotor training. As a first step for this aim, the binocular fixation patterns of strabismic stereoanomalous and normal observers were investigated. When stimulating only one eye, the unstimulated eye of normal observers perfectly followed the fixations of the stimulated eye, governed by the randomly occuring salient dot targets. The stimulated eye of strabismic observers also produced accurate fixations, whereas the unstimulated eye settled slowly at arbitrary positions, irrespective of which eye was stimulated. When both eyes were simultaneously stimulated by the salient target at corresponding locations, the fixations of both eyes of strabismic subjects were accurate. This suggests that if the non-dominant eye of a stereoanomalous subject is aided to find the corresponding point fixated by the dominant eye, its fixations are controlled and aligned with that of the dominant eye. With more noisy patterns, this might be achieved by adjusting the stimulus positions to match gaze positions.

Brain stimulation of early visual cortex improves depth perception

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Depth perception is more precise when observers view stimuli containing a mixture of bright and dark visual features (Harris & Parker, Nature, 1995). This long-standing benefit for mixed vs. single polarity stimuli has proved difficult to reconcile with standard models of stereo vision (Read et al., J Vision, 2011). However, Goncalves & Welchman's (Current Biology, 2017) recent Binocular Likelihood Model suggests an explanation based on using 'what not' suppressive signals when estimating depth. To test the biological plausibility of this idea, we applied Transcranial Magnetic Stimulation (TMS) to the visual cortex to modulate normal neural responses to disparity based stimuli. We tested fourteen participants on a depth discrimination task using random dot stereograms with single (black or white dots) or mixed (black and white dots) contrast polarity. In line with previous work, participants performed significantly better for mixed polarity stimuli. We then applied neuro-navigated repetitive online TMS over V1 (or control site CZ) during stimulus presentation. We found that stimulation of early visual cortex (V1/V2) significantly increased the benefit for mixed polarity stimuli ($p=.038$, corrected), while it did not affect performance for single polarity stimuli. This increase of perceptual benefit, as a result of applying brain stimulation, is consistent with the idea that TMS can drive active suppression. Such increased suppression may allow the brain to gain stronger 'what not' information from the stimulus, effecting an improved representation of the true depth structure of the viewed stimulus.

Mapping of interocular filter suppression

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Neutral density (ND) filters placed before one eye can quantify depth of interocular or amblyopic suppression. We investigate properties of interocular filter suppression across the central 24 deg visual field in binocularly normal adults. Suppression is quantified with luminance-defined and contrast-defined stimuli as the latter have previously revealed deeper deficits for interocular blur (J.Vis, 2015) and amblyopic suppression (J.Vis, 2016).

Stimuli were four concentric rings, each made up of eight sectors. Rings were of alternating polarity, defined by incremental or decremental luminance- or contrast-modulation. The tested sector was presented to the eye with the ND filter (0, 1.5, 2.0, 3.0) and changed (according to a 2AFC staircase paradigm) to match the surrounding ring, presented to the other eye. Other rings were fused binocularly. Suppression depth was calculated for each sector location.

For all stimulus types, significantly deeper suppression was measured centrally than peripherally ($p<0.05$). Deeper suppression was measured for contrast-defined than luminance-defined sectors ($p<0.05$). For luminance-defined rings, deeper suppression was measured with light, than for dark rings ($p<0.05$). No polarity difference was found with contrast-modulated stimuli for which mean luminance did not change.

Use of contrast-defined stimuli in suppression assessment provides greater sensitivity to binocular disruption and greater immunity to modulation polarity, compared to luminance-defined stimuli. Differences in suppression measured for light versus dark luminance rings may reflect differences in contributions of ON/OFF pathways to suppression and need to be considered in clinical assessment.

Peripheral depth estimation of disparity-defined targets

Concetta Alberti & Peter Bex

3D vision is possible with central field loss (Verghese et al., 2016), even though peripheral vision has lower contrast sensitivity, resolution acuity, and stereoacuity. Disparity-defined stimuli fall on non-correspondent retinal positions, therefore binocular contrast summation does not occur in this situation (Alberti et al 2017). However, people with central vision loss use peripheral vision for visually-guided actions in depth. We assessed peripheral stereoscopic acuity via a depth estimation task in the periphery. Depth perception for horizontal sinusoidal depth modulated random dot grating was measured with a 2AFC task (in front vs behind the screen) in 3 observers. The disparity was controlled by a staircase. A gaze contingent scotoma in each eye was a Gaussian windowed ($\sigma=0.5°$, 1° or 1.5°, independently in each eye) patch of pink noise. Dichoptic presentation of the stimuli was controlled with nVidia 3D glasses synched to a low-latency 144Hz display and eye tracking was measured at 1000Hz with an Eyelink II. Psychometric function fits to perceived depth show that as the scotoma size increased, a bias to seeing targets behind the display increased and sensitivity decreased

(p=0.03). Furthermore, unlike acuity and contrast sensitivity, depth perception was limited by the larger scotoma in either eye. This study demonstrates that visually-guided behavior in depth is impaired by central vision loss. The level of depth impairment increases with scotoma size and is dependent on the size of the larger monocular scotoma size, indicating that visually-guided behavior is overestimated by best binocular acuity.

Bayesian analysis of the influence of size-relationship-priors on distance estimation

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Our visual environment is full of ambiguities making it difficult to infer its correct state. To reach adequate decisions, it is therefore advantageous to utilize prior knowledge about the world when making inferences. One such fundamental task is the estimation of the distance of objects. Prior knowledge about the objects' shape can help inferring objects' distance if only the relative size cue is available since objects closer to the observer subtend a larger visual angle and appear bigger. Here we investigate whether humans utilize knowledge about objects' size ratios to improve distance estimation in a probabilistic fashion.

In our experiment subjects decided in a 2AFC task which of two spherical objects, shown on a computer screen, was closer. The objects differed in their textures to appear as soccer, tennis or golf balls. Used size ratios were adjusted to match realistic size ratios. Hence, subjects were assumed to have valid prior beliefs.

We investigated how humans make these decisions and how they combine prior beliefs with perceived size ratios. Based on a probabilistic computational model in the Bayesian framework we inferred subjects' prior beliefs about size ratios. Our model takes uncertainty into account both for the perceived ratio and the participants' prior belief and enables us to use the collected behavioral data to infer the shape of the subjects' internal belief structure. The results show that human decisions in size judgements can be explained as taking known object sizes into account.

Increment and decrement adjustment and the course of contrast-modulated binocular rivalry

Jan Skerswetat & Akash S. Chima

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Contrast-modulated (CM) stimuli generate more superimposed percepts than luminance-modulated (LM) stimuli during binocular rivalry (ECVP, 2015), suggesting an initial binocular processing site less likely to engage in rivalry. The proportions of exclusivity and piecemeal perception during CM rivalry may be due to a perceptual luminance increment/decrement imbalance. Since visual systems are more sensitive to decrement (dark) than increment (light) stimuli elements (e.g. Lu & Sperling, 2012), we investigated whether adjusting increment/decrement elements of stimuli affects rivalry. Four observers viewed equally visible LM and CM gratings. The task was to indicate whether an exclusive, piecemeal, or superimposed percept was seen. In the first experiment, both increment and decrement magnitude was decreased equally by 25% and 50% in each eye during rivalry. In the second experiment, adjustments of the same magnitude were made in opposite eyes, e.g. left eye decrement, right eye increment. For the first experiment, superimposition (i.e. fusion) of both gratings was significantly higher for unadjusted CM than LM gratings ($p<0.05$). For CM gratings, adjusting increment/decrement magnitude resulted in significantly less superimposition ($p<0.05$). In the second experiment, CM superimposition also reduced with increment/decrement adjustment. Superimposition of LM gratings was not significantly affected in either experiment. Our results showed that increment/decrement adjustments do not decrease CM rivalry, defined as exclusive or piecemeal percepts. Thus, CM rivalry is unlikely due to luminance increment/decrement imbalance within the visual system. Further investigation is required to understand the phenomenon of CM rivalry.

Temporal dynamics of mutually inhibiting pyramidal cells: Underlying mechanism for bi-stable perception

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Bi-stable perception has been an important tool to investigate how visual input is interpreted and how it reaches consciousness. To explain the mechanisms of bi-stable perception, it has been assumed that a mutual inhibition circuit plays a key role. It is possible that this circuit functions to resolve ambiguity of input image by quickly shifting the balance of competing signals in response to conflicting features. We recorded from two pyramidal cells in primary visual cortex in vitro using a double patch clamp technique combined with the dynamic clamp system StdpC (Nowotny et. al., 2006). With this system, connections between the two neurons are established by mutually inhibiting model synapses. We further improved the system so that the connections are mediated by model inhibitory neurons and implemented the parameters to model the membrane properties and the synaptic plasticity of fast spiking inhibitory neurons in neocortex. Simultaneous activation of the two pyramidal cells (by injection of depolarizing current) caused bi-stable activities: dominance of neural activities alternated between the two neurons with an interval of several seconds. We report the effect of implementing synaptic plasticity as well as the effect of adding noise in the depolarization current to the distribution of dominant durations. Furthermore, we investigated the effect of changing the depolarization current on the dynamics of bi-stability: analogous to Levelt's analysis of bi-stable perception with systematic changes of input intensity. Using this system, the details of neural processes that undergo bi-stable activity can be investigated.

Continuous flash suppression: The "dorsal bias" hypothesis

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Continuous flash suppression (CFS) is a relatively new method of interocular suppression. Since its introduction in 2005, it has become widely used because of prolonged suppression durations for up to several seconds, and the nearly deterministic control of suppression onset and offset. Based on functional magnetic resonance imaging (fMRI) data, it has been proposed that CFS suppresses visual processing in the ventral vision-for-perception pathway, but leaves processing in the dorsal vision-for-action pathway intact. We will present the results of a series of six masked priming experiments (total N=157) investigating this "dorsal bias" hypothesis. Using a mirror stereoscope for dichoptic stimulation, we tested the prediction that the - potentially dorsal-pathway-based - analysis of invisible prime stimulus elongation can influence the categorization of manipulable man-made objects. We analysed response times with standard frequentist tests and Bayesian linear mixed-effects models. Both types of analysis converge on the same result. Our data do not support the "dorsal bias" hypothesis, but rather speak in favour of similar CF-suppression levels in both visual pathways, possibly originating from strong suppression already in early visual areas. We will discuss our findings within the context of current models of interocular suppression. Furthermore, we will reconsider the conditions under which fMRI responses to invisible objects might be different in the human dorsal and ventral visual pathways.

A factorial approach in aging research

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The population of developed countries is aging at an ever increasing rate. Even in the absence of neurodegenerative diseases, aging affects perceptual and cognitive functions that are crucial for everyday life. The effects of healthy aging on cognitive abilities are well studied, and it has been suggested that there is a common cause for cognitive decline. However, age does not only affect cognitive but also perceptual abilities. Surprisingly, our data disprove the existence of common factors underlying perceptual change with age. For the first time, we employed a battery of nine tests that measure visual discrimination and ten tests that measure subjective perception, such as illusion strength. Generally, older adults performed worse than younger adults, whereas subjective tests did not differ strongly. Surprisingly, we found very low correlations between all tests, so that for example performance in one test was unrelated to performance in other tests (i.e., performance in coherent motion was not correlated to performance in biological motion). Our results show that anti-ageing perceptual programs need to be strongly tailored to the individual needs of people. Moreover, our results show the importance of measuring individual differences and question the use of average results, especially in aging research.

The change of age in cognitive and anticipated properties of the moving object

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The purpose of this study was to discuss anticipate and cognitive property in each generation. We reported a decline of cognitive function from the data of young (18-38y) and elder (64-81) groups in ECVP (2016). However, cognitive property in 40s and 50s was unclear. In this study the data from 19y to 81y was divided into 4 groups and discussed about the change of aging. 32 (19-81y) persons participated in this experiment. Participants were required to answer the position of a moving object at the moment of a visual trigger stimulus, which is presented after the occlusion of the object with five levels of delay (200-1000ms) by changing the color of the occluding board. The similar tasks were performed without occlusion. The object moved from left to right at a visual speed of 10deg s-1 on display. Anticipated velocity in occluded task and cognitive velocity in visible task were calculated from the answered position and the trigger delay. Cognitive velocity of the elderly group (70s-) was significantly smaller than the young groups. Cognitive velocity showed a correlation and decreased with age. It means that position cognitive error increase with age. Anticipated velocity of each group was much less than the actual object velocity and no significant difference between groups. Anticipated velocity showed a correlation and increased with age. From the results, it revealed that the aging effect on the visual and cognitive function.

Preterm birth influences the development of visuomotor skills

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Preterm birth has a potential adverse impact in development. The risk of clinical and developmental problems tends to increases as gestational age decreases. Specific domains of impact as visuomotor integration deserve further research in preterm children. The main goal of this investigation is to compare the development of visuo –motor integration, visual perception and motor coordination of children born with 32 or less weeks of gestational age, to full term born children. Other goals include studying the influence of birth weight and relevant demographic and clinical variables in the three visual functional tasks. Two groups of children, between 5 – 6 years (60 – 72 months) of age, participated in the study: 40 children born preterm, and 40 healthy children born full term, were studied with the Beery Buktenica Developmental test (6th edition). At 5-6 years of age there were significant differences in the three visual – motor domains: visual-motor integration ($t = -4.53$; $p < 0.001$), visual perception ($t = -4.29$; $p < 0.001$) and motor coordination ($t = -3.82$; $p < 0.001$). Our results are in agreement with the visual motor and visual spatial deficits already found in other studies. Visual development is different in ex-premature children, even in the absence of cerebral lesions or developmental delays. We have shown those differences to be present at the

school-entry age. Longitudinal studies of visual and spatial perception from an earlier age could help us understand its influence in visual-motor function.

Short wavelength light increases pupil constriction and visual acuity at equiluminance

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Philips Lighting

The human pupillary light reflex not only depends on illumination level, but also on wavelength, showing a larger sensitivity to shorter wavelengths. We investigated to what extent this effect can be used to improve visual acuity. In a series of experiments, we determined the relationship between spectral light composition, pupil size and visual acuity. Illumination level and spectral distribution at the eye were varied independently of task illumination. The Freiburg Acuity Task was used to measure acuity. In the first experiment, using broadband white light (4000K CCT) at three illumination levels (17, 144 and 920 lux at the eye), we found substantial effects of pupil size on visual acuity: smaller pupil size led to increased acuity, confirming previous literature results. In a second experiment, we kept illumination levels at the eye constant (40 lux), and used either monochromatic blue (short wavelength) or red (long wavelength) light. Our hypothesis was that exposure to blue light at identical illumination levels would lead to smaller pupil size and therefore to an increased acuity compared to red light. Our results supported this hypothesis: even though retinal illuminance for exposure to blue light was 2.8 times lower than for red light due to increased pupil constriction, visual acuity was 8% higher for blue than for red light. These results suggest that tuning the spectral composition of light at the eye can improve visual acuity even with constant illumination levels, showing promising new opportunities for tailored light spectra optimized for visual comfort and acuity.

Study of the elderly visual aging in Taiwan on demand for Taiwan High Speed Rail service

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People's physical states gradually decline with their ages, and the most impacted is that of vision. Visual illness and degeneration influence the action and recognition capability of elderly persons. When elderly people's visual capability declines, it causes problems related to traffic safety. Therefore, in Taiwan, which is becoming an aging society, transportation systems designed to meet the elderly needs are now an important issue. This study explores elderly people's demands for Taiwan High Speed Rail (THSR) in order to propose services that match their needs. The result reveals that the font size of the signs in THSR stations and the direction signs of platforms are critical services for the elderly, who are significantly unsatisfied with them. For the "font size of signs" and "direction signs of platforms", the result shows that the gap of importance and satisfaction are the most significant, and it's the prior service item that needs to be improved. For "clearness of signs" by THSR, the elderly with "visual difficulties" exhibit significantly lower satisfaction than those without visual difficulties. Therefore, this study suggests that at present, the font sizes of TSHR signs in Taiwan do not satisfy the elderly people and therefore should be adjusted. In order to avoid situations in which elderly people are lost or injured by entering dangerous zones due to unclear signs, we further suggest that THSR provide appropriate services by its service personnel so as to prevent potential injury of the elderly caused by wrong judgment when they can't distinguish the hazards.

Measuring visual processing speed using a time accuracy function analysis and its relation to driving performance in younger adults

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Speed of visual processing often explains a moderate proportion of variance in some cognitive abilities, particularly in older adults. Measures of visual processing speed are therefore often used to predict performance in more cognitively complex tasks, such as driving. Yet, many of these measures are often not sensitive enough to fully isolate the aspect of visual processing speed (e.g. reaction time measures). It is therefore difficult to assess how much processing speed explains the variance in driving performance. In addition, compared to older adults, where speed of processing will likely play a more critical role, work into younger adult processing speed and its relation to driving is lacking. In this experiment, we therefore investigated how a more pure measure of speed of processing, using the Time Accuracy Function (TAF) procedure, predicts driving performance in younger adults. Participants completed an orientation matching task where target stimuli are presented at different durations (67, 167, 417, 1667, 2500ms). Processing rate was modelled by fitting a function of the time-accuracy curves, taking into account take-off time and performance asymptotes and was correlated with performance on a simulated driving task. The results highlight how processing speed influences driving performance in younger adults and, more generally, offers insights into how processing speed (when isolated from other factors, such as RT, take-off time and asymptote) can predict performance in more complex tasks.

Age-related influences of distractor processing on visual working memory content

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A decrease in visual working memory is physiologically correlated with ageing and has been attributed to inefficient suppression of irrelevant information. However, such decrease was predominantly measured in tasks where relevant and irrelevant items were presented within the same hemifield or had the same numerosity when presented in opposite hemifields.

To study how the aging brain solves the competition between relevant and irrelevant information, we used a change

detection paradigm with relevant and irrelevant salient objects presented simultaneously in opposite hemifields. Two groups of participants (Young vs Old) were required to remember the items in the relevant (target) hemifield, while ignoring those in the irrelevant (distractor) hemifield. Crucially, the number of targets and distractors was manipulated orthogonally. At behavioural level, older adults performed worse than younger adults with greater target numerosity. The Contralateral Delay Activity (CDA) of the EEG signal, a neural signature of working memory, was computed for each target load by subtracting ipsilateral to contralateral activity over the retention interval (300-900ms after array onset). The results showed that when targets and distractors share the same numerosity, the amplitude of the CDA was modulated by target numerosity in both old and young. When there was a numerosity mismatch, only young individuals still exhibited a modulation related to target numerosity.

The results thus support the hypothesis that the age-induced decline in working memory predominantly coincides with inefficient selectivity.

Feature representation in a dimension switch task: How anterior prefrontal areas modulate implicit visual attention

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The most anterior part of the human brain, the frontopolar cortex (FPC), is active in a diverse range of complex decision making paradigms requiring cognitive flexibility, exploration and multi-tasking. This FPC activation may be triggered by the need for reallocation of attentional resources without a clear rule for when to switch attention. Interestingly, the role of the FPC in attentional reallocation is not limited to high-level complex decision making: Studies using pop-out search tasks show FPC involvement specifically in implicit reallocation of attention, for example from one stimulus dimension to another. Here, we employed a paradigm that operationalizes such dimension changes without a visual search component in order to (1) test whether the FPC is involved in basic attentional switches without visual search and (2) investigate the neural representation of feature information attention switches are based on. In two experiments, fMRI and EEG was measured while participants were performing a simple visual discrimination task with randomly changing target features and target feature dimensions. Also without the element of visual search, dimension change trials lead to an increase in reaction times demonstrating the need for attentional reallocation and were associated with increased BOLD activation in the frontopolar cortex (BA 10) and superior frontal gyrus (BA 9). Stimulus features could be decoded from frontal EEG activation with above-chance classification accuracy starting at the same early time point (100ms) as for occipital activation. Implications for the role of frontopolar areas in implicit attentional reallocation and the representation of switch information are discussed.

The effects of perceptual uncertainty on global motion and global form detection in developmental dyslexia

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It has been suggested that adults with developmental dyslexia experience problems on some perceptual tasks, because they cannot utilise the invariant information in a repeated stimulus to form a 'perceptual anchor' to optimise performance (Ahissar, 2007). This hypothesis, developed in the auditory domain, has received comparatively little attention in vision. To address this issue we administered a random-dot global motion detection task and an analogous form task to 40 participants with a wide range of reading abilities. Participants identified which of two sequentially presented patterns contained global motion or global form. The other pattern comprised randomly moving or oriented elements. The ability to form a perceptual anchor was manipulated by changing the degree of uncertainty associated with the axis of global motion or orientation, across different blocks of trials. Global direction or orientation on each trial was chosen randomly from a uniform distribution, centred on vertical, spanning either 0, ±45 or ±90 deg. Results showed that coherence thresholds increased (by 5%) as stimulus uncertainty increased, but only on the motion task. Regression analyses revealed regardless of task and uncertainty, reading ability did not significantly predict performance, but gender did. Thresholds were typically lower in males than females but only on the motion task. Thus the inability to form a 'perceptual anchor' only has a moderate influence on simple global motion-detection and is not especially detrimental to poor readers. These results corroborate recent findings highlighting the importance of factors such as gender and non-verbal IQ when investigating vision in neurodevelopmental disorders.

Is shift of spatial attention limited to the effective oculomotor range: A study with presentation in extreme periphery.

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Covert orienting of attention is thought to be the consequence of saccadic eye movements that are planned but not carried out. However when an eye movement can be planned but not executed, as with patients showing defective eye-movements or when eye-movements are experimentally restricted, a deficit in attention is observed. This deficit suggests that both covert spatial attention and overt eye-movements are limited to the Effective Oculomotor Range (EOMR). Here we used the Posner cueing task to examine whether exogenous, covert attentional orienting was limited to the EOMR in neurotypical participants when eye-movements were not restricted. After determining each individual EOMR, we presented a cueing task where we manipulated the eccentricity (below vs. beyond the EOMR) of cues and targets. Interestingly, results showed longer RT in the beyond EOMR condition, however, we did not observe any significant interaction between eccentricity and validity effect. Looking separately at long vs. short RT we did observe

a validity effect across all RT intervals for the below EOMR condition, but not for the beyond condition where validity effect was present only for short RT. Our results suggest that attention can be shifted towards locations beyond the EOMR when the motility of the eye is not constrained. However the timing of the validity effect suggests that there might be different underlying mechanisms involved in the shifting of covert attention.

Information acquisition as a biomarker for vision impairment

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People with vision impairments report difficulties watching video (e.g. television and movies). To our knowledge, no studies have objectively assessed this difficulty. We developed an objective measure of the ability to follow the story in video, the information acquisition (IA) metric. Here, we test whether IA can measure the impact of vision impairment. Participants with central visual loss (CVL, reduced visual acuity, N=21), with hemianopia (loss of vision on one side, N=24) or normal vision (NV, N=60) watched Hollywood video clips, and then described the clip content. An objective score was derived using natural-language processing to compare each new response to a control database of descriptions of the same clip. To test whether the impact of CVL was simply due to reduced resolution, NV participants (N=15) watched the same clips with defocus blur. Compared to the NV group, IA was worse for the CVL ($z=-4.63$, $p<0.001$) and hemianopia ($z=5.78$, $p<0.001$) groups. IA was not higher for the hemianopia than the CVL group (-0.83, $p=0.409$). The NV-blur group had better IA than the CVL group ($z=3.95$, $p<0.001$). The IA method was able to measure the difficulty following the story experienced by people with CVL and hemianopia. Also, IA showed that defocus blur failed to recreate the CVL experience. Consequently, IA can be used to measure the impact of vision impairment on the video-viewing task, and is likely to be useful for measurement of the effect of vision rehabilitation.

Allocation of visual attention in deaf and hearing signers

Chloé Stoll, Olivier Pascalis, Richard Palluel-Germain & Matthew Dye

While a substantial body of work has suggested that deafness brings about an increased allocation of visual attention to the periphery there has been much less work on how using a signed language may also influence attentional allocation. Signed languages are visual-gestural produced using the body and perceived via the human visual system. Signers fixate upon the face of interlocutors and do not directly look at the hands moving in the inferior visual field. It is therefore reasonable to predict that signed languages require observers to covertly shift their visual attention to the inferior visual field. Two studies assessed the spatial distribution of visual attention in signers both deaf and hearing in a visual search task. We estimated decision making parameters with a Bayesian Hierarchical Drift Diffusion Model for the superior and inferior visual field. The first study suggested that deaf early signers are faster than hearing non-signers to extract the relevant information in the inferior visual field but that both group need the same amount of visual information to make a decision. In the second study we tested a group of hearing native signers to dissociate the effect of early learning of sign language from early deafness.

The time course of preference for curvature

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Preference for visual curvature is a well-established effect. Munar et al (2014) found differences in the effect between long and short presentation time. These differences have not been studied in a systematic way. A useful approach to study visual preferences is microgenetic perspective, which has been used in different fields. Our first experiment is aimed at getting to know more about the time course of preference for curvature with real objects. Here, we used the same paired comparison task than in Munar et al (2014). On the other hand, curvature is considered a mid-level representation in the hierarchical perspective of the visual system (Groen, Silson & Baker, 2017). Furthermore, high-level vision implements abstraction of the visual input into semantic representations that enable easy classification or identification of the object. Thus, the content of the images of real objects could have influenced preference as well. As other researchers, we assume an interaction of bottom-up and top-down phenomena in terms of a time course contingency. The second experiment was designed to prevent, as far as possible, the influence of semantic content on preference for curvature using meaningless stimuli (Bertamini et al, 2015). The results of the experiment 1 show that 80 milliseconds presentation time is a peak in preference with real objects. The results of experiment 2 reveal that preference for curvature with meaningless patterns increases as the time presentation increases. Our conclusion is that the effect is maintained, even increased, as long as there is minimal interference from the meaning content.

Using distractor information benefits visual search: Evidence for negative search templates

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Evidence suggests humans have the capability to activate relevant target features in a target template to guide visual search. Here we investigated whether subjects can also make use of distractor information as a negative template to enhance search performance, and which brain regions support this mechanism. Subjects performed a visual search task where targets and distractors were embedded in colored circles. Each trial was introduced by a color cue that could be positive (the target will occur in the same color), negative (only distractors will occur in this color), or neutral (neither

the target nor the distractors will appear in this color). We performed behavioral analyses, whole-brain univariate analyses, and ROI analyses for early visual cortex (EVC), V4, and SPL/precuneus. Behavioral results revealed a gradient in response times showing a benefit for target > negative > neutral cues. fMRI results revealed a decrease in signal strength in large parts of the ventral visual stream following negative compared to positive cues, with a gradient in relative signal strength decreasing from target, to neutral, to negative cues. These results were maintained in the ROI analysis of EVC but not V4. We also found a general attention inhibition process in SPL/precuneus, with increased signal strength for neutral cues compared to positive and negative cues. Finally, model-based representational similarity analysis based on correlations between response times for the different cue types revealed differences in fronto-parietal attention regions and EVC. These results support a distinction between target templates, negative templates, and task-irrelevant distractors.

The time course of target template activation in visual search

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Attentional target selection in visual search is guided by templates for target-defining features. Here, we tracked the activation states of such templates by measuring N2pc components to a sequence of probes presented during the preparation for an upcoming search episode. Participants searched for targets defined either by one or two possible colours. In the interval between search arrays, a series of brief task-irrelevant probe displays was presented. In Experiment 1, target colour was constant (e.g., red), and probe arrays contained a target-colour or a distractor-colour singleton. Only target-matching probes triggered N2pc components, reflecting task-set contingent attentional capture. N2pcs to matching probes were absent directly after preceding search arrays, and largest immediately before the next search array, demonstrating that search template activation is not constant but sensitive to temporal task parameters. Similar results were found in Experiment 2 where target colour alternated predictably across successive search displays (e.g., red, green, red), and singleton probes either matched the previous or the upcoming target colour. Both types of probes triggered analogous temporal patterns of N2pc components, suggesting simultaneous activation of both colour templates even when the upcoming target colour was known. These results show that this new rapid serial probe presentation method can provide novel electrophysiological insight into the time course of template activation during visual search.

Are faces subject to IOR? Evidence from dynamic displays.

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Inhibition of return (IOR) is traditionally explained as a mechanism designed to reduce our ability to reorient to a previously attended location. However, given that IOR can be separated from the orienting process, this explanation is insufficient. Subsequently, IOR has been proposed as a form of habituation to resolve this inconsistency. Although this accounts for IOR without orienting, it appears inconsistent with research that has found IOR even for highly relevant and salient objects, including social stimuli. It is proposed that this inconsistency is a result of previous research conflating location and object IOR. Four experiments are presented where IOR was examined for faces using dynamic displays: this allowed location IOR and object IOR to be measured separately. In all experiments, faces (both schematic and real) did not produce IOR, while IOR was observed for squares and real houses. This suggests that faces are not subject to IOR in dynamic displays and provides an indication that previous contrary results primarily reflect a location IOR. By showing that social stimuli do not generate IOR, these results support a habituation account of IOR.

Behavioral rhythms of attentional sampling

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Behavioral experiments have revealed rhythms in perceptual and attentional processes by showing that performance fluctuates over time. However, little is known about the mechanisms underlying the periodicity of behavioral performance. In this experiment, we used a well-established psychophysics protocol to identify attentional rhythms and characterize the mechanisms underlying the rhythmic attentional exploration of the visual space. We manipulated covert, endogenous attention, i.e. the allocation of attention to a particular location without eye movements, using a central cue. Participants performed a 2AFC orientation discrimination task in which they had to report the orientation of a target grating (clockwise or counter-clockwise relative to vertical). Trials could be valid, when the target is at the attended location (75% of the trials) or invalid, when the target is at the unattended location (25% of the trials). Additionally, two probes (Landolt C's squares or rectangles; 12 possible probes) were then flashed after a variable delay after stimulus offset. Performance in reporting the probes was used to infer attentional deployment to those locations. By solving a second-degree equation, we determined the probability of probe report at the most (P1) and least (P2) attended locations on a given trial. Because P1 was higher than P2, we show that processing was nonuniformly distributed across locations. We further argue that this probability estimation method, recently used successfully by Dugué et al. (2015b; 2017b) to characterize perceptual rhythms, is a powerful tool to investigate the temporal dynamics of attention exploration.

A cross-linguistic perspective on attention capture: Is there an influence of the participants' native language?

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How language affects vision is an important question. Here we tested if language differences in spatial terminology affect visuo-spatial attention. The Korean but not the German language uses one spatial word (kkita) for tight-fit events

(such as in a ring on a finger) and a different word (netha) for loose-fit events (such as in an apple in a bowl). We tested whether this language difference influences a speaker's spatial capture of attention. We let Korean and German speakers search for a target disk that was defined by a tightly or loosely fitting ring around it. Prior to the target a cue with the same or an alternative ring-fit than the target was displayed equally likely at the same or a different position than the target. Usually, same-position cues facilitate target search relative to different-position cues, although the cues are uninformative of the target's position. However, this cueing effect is typically restricted to cues sharing a feature with the target, as only such cues inadvertently capture attention by means of their match to the top-down search settings. Here, we hypothesized that Korean speakers would be more sensitive than German speakers for picking up upon (uninstructed but) target-signalling tight- versus loose-fitting rings. While our first experiment yielded no evidence for the cues' fitness on attention capture, our follow-up experiments showed cueing effects based on cue fitness that were sometimes unaffected by the participants' language. We discuss our results in regard to language influences on visuo-spatial attention.

Response of the multiple-demand network during simple perceptual discriminations

Tanya Wen, Daniel Mitchell & John Duncan

The multiple-demand (MD) network is sensitive to many aspects of task difficulty, including such factors as rule complexity, memory load, attentional switching and inhibition. Many accounts link MD activity to complex task control, raising the question of response when performance is limited by simple stimulus discriminability. Here we examined judgments of motion direction, manipulating difficulty by either sensory (motion coherence) or attentional (distracting dots) means. We manipulated each difficulty type across six levels, from very easy to very hard, and additionally manipulated whether difficulty level was blocked, and thus known in advance, or randomized. Overall, MD activity did increase with increasing difficulty, but despite the very large manipulation employed, this effect was generally weak, especially when difficulty level was randomized. The MD system, we suggest, has a role in many aspects of behavioral organization, but can be relatively insensitive to simple sensory demands. Variable recruitment across conditions may reflect variable attentional investment as difficulty is perceived to increase.

Eliminating facilitation and inhibition-of-return in the Posner task

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In the original Posner paradigm (Posner & Cohen, 1984. Attention and performance X: Control of language processes, 32, 531–556) participants are asked to quickly respond to a visual target preceded by a cue at the same or a different location. If the stimulus onset asynchrony (SOA) between cue and target is short, participants typically respond quicker to a target cued at the same location than a different location (facilitation). For longer SOAs participants respond more slowly to a target cued at the same location compared to a different location (Inhibition Of Return, IOR). Many studies have investigated facilitation and IOR but the dependency between the two contrasting effects is not well understood and facilitation is not always observed. Here we employed two successive cues to test whether a second cue with different SOAs can modulate facilitation and IOR. We tested N=20 participants (aged 20.8 ± 2.5 years) using randomly intermixed trials with single- and double-cueing. In trials with single cueing we observed facilitation after 100ms SOA and IOR after 800ms SOA. For double cueing, we established robust IORs after 100+800ms. Interestingly, if the two cues appeared at the same location and after 800+100ms then IOR was eliminated. Facilitation was removed if both cues appeared at the same location after 100+100ms. We used untransformed response times and the most parsimonious general linear mixed models on to establish effects.

Unusualness and threat?: The effect of context on an eyewitness' attention to weapons

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The Weapon Focus Effect (WFE) is a phenomenon that a weapon impairs eyewitness' memory of peripheral (e.g., robbery's clothes) due to drawing attention to the weapon. The mechanism of WFE has been proposed by an emotional arousal to the criminal situation with the weapon or a weapon's unusualness in the surrounding context. Some studies showed that an incongruent weapon in the context (e.g., a gun in a grocery store) drew attention as much as an incongruent non-weapon (e.g., a feather duster in the store). These results suggested that the weapon's unusualness drew attention on WFE. However, it was unclear whether the arousal was involved in the attention to the incongruent weapon because the previous studies did not separate the weapon's unusualness and the arousal. Therefore, present study investigated whether the incongruent non-weapon drew more attention than the congruent weapon (e.g., a knife in a kitchen) with an additional singleton paradigm. The results revealed that the congruent weapon captured less attention than the incongruent non-weapon. In Experiment 2 in which the effect of context was weaker than Experiment1, the congruent weapon drew attention as much as the incongruent non-weapon. Moreover, the tendency that the unusualness and the arousal were contributed to the attentional capture to the incongruent weapon was observed. The findings showed that the attentional capture via the arousal added to the capture via the unusualness. We suggested that not only the unusualness but also the arousal influenced the attention on WFE.

Eccentricity effect of inhibition of return: Asymmetry between the nasal and temporal visual fields

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Spatial attention can be oriented towards both novel and previously attended locations in the visual field. However, an

inhibitory bias (called "Inhibition of return", IOR) was discovered in mid 1980's, showing a slower response time to targets appearing at the previously cued (attended) locations relative to the uncued novel ones. In recent years, a series of attention studies further demonstrated that the inhibitory magnitude of IOR is much stronger in the periphery relative to the perifoveal visual field [Bao and Pöppel, 2007; Bao et al., 2011; Lei et al., 2012; Bao et al., 2013a; 2013b]. This effect is termed "Eccentricity Effect of IOR". The present study aims to further explore whether this effect shows an asymmetry between nasal and temporal visual field under monocular viewing condition. Using a typical double-cue procedure, IOR effects at both 7 and 21 degree eccentricities were measured in a group of university students, who performed a simple detection task with their left or right eye. The results showed that IOR magnitude was significantly larger for 21 degree vs. 7 degree stimuli, showing an eccentricity effect of IOR. However, this eccentricity effect was only observed in the temporal visual field, and not in the nasal visual field. This asymmetry was observed independent of which eye was used. These results match the neuroanatomical observations that nasal retina has a stronger geniculocortical projection with a higher degree of divergence, presumably also applies to the collicular projection.

Differential processing in ignore-color and ignore-location cue effects in visual search

Tomoya Kawashima & Eriko Matsumoto

Although presenting participants a cue indicating what color a target is or where in space a target is likely to occur can guide their attention effectively in subsequent visual search task, some studies found that participants failed to reject attention to up-coming distractor's information (e.g., Becker, Hemsteger, & Peltier, 2016). To address the underlying mechanisms responsible for the use of each cue, the present study investigated the time course of the cue type effects observed among target color, distractor color and distractor location cues. Participants performed visual search task where the 16 search items were presented in a circular arrangement. In attend-color condition, 16 colored placeholders were given to the participants where they knew in advance the target color (8 of 16 holders were target color). In ignore-color condition, 8 of 16 colored placeholders were a distractor color. In ignore-location condition, 8 colored placeholders were presented, indicating the to-be-ignored locations for the subsequent visual search. We also manipulated the duration of the placeholders as 100 ms, 800 ms, and 1500 ms in order to explore the time course of each cue type effect. The analysis of reaction times showed that attend-color cue was the most effective regardless of the placeholder durations. Ignore-color and ignore-location cues, on the other hand, were effective at different placeholder durations. These different time courses of ignore-color and ignore-location cue effects suggest that each distractor suppression depends on distinct cognitive mechanisms.

Searching for a unique visual rhythm: Tone may help, but phase is crucial!

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Rhythm perception is typically associated with auditory modality as we often experience in listening to music or speech. However, it also exists in other modalities. In a recent study it has been suggested that searching for a target defined by a unique visual rhythm is not a "pop-out" process, but a serial one that demands considerable attention [Li, Bao, Pöppel, & Su, 2014, Cognitive Processing, 15: 93-97]. To understand what factors influence the efficiency of visual rhythm search, several pilot experiments using similar dynamic search display with periodically "bouncing dots" are examined. The target in the search task is a bouncing dot with either shorter or longer period among all distractor dots with same bouncing period. When all the distractors not only share the same period but also share the same bouncing amplitude, an inefficient serial search is observed. However, when all the same rhythmic bouncing distractors are phase synchronized although their amplitudes are randomized, a parallel "pop out" is demonstrated. Further manipulation changing the direction of bouncing dots from vertical to horizontal or oblique direction does not ensure a "pop out". An auditory tone synchronizing with the target period improves search efficiency (i.e., decrease the search slope) in dependent of target type. These results suggest that synchronized phase is the crucial factor for a "pop out" search, and accompanying tone matching the target rhythm helps to improve the search efficiency, while moving direction and amplitude seem to have little influence.

Early facilitation and perceptual merging: The role of alpha band power and neuronal dynamics in exogenous orienting

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Exogenous orienting is characterized by faster responses to targets presented at validly cued locations with a short cue-target onset asynchrony (CTOA). Recently, a new account was proposed to explain early facilitation as a result of perceptual merging caused by interactions between feedforward visual processing and feedback corrections (Krüger et al., 2014). The present study was designed to clarify the role of perceptual merging in genesis of early facilitation and to detect a possible anticipatory bias in the typical cueing task. We combined a modified version of the behavioral cueing paradigm (Krüger et al., 2014) with examination of alpha activity that was shown to indicate a release from cortical inhibition in voluntary orienting (Thut et al., 2006) and predict performance in visual tasks. We manipulated the validity of location and the order of presentation, with the cue displayed either before (pre-cue) or after (post-cue) the target with a 110 ms CTOA. Behavioral results showed a well-pronounced facilitation in the pre-cue condition but no perceptual merging in the post-cue condition. Nevertheless, there were significant positive correlations between post-cued manual reaction times and neuronal dynamics estimated with long-range temporal correlations (LRTC) (Hardstone et al., 2012) in the

alpha band. Also, a validity effect correlated positively with pre-cued LRTC and negatively with post-cued LRTC suggesting that expression of cueing effects depends on dynamics of alpha oscillations. Overall, the data indicate that increased LRTC in the alpha band plays an inhibitory role and provides the speed-accuracy tradeoff, whereas cueing releases this inhibitory set.

Attentional capture effects by stereoscopic depth information

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There is broad evidence that visual attention can be captured by certain stimulus properties such as object color, form, or motion. However, there are also findings indicating that such attentional processing can be affected by completely irrelevant, yet salient singletons. For instance, in the additional singleton search task a target (e.g. vertical or horizontal line) is located within a clearly defined singleton (e.g. green circle among red circles) while an additional irrelevant distractor (red diamond among red circles) is presented simultaneously. Using this paradigm it has been shown that irrelevant singletons cause prolonged response times, even though participants are well aware that the target will never be associated with this irrelevant singleton. In the present study, 3 experiments were conducted to gain further insight into the relationship between attentional processing and stereoscopic depth information. For this purpose, singletons were shifted towards or away from participants (either as target or irrelevant singleton) in order to test whether there is an impact on attentional capture. Using color singletons it was found that neither type of irrelevant distractor (near or far) caused an increase of response times. In contrast, although near and far singletons clearly captured attention, in these respective conditions response times were prolonged due to irrelevant distractors. Thus, the current findings imply that attentional mechanisms are depth sensitive. However, depth information seemingly is less salient as compared to color information and therefore might not be used automatically but rather represents a higher level processing component.

Selection across a bilateral visual field: Simultaneous vs sequential selection mechanisms

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Recent investigations have shown that stimuli in a dual stream Rapid Serial Visual Presentation (RSVP) task can be perceived at very brief presentation intervals, even if presented in different visual fields. Here we investigated whether this occurs via fast-moving, left-to-right covert attention or true simultaneous selection of these non-contiguous visual stimuli. Previous research has shown that right field dual RSVP performance is affected markedly despite preserved left field report. Thus, we hypothesized that an increase in perceptual noise would result in even poorer right field performance if processing occurs sequentially, whereas simultaneous processing would result in a net reduction across both fields. Using a within-subjects design, we presented 33 participants with 2 blocks of single and dual stream RSVP tasks, with the second block using stimuli embedded in 1/F noise. Performance in identifying target letters was poorer across all conditions with embedded noise; however, a comparison of the ratio difference of the left and right visual field fields differed significantly across noise and no-noise conditions. Here we suggest this is consistent with an account in which noise masking attenuates the serial tokenisation of stimulus type nodes.

Study on demand for parking information system by drivers' visual identity

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When using parking areas, drivers in the past typically could only recognize the number of vacancies by electronic signs at the entrance, and once they entered the parking lot, they would spend time and concentration on searching for an open parking grid. Moreover, they have to pay attention to the driving situation in the area. Currently, some parking lots have been installed with a parking information system for drivers to search for parking grids, but some information is presented by images and color and some is shown by numbers. Thus, the impact of these two kinds of information on drivers varies. This study explores the effect of parking information offered to drivers and further analyzes drivers' preferences for information presented by images, color, or numbers. According to questionnaire survey results, the average parking time of drivers simply by searching for parking grids with eyes is 11.1 minutes. However, with the instruction of automatic detective signs, they can rapidly find a parking place, saving 5.3 minutes on average. It demonstrates that offering image and numeric information assists in drivers' recognition and searching. As to the interface of parking information and regarding drivers' visual cognition function, this study reveals that image and color information are more favorable versus numeric information. Hence, in a changeable environment, simple image and color are effectively helpful for drivers.

Effect of object category prediction on individuation

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In this study we investigate the effect of prediction on detection of spatial location of briefly presented intact images (individuation). Centrally presented cues, face or house, provided prior information about the likelihood of the upcoming stimulus category. Next, an intact image was shown on either left or right periphery. On the opposite side a scrambled version of the same image was presented. This was followed by presentation of masks, which were different scrambled versions of the target image. Participants' task was to report the spatial location of the intact image, not its category. The

validity of the category cue was set at 100%, 75%, 50%, 25% in different experimental sessions. In each trial, the duration of intact image presentation was determined using a 2-AFC adaptive staircase procedure. Duration thresholds (75% correct) were computed in congruent and incongruent trials separately (in terms of cue-target category associations). Our results showed that thresholds were higher in incongruent trials than in congruent trials only in the 75% cue-validity condition, suggesting that prediction has an effect on spatial location detection only when prediction's validity is relatively high. Drift diffusion model (DDM) was applied to estimate the processing efficiency and threshold setting for congruent and incongruent trials in the 75% condition. The DDM analysis revealed that predictive information modulates only the boundary separation by increasing it in incongruent trials compared to congruent trials. We also frame the results using models inspired by the microcircuitry, albeit abstracted, of the visual cortex and Bayesian decision rules.

On the influence of task demands and novelty on visual attention of competing stimuli

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What captures human attention in natural scene viewing is influenced by physical properties of the scene and higher-level factors, such as its semantics or task demands. However, the interaction between these and other factors is not fully understood yet: are unseen stimuli more likely to capture the initial saccade than previously observed ones when presented together? To what extent do passive task demands influence the initial saccade? Through this study, we research how visual exploration of spatially competing stimuli is influenced by stimulus novelty and passive tasks by analyzing the performance of a computational model trained on eye-tracking data. Participants viewed pairs of images (left and right) from different categories. Then we trained a logistic regression algorithm enhanced with bias terms that account for some of the factors that potentially influence human viewing behavior. First, we show that the proposed model effectively predicts the location of the first fixation on those competing visual stimuli. Second, our results suggest that neither the familiarity with one of the stimuli nor passive task demands play a strong role in the global, immediate saliency of the stimuli. These findings shed more light on the notion that the initial saccade after stimulus onset is only slightly affected by this kind of subject factors, whereas the semantics of the stimuli play a more important role.

A potential benefit of eye blinks? Boosted performance in an RSVP task after blinks (and blanks)

Jit Wei Ang & Gerrit Maus

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We blink more often than is required for eye lubrication, frequencies fluctuating greatly depending on task. Could there be a benefit of increased blink rates? Some evidence suggests that blinks cause deactivation in dorsal attention areas (Nakano et al., 2013), possibly causing a "reset of attention". On the other hand, retinal transients such as abrupt stimulus appearance, usually causing enhanced discrimination performance (e.g. Yantis & Jonidas, 1984), are known to be suppressed in cortical processing after eye blinks (Golan et al., 2016; Hari et al., 1994). Here, we tested the effect of blinks and stimulus blanks on performance in a rapid serial visual presentation (RSVP) task. Participants identified a target digit embedded in a random stream of letter distractors, presented for 60ms each. An eye tracker was used to identify blinks in real-time and present the target at varying delays after blink offset. Stimulus blanks were produced using shutter glasses, emulating the temporal properties of each observer's voluntary eye blinks. We found transient enhancements of performance (15% increased accuracy) for targets appearing up to 180 ms after blink offset for both blink and blank conditions. Despite previous reports of cortical suppression of blink-related transients, we observed an attentional boost after blinks, similarly to stimulus blanks. This suggests that eye blinks are accompanied by transient enhancement of attention.

Gaze-contingent stimulus removal leads to subsequent changes in attentional allocation

Karin Ludwig, Doris Schmid & Thomas Schenk

Ludwig-Maximilians-Universität München

According to the premotor theory of attention, brain circuits that prepare and control (eye) movements also serve to shift or maintain spatial attention. The aim of this study was to determine whether reducing eye movements to one visual hemifield over the course of several hundreds of trials led to a subsequent decrease in deployment of attention to this hemifield. The participants carried out a visual feature search during which the stimuli in the left visual field were removed whenever the participants made eye movements to the left. The stimuli in the right field were unaffected by eye movements. Indeed, this led to a steady decrease in left-sided fixations over the course of the intervention. In four experiments, the performance in different spatial attention paradigms was measured before and after this intervention. In two visual search paradigms (feature and conjunction search) the proportion of left-sided fixations significantly decreased from pre to post measurement, which was also true for the first fixation. In a Posner task with exogenous cues, a partial effect of the intervention was found. The fourth experiment showed that performance in a line bisection paradigm was not significantly influenced by the intervention. To conclude, transfer effects of the gaze-contingent removal of left-sided stimuli were found in two visual search tasks and a Posner task but not in a line bisection task.

Attentional capture by task-irrelevant angry faces outside the focus of attention

Nicolas Burra, Jessica Robinson, Léa Poitrine, Caroline Barras & Dirk Kerzel

Attentional capture by irrelevant threatening stimuli relative to non-threatening stimuli outside the focus of attention is a crucial aspect of the threat-capture hypothesis. However, evidence for this hypothesis is scarce. Therefore, we investigated whether threatening faces capture attention despite

being entirely task-irrelevant and outside the focus of attention by measuring the N2pc component, an electrophysiological marker of attentional selection. In Experiment 1, participants had to detect luminance changes of the fixation cross that occurred on 25% of trials. Meanwhile, two lateralized irrelevant faces were displayed to the left and right of fixation. One face was neutral and the other was happy or angry. Interestingly, no N2pc was elicited either for angry or happy faces. In Experiment 2, we presented a non-face object (a house) as a competing irrelevant stimulus to increase the distinctiveness of the irrelevant face. We observed an N2pc to all facial expressions (neutral, happy, angry) when the fixation cross did not change luminance and no response was required. In trials with luminance change that require focal attention at fixation and a response, however, an N2pc occurred only to angry faces. A control experiment showed that this pattern did not occur for inverted faces. Finally, when the task at fixation was changed and required a response on each trial, the pattern of results was unchanged. Our results show that an irrelevant threatening face outside the focus of attention is able to capture attention, however, this effect depends on the category of stimuli competing with the irrelevant face stimulus.

The price of saccades

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Universität Osnabrück

Theories of embodied cognition postulate the world as an external memory. It implies that instead of storing visual information in working memory the information may be equally retrieved by appropriate eye movements. Effectively, humans trade the effort of memorization with the effort of active sampling information. This reasoning predicts that the balance of memorization and active information sampling might be shifted by making one or the other more effortful. Here we test this prediction in a block copying task.

In the experiment, we divided a computer screen into three main areas: Resource Space, Work Space, and Model Space. Participants had to drag and drop blocks from Resource Space to Work Space in order to copy a model of eight blocks in Model Space. Each block was of one of two colors and one of three types (square, vertical, or horizontal rectangle). In an Unconstrained condition, the model appeared immediately after eye-fixation into Model Space. In a Constrained condition, we introduced a 700 ms delay for uncovering of the model.

In the Constrained condition, participants made 8% more Model Space □ Model Space saccades, whereas they only made 5% less penalized Resource Space □ Model Space and Work Space □ Model Space saccades. The median numbers of saccades in Unconstrained and Constrained conditions were 51.6 and 58.3 respectively. In the study, we demonstrated that the balance of memorization and active information sampling shifted when we introduced a cost for saccades.

Faster access to awareness for stimuli associated with negative social experience

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When stimuli compete for access to visual awareness, their perception is influenced by low level image properties as well as their cognitive significance. For example high contrast or moving stimuli have higher perceived dominance durations under condition of binocular rivalry than low contrast or stationary object. In a similar paradigm, it has been shown that faces are seen for a longer duration than houses and this face dominance is even more pronounced for stimuli containing expressions of emotion. Extending this body of research, we have reported on experiments where the face valence was manipulated via social-learning experiences. We have shown that faces paired with negative personality-related information were seen for longer duration than those paired with positive information. Cyberball is a ball tossing game used to trigger ostracism. In Cyberball, the participant plays against two identities, one being an includer (throws the ball back to the participant) and one excluder (rarely throws the ball to the participant). We have shown that face dominance is significantly longer for stimuli associated with negativity (excluder), thereby demonstrating the effects of social learning on binocular rivalry. We have extended our work using Continuous flash suppression (CFS) technique, which is a variant of binocular rivalry where stimuli compete for access to awareness with dynamically salient stimuli under dichoptic viewing conditions. Combining Cyberball and CFS, we have found that stimuli associated with negativity (excluder) emerged into conscious vision significantly faster than those with positive association (includer). Overall the findings show enhance processing for negative stimuli.

Adaptive adjustment of posture for the performance of a visual search task

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Eight participants stood either on a wide plank or a 15cm wide folded yoga mat for one minute while performing a visual search task that entailed counting the number of times a specific letter appeared in a short passage placed 0.4m or 3m away from them. To assess the effects of target distance and surface characteristics on postural control, postural motion was recorded from the head, sacrum, shoulder, hip, knee, and ankle. In the control condition, participants stood still looking at a blank wall 3m away. Moving window standard deviations, estimates shorter time-scale (< 1 sec) postural activity, of the head position data along the anterior-posterior and medial-lateral axes were used to assess body sway; and cross-correlations between joints (hip-knee, hip-ankle, and knee-hip) were used to construct coordination patterns. Results showed decreased sway in the near target condition and on the more stable plank surface. Importantly, surface and task interacted significantly due to reduced sway on the less stable narrow yoga mat when the target was near. It is the case that, for the same amount of postural sway, closer

objects induce larger optical perturbation than more distant targets. Thus a more rigid posture is necessitated when searching letters in a nearby text. The required reduction of sway in the close target condition appears to be achieved by tighter coupling between the knee and ankle. Results corroborate the hypothesis that postural control is modulated adaptively to facilitate performing suprapostural tasks

Looking for the glossy object: Visual search asymmetries in material perception

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Searching for a target among distractors is usually directed by a set of attributes that guide visual attention. Among simple properties like color, orientation and size, also mid-level vision cues that describe the properties of surfaces have been proposed to guide attention (cf. Nakayama & He, 1995). Recent experiments however, indicated that visual search for a material is an inefficient search (Wolfe & Myers, 2010). In the current study we investigate participants ability to search for a target with a particular material within distractors of a different material. The materials for targets and distractors were chosen to differ along a single physical continuum (2 conditions: glossy vs. matte & rough vs. smooth). Differences in contrast between materials were omitted by equalizing the luminance histograms. For each condition both materials served as distractors and as targets in distinct small blocks. We used three different set sizes and participants made target-present or target-absent responses. We compared response times and error rates for target-absent and target-present trials in both conditions. Our results show that glossy and rough targets were detected faster than matte and smooth targets indicating an asymmetry in visual search for different materials. Detecting the presence of a target was only little influenced by the set size and error rates were similar to typical error rates in visual search (<10%). Glossy targets are characterized by highlights that cover the surface and the rough targets are characterized by their 3D mesotexture. Both, highlights and 3D texture seem to facilitate and guide visual search.

Human affectiveness on color arrangements in geometrical figures

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We investigate influences of geometrical shapes to color preferences when colors are assigned to the shapes. We conducted an experiment of color assignments to segments within a square. Respondents were requested to select a color specimen card from the 24-color hue circle and put it onto each segment.

The employed segment arrangements are as follows: - "3-elliptical vertical": A vertical ellipse contacts the top and bottom sides of the square, and separates it horizontally symmetrically into three segments. - "3-elliptical horizontal": Rotation of "3-elliptical vertical" by 90 degrees. - "3-elliptical diagonal": An ellipse is fitted diagonally and contacts all the sides. - "3-triangular vertical": The midpoint of the top side and each of the bottom corners of the square is connected by straight line, and the square is separated horizontally symmetrically into three segments. - "3-triangular horizontal": Rotation of "3-triangular vertical" by 90 degrees clockwise. - "4-triangular": A triangle is fitted inside the square, and the vertices of the triangle contact to the right bottom corner, top side, and the left side of the square.

We define the color range as the minimum center angle of the sector containing all the selected colors in the hue circle. We found that the average range was significantly larger in the 4-triangular arrangement than in the 3-triangular arrangements. We also found that the ratio of respondents who assigned colors symmetrically was larger in the 3-elliptical vertical and horizontal arrangements than in the 3-elliptical diagonal arrangement.

Not a shift of attention: Buffering and binding of visual stimuli

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Cueing a stimulus often benefits task performance. This is usually thought to reflect an attention shift. However, previous work indicates that stimuli are sometimes reported via "buffering and binding" - representations of the stimuli are stored in a temporary buffer and one is bound with the cue. In a task where participants must report a cued letter from a stream of letters, they often report letters from shortly before the cue. This occurs at a rate higher than can be accounted for by guessing. Moreover, whereas an attentional shift should result in a positively skewed pattern, the distribution of reported letters' temporal positions instead appears symmetric (Goodbourn & Holcombe, 2015). New results with eight simultaneous streams of letters suggest that even eight letters can be simultaneously activated and buffered prior to the cue's presentation. At a random time during the trial, one of the eight simultaneous streams was cued with a ring. The presentation time, relative to the ring, of the letter reported was aggregated across trials into a histogram for each participant. Symmetric distributions centered after but near the time of the cue fit the data better than skewed distributions. These findings are consistent with the theory that in these tasks, the cue does not trigger an attention shift. Rather, even before the cue's onset, the letters of multiple streams were recognized and their representations buffered. The cue then binds to one of the letter representations. The relation of this phenomenon to theories of fragile short-term memory will be discussed.

Temporal color induction between transient stimuli

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Purpose: We investigated the temporal color induction between transient visual stimuli. Method: The two transient stimuli were presented. The first stimulus had a gray semicircle inducing field on the right of the fixation dot in the

uniform red background. The red and the gray were equiluminant. The second stimulus had two gray semi-circle test fields on the both sides of the fixation dot in the uniform black background. The black line was delineated between two semi-circles. After 1 second fixation, the first stimulus was presented for 30ms. The SOA was 80ms (ISI was 50ms). The second stimulus was presented for 80ms. Results: The right test field was perceived as "reddish." The left was perceived as "bluish." Discussion: The uniform red background of the first stimulus was necessary for the induction. The "reddish" result was anormal, being derived from the red background of the first stimulus. The "bluish" perception might be the color induction over short temporal interval. The induction changed depending on the SOA, like B-type meta contrast. The similarity between the time course of our two transient stimuli and the conventional meta or para contrast paradigm was highly provocative, though our scheme was different in that the edges of the left test field were exactly overlapped with that of the first stimulus. The preliminary dichoptic presentation test was negative for color induction. Conclusions: We confirmed the temporal color inductions. One of the inductions was anormal. The similarity to B-type meta contrast was suggested.

Asymmetrical attentional selection modulated by emotion: A right-side bias for selecting neutral Chinese characters, but no bias for selecting negative Chinese characters

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How do we select multiple streams of information in the visual field? We presented dual streams of rapid serial visual presentation (RSVP) bilaterally, whereby participants had to identify the items cued by briefly presented rings in one or both streams. Previous studies that used Roman alphabets have demonstrated a left-side advantage when one had to simultaneously select items in two streams. In this study, we first replicated the left-side bias with Roman alphabets, and further tested the generalizability of the left-side advantage with Chinese characters. A benefit of using Chinese characters is that one single character occupies a small region roughly corresponding to a letter, but it has a specific meaning that enables us to manipulate its emotional value. In this study, the participants' task was to select items from one or both streams of RSVP with neutral or negative Chinese characters, and the results showed that the left-side advantage reversed for neutral Chinese characters. For Chinese characters with negative connotations, they were generally processed more efficiently than neutral characters, without an asymmetry. The results of this study indicate that the direction of asymmetrical attentional selection is modulated by the linguistic properties of the items, and the emotional value implied by the items.

Spectral comparison of color fidelity metrics CIE CRI and IES TM-30-15

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The incursion of solid-state lighting technologies brought a wide variety of characteristics usable for diverse applications in general lighting that earlier were limited by the existing light sources. These properties improve performance in terms of efficiency, efficacy and color rendering; however, the actual assessment index for color rendering does not fully represent the visual perception of the end users of this kind of technology. For that reason, along the last years were proposed different fidelity metrics to evaluate this one. Color Rendering Index (CRI) is the actual method to calculate the color fidelity index, comparing 8 or 15 color test samples in the way to identify the light source performance. IES TM-30-15 is the last proposed method by the Illuminating Engineering Society (IES) to calculate the color fidelity; this one assess the performance of light sources using 99 color test samples. The comparison of this two metrics was made optimizing the spectral performance of the color rendering according these two indexes for a spectrally tunable LED light source with 14 channels, setting a specific correlated color temperature, and using the less amount of energy possible. The results demonstrate that to maximize the performance for CIE CRI is required less spectral components, and the Ra value does not fully describes the color behavior of a light source, opposite to IES TM-30-15.

After-effects from implied colours of natural objects

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It is well known that after viewing a coloured stimulus the perception of subsequent stimuli is chromatically shifted in the opponent direction, because of biased output of early chromatic mechanisms. Recent studies [1,2] show that known colours of familiar objects affect the perception of those objects, biasing the white-point in the direction opposite that of the memory colour. We investigated whether familiar object colours cause an after-effect by adapting observers to greyscale images of objects with diagnostic colour, before measuring the perceived white-point of simple geometric stimuli. In control measurements the adapting images were phase-scrambled. Despite the measurements being made with judgements of simple geometric stimuli, chromatic shifts were observed, relative to the control measurements. These shifts were consistent with adaptation to the colour implied by the objects. Our experiment was designed to eliminate potential response bias. These results could be interpreted as adaptation of colour-signalling mechanisms that are receiving top-down input, or in the context of colour constancy where the greyscale images are assumed to be the result of a prevailing illuminant with a colour complementary to the object colour.

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Strong post-transduction colour and luminance interactions with gradients

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We studied colour and luminance interactions for gradients (4˚size; 0.125cycle/degree). Threshold-versus-contrast detection and discrimination functions were measured for crossed achromatic (Ach) and red-green (RG) gradients and uncrossed conditions (either Ach or isoluminant RG gradients alone). A two-interval forced-choice with 2down-1up staircase paradigm was used to determine thresholds in three observers. Both crossed Ach and RG discrimination functions showed the conventional dipper shape, but with a broader dipper portion extending to 4x multiples of pedestal detection threshold. The cross-detection functions (Ach detection with increasing RG pedestals and vice e versa) showed a large facilitation of Ach gradient detection by nearly all RG pedestals contrasts and marked masking of RG gradient detection by Ach pedestals at threshold and suprathreshold contrasts. Both Ach and RG cross-discrimination functions (Ach discrimination with a fixed RG pedestal and vice e versa) had similar shape to their counterpart uncrossed condition, except that masking was more marked in the crossed Ach discrimination condition than the uncrossed one. In agreement with current views, the results from the uncross- and cross-discrimination conditions suggest that Ach and RG gradients are processed separately. Some of the interactions found might be explained by post-receptoral processes after the separate transduction of colour and luminance had happened. However, some of the strong interactions found for example in the cross-detection conditions suggest that those post-receptoral interactions with gradients may play an important role in visual perception such as disambiguating colour or luminance changes of a surface from the illumination.

The role of one-shot learning in #TheDress

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The first amazing effect with #TheDress is that a large number of people perceive it as white and gold even though the true colors of the dress are black and blue. Such apparent changes in color are common in many illusions. What makes #TheDress even more interesting is that there is a bimodal split of the population in the perception of the dress's colors (white-gold vs. black-blue), contrary to most color illusions where almost all observers perceive the colors in the same illusory way. On top of this, the percept rarely switches in a given individual. What causes this phenomenon? Here, we tested the role of one-shot learning during the first presentation of the image. By hiding large parts of the image, we were able to influence the perceived colors in naïve observers who had never seen #TheDress before. When the image was covered by white occluders, the majority of participants perceived the dress as black and blue. With black occluders, the majority of observers perceived the dress as white and gold. Importantly, the percept did not change when we subsequently presented the full image, arguing for a crucial role of one-shot learning in #TheDress. Next, we tested whether there are differences in the eye movement patterns of white-gold vs. black-blue perceivers. We did not find any obvious pattern. Hence, our results show that one-shot learning during the first percept, but not the first fixation or the subsequent eye movements, plays a crucial role for color perception in #TheDress.

Asymmetric single-pulse detection and double-pulse resolution of color opponent pathways

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Previously, impulse response functions and temporal contrast sensitivity functions were measured to study temporal characteristics of color opponent pathways. I studied the single-pulse detection and temporal double-pulse resolution of color opponent pathways here. Firstly, positive and negative chromatic contrast detection thresholds of single-pulse detection at various background conditions were measured. Secondly, based on the previous measured detection thresholds, temporal double-pulse distinguishing inter-stimuli-interval (DPDISI) thresholds were measured. 15 points in Smith and Pokorny's cone chromaticity space proposed in 1996 were sampled which were corresponded respectively with the S/LM and the L/LM axes at following levels, S/LM: 0.8, 0.9, 1, 2, 3, and L/LM: 0.3,0.335,0.37. The stimulus was a Gaussian patch which chromatic coordinates were gradually changed from the peak to the background along one of the six directions, +S/LM, -S/LM, +L/LM, -L/LM, +LM, and -LM. The luminance of the peak was the same with the background except at +LM and -LM conditions which were luminance contrast cases. Results showed that, (1) asymmetric single-pulse detection thresholds existed in all three color opponent pathways; (2) the DPDISI thresholds of -S/LM were different from those of +S/LM, +L/LM, -L/LM, and +LM respectively which suggested unique temporal resolution of -S/LM among color opponent pathways. Acknowledgment: This study was supported by National Natural Science Foundation of China (61368005).

Is luminance a key factor for static and flashed chromatic assimilation?

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Chromatic induction, i.e. both chromatic contrast and chromatic assimilation, have been widely studied for static stimuli. In contrast, chromatic induction for dynamic (flashed) stimuli have only been studied for chromatic contrast (De-Valois et al., 1986; Kaneko and Murakami, 2012).

We present new pyschophysical results using flashed and static stimuli for both striped and uniform surround, respectively expected to induce chromatic assimilation and contrast (Monnier and Shevell, 2003&2004; Otazu et al, 2010). Our stimuli were equiluminant and both the achromatic target and chromatic inductors laid in the same red-green or purple-lime opponent axis.

For uniform surround stimuli, and red, green and lime inductors, the strongest contrast induction was observed when the stimuli were flashed during 40ms. By contrast, we observed a completely different behaviour when the inductor was purple. For static striped stimuli we did not observe chromatic assimilation (in some cases, we found chromatic contrast) as in Fach and Sharpe (1986) and De Weert and Spillmann (1995), but observed it for a red/green surround (red-1st inductor, green-2nd inductor). No chromatic assimilation was observed for flashed striped stimuli.

Since non-equiluminant striped static stimuli induce chromatic assimilation (Monnier and Shevell, 2003 and 2004; Otazu et al, 2010), our results suggest that the luminance could be a key factor to induce chromatic assimilation. In addition, observers could not perceive any of the purple-lime 10ms flashed stimuli, a possible consequence of the reduced speed of processing in the koniocellular pathway (Briggs and Ursey, 2009).

Applying machine learning to gloss perception

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Humans effortlessly distinguish between matte and glossy surfaces, but the visual computations underlying this ability remain poorly understood. In the last decades, gloss perception research has mainly concentrated on identifying low-level image features that separate matte from shiny surfaces. However, researchers typically identify candidate cues by hand (e.g. contrast, histogram skewness), resulting in considerable debate about the role of individual cues, and even whether simple image statistics could in principle suffice for gloss perception. Here, by contrast, we take a data-driven approach to identifying gloss cues, based on learning from massive numbers of images. We trained a set of convolutional neural networks to discriminate high gloss from low gloss materials in random computer generated scenes. For this purpose we created a dataset of 89 000 scenes, each showing one of 1800 objects rendered under one of 214 image based illumination maps. We showed that humans can discriminate high gloss from low gloss objects even at low resolutions, as used to train the network. For simple non-textured materials we found that basic image statistics can be used to discriminate between the two categories with over 70% accuracy and that a simple convolution network achieves near perfect performance. A second stimulus set including surface texture variations cannot be easily discriminated using simple pixel statistics, but can be discriminated by humans and the network. Analysing the network reveals a large set of image features that humans could use to identify gloss.

Luminance modulates color detection thresholds in natural scenes

Camille Breuil, Simon Barthelmé & Nathalie Guyader

Luminance and chrominance information is extracted from natural scenes by different cone-opponent mechanisms at an early stage of visual processing. How independently the two streams are then processed along the visual pathway is still a controversial issue. While some authors believe that luminance and color signals are processed separately and in parallel up to V1, others suggest that they could interact as early as the LGN. Supporting the latter assumption, Párraga et al. (2002) introduced a model which includes a divisive normalization of the color-opponent channels by luminance. Here we try to access the relevance of this model when viewing natural scenes.

In our main experiment, which used a 2AFC paradigm, subjects had to decide which image was colored, between two images of the same scene containing identical luminance information. We found that color detection thresholds increased with global luminance level, as predicted by the model of Parraga et al.. While this suggests an early interaction between chrominance and luminance channels, a misalignment of individual cone-opponent channels with our color space cardinal directions combined with a contrast normalization mechanism occurring independently in each channel could also account for our results. This explanation was excluded by measuring in a second experiment detection thresholds for luminance in the same natural scenes, which under this hypothesis could have been predicted from our first results.

Our findings suggest an early interaction of luminance and chrominance in the visual system and supports nonlinear divisive normalization of color channels by luminance in natural scenes.

Training restricted Boltzmann machines to generate human-like eye movements

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Approximately twenty years ago, Laurent Itti and Christof Koch created a saliency map of visual attention in an attempt to recreate the work of biological pyramidal neurons by mimicking neurons with centre-surround receptive fields. The Saliency Model launched many studies that contributed to the understanding of layers of vision and the sphere of visual attention. The aim of the current study is to create an artificial network that is able to learn to generate saccades similar to a human being, but with more accurate prediction and in a more biologically plausible way as compared to the Saliency Model. The methods of the current study will use a similar Leaky Integrate and Fire layer, but will replace salience map creation with a Restricted Boltzmann Machine in order to create a generative model that is biologically precise for both spatial and temporal output. The initial results of the study involve a Restricted Boltzmann Machine able to generate eye movements based on general temporal and spatial parameters of saccadic eye movements from a two-dimensional array dataset as input. The results imply that salience modelling can be improved by matching of spatial and temporal distributions of the model to spatial and temporal distributions of human participants.

Regional sensitivity for Shape Discrimination (SD) in colour vision: Concentric and eccentric presentations of Radial Frequency (RF) patterns

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We investigated performance for shape discrimination in human colour vision in concentric and eccentric conditions (N=5). Stimuli were designed to isolate the red-green, yellow-blue or achromatic post-receptoral mechanisms, and were displayed in a CRT monitor using the ViSaGe system. In the concentric condition, RF patterns (peak spatial frequency 1c/deg, frequency 6c/deg), were presented at 0° with four radii (1.2°, 5°, 10°, 15°) and in the eccentric condition, at four eccentricities (0° to 15°) with stimuli scaled according to the cortical magnification factor. Discrimination between circular and non-circular shapes was measured using two-interval forced choice (2IFC) staircase procedure.

In the concentric condition, we found stable levels of performance for chromatic stimuli between 5-15° and between 1.2-15° for achromatic RF patterns. For the red-green stimuli, thresholds at 15° were measurable only for one observer.

In the eccentric condition, level of performance was maintained for red-green and achromatic stimuli between 1.2-10° with a worsening at 15° and for yellow-blue stimuli between 5-10° with a worsening at 1.2° and 15°. At 15°, thresholds for chromatic stimuli were measurable only for one observer.

We found that, in general the achromatic mechanism performs best. However, invariance in performance at different eccentricities for red-green, yellow-blue and achromatic stimuli suggests that similar mechanisms are involved in achromatic and chromatic shape discrimination. Some deviations from the general trends, e.g. elevated thresholds for yellow-blue stimuli presented at 1.2°, can be explained by inhomogeneous distribution of cones in the retina.

Recurrent convolutional neural networks suppress occluders and enhance targets in occluded object recognition

Courtney Spoerer & Nikolaus Kriegeskorte

Medical Research Council

Feedforward neural networks provide the dominant model of how the brain performs visual object recognition. However, these networks lack the lateral and feedback connections, and the resulting recurrent neuronal dynamics, of the ventral visual pathway in the human and nonhuman primate brain. Here we investigate recurrent convolutional neural networks with bottom-up (B), lateral (L), and top-down (T) connections. Combining these types of connections yields four architectures (B, BT, BL, and BLT), which we systematically test and compare. We hypothesized that recurrent dynamics might improve recognition performance in the challenging scenario of partial occlusion. We find that recurrent neural networks outperform feedforward control models (approximately matched in parametric complexity) at recognizing objects under varying levels of occlusion. The recurrent models learn dynamics that suppress internal representations of occluders and enhance representations of targets over time. It has been hypothesized that recurrent processing completes feedforward responses that are missing as a result of occlusion. We find that the enhancement of target representations is not explained by completing missing feedforward responses to the target. Instead, our results are consistent with the networks learning dynamics that, after multiple steps of recurrent processing, converge to a response that is invariant to amount of occlusion present in the image. Recurrent neural networks are not only more neurobiologically plausible in their architecture; their dynamics also afford superior task performance. This work shows that computer vision can benefit from using recurrent convolutional architectures and suggests that the ubiquitous recurrent connections in biological brains are essential for task performance.

Functional effects and interaction of voluntary and involuntary phantom vision on conscious perception

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Visual experience is typically based on retinal input, however, under certain circumstances, phantom visual experience can be created without concurrent corresponding retinal input through both voluntary and involuntary processes. Examples of phantom vision include mental imagery, neon colour spreading illusion and McCollough effect. Little is known regarding the functional effects of phantom vision on conscious perception and the commonalities between voluntary and involuntary forms. Here we used binocular rivalry to quantify the functional effects and characteristics of different phantom colour processes. We found that while colour mental imagery could facilitate dominance of same colour in the subsequent rivalry perception, neon phantom and McCollough-effect induced colour experiences both had suppressive effects. All these perceptual biases could be attenuated by the presentation of uniform background luminance during phantom vision generation. For involuntary phantom vision, perceptual biases could be changed by manipulating induction duration and inducer contrast. When performing colour imagery and viewing neon phantom colour successively within a single trial, the overall perceptual bias was contingent on the combination of the two colour experiences, suggesting a functional interaction. These data suggest that the functional effects of phantom vision are based on the sensory representation in early visual cortex, and this is similar to that formed during perception. Although sensory representations formed by voluntary and involuntary phantom vision have different strength and/or energy, they may share common mechanisms given the functional interaction.

What limits peripheral sensitivity?

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The drop in peripheral sensitivity with eccentricity has usually been attributed to reduced cortical representation, and modeled by scaling according to the cortical magnification factor (Rovamo, Virsu, & Näsänen, 1978). We reexamined this. Pelli & Farell (1999) showed that by measuring two thresholds, one on a blank field and one on a noisy field,

visual sensitivity can be factored into efficiency and equivalent input noise. Recent measurements show unimpaired efficiency out to large eccentricity, with no scaling, suggesting that the cortical computation to identify a simple target doesn't change with eccentricity (Rosen & Pelli, submitted). Here, we report measurements of equivalent noise vs. eccentricity, finding that the equivalent noise rises steeply with eccentricity, much like the reciprocal of retinal ganglion cell density (Curcio & Allen, 1990; Watson, 2014). We developed a simple model of the retina and estimate its equivalent input noise, for comparison with the human-observer measurements. The noise in our model is the approximately Poisson spike generation process of the retinal ganglion cells. We will present comparison between our model and our human measurements at wide range of letter size (1 to 16 deg) over a wide range of eccentricity) 0 to 60 deg, nasal and temporal).

Colors of the sublunar domain

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Colors (or reflectance spectra) of the sublunar domain are predominantly gray with a little articulation in the orange/greenish-blue, and even less articulation in the green/dark-purple "opponent" dimensions. This derives from basic physics, granted the generic make–up of the human visual system. Since RGB-images cater to human vision, they implement a coarse spectroscopy involving only three spectral bins. These bins can be derived from basic colorimetry. Such a spectral description yields the optimum RGB-system in the sense of exhausting the largest possible part of the Schrödinger color solid. Images yield samples of enormous size, collections of a hundred-million samples not being anything special. This allows informative statistical inferences to be drawn despite the general lack of calibration and control. Using internet image databases one really can "let the data speak". The results conform closely to expectations from generic principles of physics. We show that the Hering opponent color mechanisms correspond closely to the eigenvectors of the mean covariance matrices. These eigenvectors are the mean radiant power, the spectral slope and the spectral curvature. The eigenvalue corresponding to the mean largely dominates the chromatic dimensions, whereas that of the slope dominates that of the curvature. The precise ratios depend upon the type of scene in a characteristic manner.These findings enable useful applications, such as generic random color-generators for sublunar domains, that might find use in computer graphics, camouflage color design and so forth.

Distinguishing between evidence accumulation and temporal probability summation in perceptual decision making

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University of Bristol

Models of perceptual decision making typically assume temporal integration of a decision variable (e.g. sequential sampling models). The sensory input to these models, and therefore the precise input to the decision variable, is typically left unspecified. In contrast, models of early visual system specify the decision variable precisely as a scalar variable that reflects the match between noisy sensory input and a filter or matched template. These models often assume that this decision variable is not integrated but evaluated independently at different instances of time (i.e. temporal probability summation). Both models can account for choice and reaction time data. Through simulation, we establish that we can distinguish between these models by analysing the full reaction time distributions, using Ex-Gaussian distributional fits. The models generate different predictions about how reaction time distributions shift with a change in signal-to-noise ratio (SNR) of the sensory input. Moreover, the nature of this shift depends on whether the signal or noise component is varied. In a study where participants were asked to identify one of two numeric characters in a noisy animation, we found that the parameters of fitted Ex-Gaussians shifted in line with the sequential sampling model. We also found the same pattern of parameter shifts irrespective of whether the SNR was manipulated through varying the signal (Session 1) or noise (Session 2). This finding suggests that the decision variable is related to the SNR of the stimulus, rather than the ideal decision variable that represents the difference in matched template responses.

Low-level determinants of stimulus salience: Distinct contributions of colour and luminance on PCN waves

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Previous electroencephalographic (EEG) research on salience did not systematically vary low-level colour and luminance content of stimuli. Thus, it did not fully capture the complexities of low-level vision, which relies on cone-opponent and cone-additive mechanisms, or explore the effect of combining chromatic and luminance signals. Our first experiment used visual search patterns containing items defined by contrast that isolated cone-opponent, colour and cone-additive, luminance mechanisms. The latency of the posterior contralateral negativity (PCN, or N2pc) component of the event-related potential correlated with reaction times (RTs), and can therefore be used as a measure of color salience. Achromatic stimuli produced PCNs with lower amplitudes and faster latencies than chromatic stimuli; PCNs for achromatic stimuli were mainly driven by an amplitude change, while for colour they were driven by a latency shift. The second experiment used visual search patterns containing items defined by contrasts that isolated or combined achromatic and chromatic mechanisms. RTs suggested the salience of all features is combined to produce an overall level of salience, whereas PCN latencies indicated salience is determined by the feature with the highest level of individual feature-contrast. This difference between salience measures may be due to the RTs reflecting not only salience computations, but also subsequent stages of processing (e.g. motor processes). In conclusion, we found that neural processing of stimuli that isolate colour and luminance is distinct at stages that index salience computations, but that this is not the case for combined colour/luminance stimuli.

On the cortical mapping function

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The retino-cortical visual pathway is retinotopically organized: Neighborhood relationships on the retina are preserved in the mapping to the cortex. Size relationships in that mapping are also highly regular: The size of a patch in the visual field that maps onto a cortical patch of fixed size follows, along any radian and in a wide range, simply a linear function with retinal eccentricity. This is referred to as M-scaling. As a consequence, and under simplifying assumptions, the mapping of retinal to cortical location follows a logarithmic function along a radian, as already shown by Schwartz (1980). The M-scaling function has been determined for many visual tasks and is standardly characterized by its foveal threshold value together with the eccentricity where that value doubles, called E_2. The cortical location function, on the other hand, is specified by a logarithmic function, or its inverse, an exponential function, with empirically determined parameters. Here we aim to bring together the psychophysical and neuroscience traditions and specify the cortical equations in terms of the parameters customary in psychophysics. The resulting cortical-location function is applied to data from a number of fMRI studies. One pitfall is discussed and spelt-out as a set of equations, namely the frequently employed omission of a constant term in the exponential or logarithmic function. That omission renders the equations undefined in the retinotopic center and meaningless in the center's vicinity. As a final point, the equations are extended to describe the cortical map of Bouma's Law on visual crowding.

Investigating links between artificial neural networks and human visual perception

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Humans achieve remarkable performance in object recognition. This success is mediated by hierarchical visual system consisting of several brain regions, each of them constructing representations of object features on a particular level of complexity. Numerous sources of evidence from neuroimaging and neuropsychology show that humans evolved specialized network that is involved in the perception of faces. Holistic hypotheses suggest that we look at faces as wholes as compared to other objects and it finds support in Face Inversion Effect. Although it's harder to recognize any object from upside-down, face recognition is disproportionately impaired by inversion(Epstein, Higgins, Parker, Aguirre, & Cooperman, 2006).

Advances in computational modeling using deep neural networks achieve almost human-level performance in visual recognition tasks (LeCun, Bengio, & Hinton, 2015). Although most studies have engineering goals and don't account for biological plausibility it has been shown that features learned in the hidden layers of neural network resemble hierarchical processing stages in the human visual cortex(Kriegeskorte, 2015).

In present study we are going to tackle the hypotheses if artificial neural network process visual information similarly to humans by testing if FIE applies to neural networks.

Our initial results with Deep Neural Network stacked of 2 Autoencoders and a Softmax layer provide mix support for this idea, although neural network achieved novel accuracy when it was tested on upright images of faces and houses, It didn't perform rotation well.

Microsaccade and pursuit inhibition during smooth pursuit

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Microsaccades, which are small saccades that typically occur during fixation, are known to be inhibited in response to transient stimuli with a time-course that depends on the stimulus parameters and attention. We have recently found (Bonneh et al, JOV 2015, 2016) that the onset and duration of this inhibition could provide accurate and involuntary measures of low-level visual properties such as contrast sensitivity. Here we asked whether the oculomotor inhibition mechanism is specific to fixational eye movements, or generalizes also to other conditions such as smooth pursuit, which allows the eyes to maintain fixation on a moving target. In our experiments, observers (N=10) were asked to fixate and follow a small fixation point that slowly moved horizontally back and forth around the center of the display, while Gabor patches were briefly flashed centrally, at 0.5 Hz rate, with varied spatial frequency or contrast. We found that microsaccade inhibition occurred during smooth pursuits and its time course depended on the superimposed stimuli flashed during the pursuit movement in very a similar way as for a static fixation, with stronger inhibition and faster release of inhibition for more salient stimuli (higher contrast, lower spatial-frequency). Moreover, the pursuit movement itself slowed down transiently around the time of microsaccade inhibition, with a similar dependency on stimulus contrast and spatial frequency, demonstrating a stimulus-driven "pursuit inhibition". Our results thus show that the phenomenon of oculomotor inhibition generalizes to conditions of smooth pursuit for both microsaccades and the pursuit itself.

Eye-movement parameters reflect visual complexity and aesthetic appraisal of car fronts: Replication with a Russian sample

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Appraised aesthetic pleasure (AP) of an image is related to its subjective visual complexity (VC) as an inverted U-shape function (Berlyne, 1971). The function was found to hold for car front images; both subjective measures are also associated with eye-movement parameters, fixation count and dwelling time (Chassy et al., 2015). We replicated this UK-based study for a Russian sample (N=21) using the identical set of car front images (N=50) and procedure. Eye movements were recorded (SMI Hi-Speed; 1250 Hz) while participants inspected an image (10 sec), followed by subjective rating of AP and VC. Fixation count was confirmed as a behavioural measure of VC, revealing a strong positive correlation ($r=0.81$, $p<0.001$). However, in contrast to the original study, average dwelling time was also positively correlated with VC ($r=0.37$, $p=0.007$), while fixation count showed

a marginally significant correlation with AP (r=0.27, p=0.055). Furthermore, the relation between subjective measures VC and AP was positive and linear: AP=0.258VC–0.626 [r2=0.42, F(1,48)=34.4, p<0.001], unlike the quadratic best-fit in the original study. The findings imply that elaborated car front images are more attractive for Russian participants and inspected by them more densely and longer. The discrepancy may be interpreted from a dual-process perspective on aesthetic liking, allowing cognitive enrichment to override stimulus' processing affordance (Graf & Landwehr, 2015): for Russian observers, Western car brands with frontal design sophistication are supposed to manifest affluence and, hence, more attractive.

Investigating eye movements as an exploration/exploitation dilemma using a new gaze-contingent viewing task

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Visually scanning a scene entails a decision process between further analysis of the presently fixated region (exploitation) or to move on and saccade towards a not yet fixated region (exploration). Thus, eye movements can be described as an exploration/exploitation dilemma. Here we investigate whether knowledge of the scene context influences this decision process. Subjects (N=20) explored urban images through small 3° Gaussian apertures („bubbles"). We experimentally controlled the fixation durations by displaying an aperture for variable time intervals. After fixating for a given time, between one and 16 new "bubbles" appeared and subjects chose one of these by making a saccade, and the procedure was repeated. In a variation of this paradigm, we displayed a white patch at the saccadic target location before presenting the new patch. This allowed to temporally separate subsequent saccades. We analyzed the resulting saccadic reaction times (SRTs) using linear mixed models. Replicating a previous study, we observed a monotonic decline of SRTs with the time allowed processing the bubble displayed before the saccade. Further, the SRT increased monotonically up to the largest number of bubbles. A temporal gap before the display of the new patch did not lead to shorter SRTs. In summary, these data demonstrate a dynamic trade-off of visual exploration and exploitation. An increasing number of targets delays the decision of the new target selection. This is in contrast to simple race-to-threshold models. A resting period, separating the decision process from previous saccades does not accelerate the decision process.

The effect of different brightness conditions on visually and memory guided saccades

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It is commonly assumed, that saccades in the dark are slower than saccades in a lit room. The few studies that investigated this issue often compared memory guided saccades in darkness to visually guided saccades in an illuminated room. In the present study, we independently manipulated task (memory guided/visually guided) and screen brightness (dark, medium and light) in an otherwise completely dark room, and measured the peak velocity and the duration of the participant's saccades.

We found that memory guided saccades were generally slower than visually guided saccades. In both tasks, eye movements on a medium and light background were equally fast and had similar durations. Saccades on the dark background were slower and had longer durations. Our results show that peak velocity and duration do not linearly change with increasing screen brightness.

Variation in sensitivity during visual fixation

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University of Nottingham

While large exploratory saccades are eliminated during periods of steady fixation, the eyes are never still. We make small amplitude ballistic movements, termed microsaccades, at a rate of 1-2 every second. How perceptual stability is achieved is currently unknown, though a prevalent view is that vision is suppressed during microsaccades - akin to the well-established suppression associated with larger saccades. Here, we present data that support a role for suppression but also reveal facilitation of visual sensitivity some time after the eye has stopped moving. Subjects fixated and performed a contrast detection task while their eye movements were recorded. Stimuli were large centrally-presented Gabors (sd = 5 degree) and contrast was varied in a staircase procedure for a range of interleaved spatial frequencies (0.33 – 5 c/deg). Microsaccades were detected and trials sorted depending on the timing of the nearest microsaccade. The time course of sensitivity relative to microsaccade occurrence was then computed. The magnitude of suppression and facilitation of visual sensitivity was related to the spatial content of the stimuli: suppression was greatest for low spatial frequencies while sensitivity nearly doubled for spatial frequencies to which we are already most sensitive. Suppression was evident early (50ms before a microsaccade) while facilitation occurred later (150ms after). We propose that mutual inhibition between spatial frequency channels could account for the time-varying spatial tuning of suppression and facilitation. Our data confirm that microsaccades actively modulate vision, suppressing input to avoid motion blur and later enhancing sensitivity after the movement is complete.

Dissociation between microsaccadic and perceptual timing

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University of Nottingham

Abruptly presenting a visual stimulus during fixation triggers a characteristic biphasic modulation in microsaccade rate – an initial dip followed by a rebound and return to baseline rate. While this rate signature occurs without any conscious awareness, its properties can provide insight into the perceptual state of the observer. For example, the amplitude

of the rate signature is strongly correlated with the visibility of the stimulus and can be used to derive accurate estimates of contrast sensitivity (e.g. Scholes et al., 2015; White & Rolfs, 2016). Here we ask whether a similar coupling exists between microsaccadic and perceptual estimates of interval timing. Observers were presented with two brief Gabor stimuli separated by a variable time interval and asked to immediately reproduce the interval by pressing a button. Within a testing session, intervals were either fixed (800, 1200 or 2000ms) or sampled from a uniform distribution (800-1200ms or 1200-2000ms). Reproductions in uniform distribution conditions exhibited classic central tendency biases – on average, observers tended to over-estimate the relatively short intervals in each distribution and under-estimate the longer ones. However, a different pattern of results emerged when time intervals were estimated from the delay between the microsaccade rate signatures elicited by marker stimuli. These microsaccadic interval estimates closely matched the physical timing of the stimuli and showed no sign of contextual modulation. Thus, while rate signature amplitude is coupled to the observer's detection of a visual stimulus, rate signature timing does not predict perceptual judgements of time.

The burnout syndrome in figure skaters: The eye tracking study

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The burnout syndrome entails three distinct states in which people feel emotional exhaustion, display a detached attitude towards others and experience a low sense of efficacy at work (Maslach & Jackson, 1986). The aim of this study was to develop a new method of burnout diagnostic in sportsmen using the eye tracking technique. 48 professional figure skaters with experience in skating of more than 10 years participated were divided into two groups. The first group consisted of the skaters with high level of burnout and skaters with low level of burnout were in the second group. Burnout was assessed with the Maslach Burnout Inventory. The experiment session involved 32 presentations of matrices (2x2) containing 4 images. Matrix were presented randomly for 5000 ms. Each matrix consisted of photos of training, competition, failure and neutral image. Eye movements were recorded (SMI RED 120; 120 Hz). Two-way ANOVA with repeated measures revealed the significant differences in eye movement parameters between two groups of participants ($F=6.462$, $p<0.001$). Fixation count and fixation duration were significantly higher in the first experimental group while they observed training and failure photos. It was also found that skaters from the second group payed more attention to the photos of competitions. Thus it is suggested that figure skaters with burnout are more interested in dysphoric stimuli and demonstrated low motivation to win and rewards. We also concluded that eye tracking may be used for objective burnout diagnostic.

Testing the English language proficiency level of Russian students using eye-tracking technology

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The aim of our work was to create a method for testing the English language proficiency level of Russian students using eye-tracking technology. It is shown, that the characteristics of eye movements provide valuable information for studying reading and information processing (Rayner K. 1998). Thirty participants (12M, 18F, 18-26) took part in the experiment. They were divided into two groups by levels of English using placement test. The task consisted of 15 sentences in English with the missing words and four response options (1 correct and 3 incorrect). The participant's task was to choose a correct response option. The sentences were presented for unlimited time. Registration of eye movements is carried out in monocular mode using the SMI iViewXTM Hi-Speed 1250 tracker. The images were displayed on a 23-inch LCD monitor mounted at a distance of 75 cm from the viewer. During the execution eye movements were recorded. The results show that in the first group with a high level of English average fixation durations during the fixation on a correct response option were significantly larger than on an incorrect response option. And there is no significant difference between the average fixation durations on correct and incorrect response options in the second group with a low level of English. Our results are in good agreement with the E-Z Reader Model (Reichle et al. 1998). Thus, eye movement characteristics allow to develop the effective method of testing the English language proficiency of Russian students.

Masking of random-walk motion by flicker, and its role in the allocation of motion in the on-line jitter illusion.

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Typically, perceptual stabilization mechanisms make us unaware of the retinal image motion produced by the small, involuntary eye movements our eyes constantly make during fixation. The breakdown of perceptual stability is demonstrated by the on-line jitter illusion, in which a circular static pattern appears to jitter coherently when surrounded by a flickering annular pattern. Although both regions of the stimulus are subject to retinal motion from eye movements, the visual system attributes this motion to the central static region in the form of visual jitter, while the surrounding flickering region remains perceptually stable. We investigated factors influencing this allocation of motion and reference frame in the on-line jitter illusion. The flickering of the surround was found to impair the detection of simultaneous random-walk motion in this area, giving a detection reliability of around 80% for motion approximating that from fixational eye movements. Changes to spatial texture and location of flicker (centre vs. surrounding annulus) had little effect on the final percept. However, use of a nonconcentric stimulus resulted in a marked reduction in apparent jitter in all subjects. Our results suggest for the on-line jitter illusion, allocation of motion and reference frame is influenced by the general principle that, if one region surrounds another,

the surrounding region tends to be allocated as the frame of reference. When this factor is controlled for, spatial textures, location of flicker, and the masking of motion by flicker have a smaller but measurable influence on the final percept.

Localizing hemianopic visual field defects based on natural viewing behavior while watching movie clips

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Performing standard perimetry is a tedious and fatiguing task that is sometimes even impossible to perform in certain patient groups, like children and elderly. For this reason, we asked whether -in principle- we can identify the location of a visual field defect in an easier way using eye-movements. We tested this idea using simulated Homonymous Hemianopia (HH). In our data analysis, we exploited the fact that visually healthy observers usually show quite consistent gaze behavior when watching movie clips (Marsman et al, 2016). We hypothesized that in case of HH, observers will rarely direct their gaze to locations in the blind hemifield, even when these are prioritized by healthy observers. In the experiment, participants watched 90 movie clips of 1 minute under different visual (simulated right or left HH and without HH) and auditory conditions (stereo, right, left and no sound), while their eye-movements were recorded. A measure for viewing priority at different locations of the visual field in the control condition was computed as a reference. Next, averaged over the various movie clips, we determined viewing priority for each observer in each simulation condition. We found that in the simulated HH conditions, average viewing priority in the blind half of the visual field is significantly lower than in the seeing half of the visual field. Differential auditory stimulation had no effect on viewing behavior. We conclude that that we can derive the location of a hemianopic visual field defect from natural viewing behavior exhibited during movie viewing.

Eye movements during viewing of natural scenes: Prior object-knowledge restructures salience

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The extent to which eye movements during viewing of natural scenes are guided by low-level features or by high-level object representations is a matter of intense debate. The finding that low-level feature models show good performance in predicting eye-movements might indicate low-level guidance but could also result from the fact that features and object locations are confounded in natural scenes. Experimental work relating to this question has manipulated low-level properties of stimuli. Here, we take a different approach: leaving low-level features of images intact, we manipulate the ability to perceptually bind them into high-level scene representations by controlling observers' amount of prior object-knowledge. We used ambiguous, two-tone images as stimuli. These are derived from photographs of natural scenes, the templates. On first viewing, two-tone images appear to consist of meaningless patches. Once an observer has acquired prior knowledge of image content by viewing the templates, however, the visual system binds a two-tone image into a coherent percept of a scene. In the current study, we collected eye-gaze data while observers free-viewed template photographs (Template condition) as well as two-tone images before (Unresolved) and after (Resolved) providing prior object knowledge. Despite the fact that low-level features of two-tone images are identical in the Unresolved and Resolved conditions, we show that observers' eye-gaze patterns are more similar between Template and Resolved conditions than between Template and Unresolved conditions. These findings indicate that processes of perceptual organisation that are guided by prior object knowledge override low-level features in the control of human eye-movements.

Optimizing clustering-based smooth pursuit detection

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We investigate gaze behaviour with dynamic natural scenes, with an emphasis on smooth pursuit (SP). Unlike fixations and saccades, SP is not as clearly defined by its upper and lower bounds of speed, so that oculomotor and tracker noise can unpredictably influence its detection. Therefore, we previously developed an algorithm that leverages inter-observer similarity: SP should be driven mainly by local stimulus characteristics, hence its detection can be facilitated by clustering dynamic point-of-regard samples of multiple people in space and time simultaneously. Without any parameter tuning, this approach outperformed the state-of-the-art algorithms, although it often produced fragmented SP episodes. We now improved several aspects of our approach. First, we tuned parameters by a cross-validated grid search in log-space. Then, to tackle fragmentation, we trained a Hidden Markov Model to implicitly smoothen detected SP episodes. We evaluate both fixation and SP detection performance using the F1 metric (harmonic average of precision and recall). Our previous algorithm achieved 57.1% SP-F1, 90.8% fixation-F1. With optimized parameters, SP-F1 increased by 7.5%, while fixation-F1 decreased by 2%. HMM-based postprocessing increased SP-F1 by 1% with hardly any effect on fixation-F1, but made the SP episode duration distribution closer to that of hand-labelled ground-truth data. Combined, these methods achieve final performance figures of SP-F1: 64.9% (68.9%/61.3% precision/recall), fixation-F1: 88.7% (93.1%/84.6%), with the additional benefit of a more natural episode duration distribution (Kullback–Leibler divergence down from 1.385 originally to 0.358). The source code and our data set are publicly available at http://michaeldorr.de/smoothpursuit.

Perception of hyper-realistic face masks

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Recent use of hyper-realistic silicone masks in criminal settings suggests that these masks are both effective in disguising identity and difficult to detect. In three separate

studies we examined conditions where viewers detected the masks rather than accepting them as real, comparing British and Japanese participants. In Study 1, viewers were strikingly poor at distinguishing between real faces and hyper-realistic masks onscreen, even when they knew that masks were present. Study 2 shows that the task is also difficult when viewing live models outdoors, even at short distances (3m vs 15m). British participants outperformed Japanese participants when viewing western masks, suggesting a possible race effect in mask detection. Study 3 investigates this other-race disadvantage in a controlled 2AFC lab study, replicating the effect. Our findings suggest that more targeted strategies—such as analysis of facial expression or facial speech—may be required if hyper-realistic masks are to be reliably detected.

Switch from ambient to focal processing mode explains the dynamics of free viewing eye movements

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Previous studies have reported that humans employ ambient and focal modes of visual exploration while they freely view natural scenes. These two modes had been characterized based on eye movement parameters such as saccade amplitude and fixation duration, but not by any visual features of viewed scenes. Here we propose a new characterization of eye movements during free viewing based on the sequence gazes at objects in a visual scene. We conducted eye-tracking experiments in macaque monkeys freely viewing scenes composed of multiple complex visual objects. We analysed their eye movements focusing on whether individual saccades are performed within an object or across objects. Our results indicate that the monkeys perform global exploration across objects at the beginning of a free viewing trial followed by focal examination of individual objects, consistently with the previous observations of ambient/focal exploration modes. We formulated a hidden Markov model of saccade sequence generation based on a switch between two distinct saccade generation modes, corresponding to the observed two exploration modes. This model quantitatively explains the dynamics of free viewing eye movements performed by the monkeys and enables to infer the timing of the mode switch from empirical data. These results have three direct implications: First, our findings provide a solid support for the two-mode hypothesis, which postulates distinct ambient and focal processing modes, second, our model demonstrates the possibility of abrupt switches from ambient to focal modes, and third, the dynamics of these modes seem to be shared between humans and monkeys.

Voluntary smiles make faces objectively more feminine: Comparing computational shape analysis and observer perceptions

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Voluntary smiles are a remarkably powerful way to manipulate the social responses of other humans – a crude form of control at a distance. For example, a voluntary smile can make other people think you look more attractive. Favourable responses from observers could be due to what they have learned about the meaning of smiles. However, a smile also changes the shape of the face and its features, including the eyes, brows, mouth, and jaw. These shape changes may themselves change the inferences drawn from the face. Here we used computational pattern analyses to quantify the shape changes produced by voluntary smiles, and estimated how and whether these changes could explain observer perceptions. Our analyses showed that voluntary smiles gave men's and women's faces an objectively more feminine shape. Comparing our objective ratings of femininity from shape with other ratings from human observers led us to conclude that voluntary smiling makes women more attractive by increasing the femininity of their face shape. Voluntary smiles also made men's faces more attractive but not directly due to shape changes in sexual dimorphism.

Numerosity estimation benefits from trans-saccadic information integration

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Humans achieve a stable and homogeneous representation of their visual environment, although visual sensitivity and resolution varies across the visual field. In the perception of numerosity, there is even a miscalibration between peripheral and foveal vision, leading to an underestimation of numerosity in the periphery (Valsecchi, Toscani, & Gegenfurtner, 2013). Here, we investigated if, and how the human visual system integrates peripheral and foveal information for numerosity estimation across saccadic eye movements.

We asked our participants to judge whether the number of black and white dots on a screen is above or below the perceived mean numerosity of all previously presented stimuli. Information was presented either in the periphery before a saccade, in the fovea after a saccade, or in both areas consecutively to measure trans-saccadic integration. In contrast to previous findings, we found an underestimation of numerosity for foveal presentation but a rather accurate estimation for peripheral presentation. We used a maximum-likelihood model to predict accuracy and reliability in the trans-saccadic condition based on peripheral and foveal values. Regarding reliability, we found near-optimal integration of peripheral and foveal information, consistently with previous findings about orientation integration (Wolf & Schütz, 2015). Regarding accuracy, the integrated numerosity estimation put a higher weight on peripheral than foveal information.

Overall, our results suggest that trans-saccadic integration also works for complex visual features such as numerosity. The integrated percept shows a high accuracy in spite of mismatches between foveal and peripheral vision. This is important to achieve a seamless and stable perception of our environment.

The role of holistic, configural, and featural information in the recognition of individual emotional expressions

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While facial identity perception relies heavily on holistic processing, recognising facial expressions seems to involve holistic, configural, and featural information. However, the extent to which each type of information is engaged in the expression recognition process is not well understood. To investigate the relationship between configural, holistic and featural information in the recognition of "basic" facial expressions, participants completed a battery of expression recognition tasks in upright and inverted recognition, scrambled-blurred, composite and bubbles tasks. Results showed typical effects of emotion in upright expression recognition accuracy. Inversion impaired recognition of all expressions, except happy. Fear was recognised worse when blurred than scrambled and intact. Sad expressions were recognised worse when scrambled or blurred than intact. There were no differences between intact, scrambled, and blurred conditions for angry or happy expressions. A composite effect suggested recognition of angry and sad expressions used holistic processing, while no effect was found for fear. The bubbles task indicated that the amount and type of information needed for accurate recognition varied for different emotions. Correlations varied in significance when comparing accuracy scores for each expression between tasks, suggesting common perceptual mechanisms may have been employed for recognition of certain expressions. Multiple regression analyses revealed significant variability in expression recognition ability was due to performance within the inverted condition and the bubbles task. The relationship between performance in each task varied by emotion suggesting that the extent to which emotional expression recognition relies on holistic, configural and featural information depends on the emotion in question.

Exploring the eye-movement differences between correct and incorrect answerers of spatial ability scale items

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Spatial ability is important in daily life and is applied to many fields like mathematics, natural sciences, engineering, meteorology, chemistry, physics and sports. Spatial ability involves in processing information through visual representation in our mind. The purpose of this study was to compare participants' differences between who answered correctly and incorrectly in three items of a spatial ability scale. A Tobii T120 eye tracker with a sampling rate of 120 Hz was used to collect eye-movement data when the participants orally answered the spatial ability scale shown on the computer monitor. The participants of this study were thirty undergraduate and graduate students from various backgrounds of one university in Taiwan. We analyzed eye-movement data from three items, with one item from each of the three subscales (spatial perception; two-dimensional rotation; and solid rotation), and these items were chosen because they were of the highest failure rate among each subscale. For the spatial perception item, we found that participants who answered correctly fixated and visited the figure longer than those who answered incorrectly. For the two-dimensional rotation item and the solid rotation item, the results showed that participants who answered correctly were significantly more likely to fixate and visit the correct choice than those who answered incorrectly. From the above results, we found that those who answered correctly allocate more attention on correct choice than incorrect choices, and also more than incorrect answerers. The fixation position of correct choices may contribute useful information to spatial training.

Attractiveness judgment of facial parts: Attractive facial parts are looked at longer

Chihiro Saegusa & Katsumi Watanabe

Visual attention tends to be captured by and to require longer time to disengage from attractive faces (Sui and Liu, 2009). Our previous study implicated that attractiveness judgment for facial parts, particularly for the eyes, has similar characteristics with the whole faces (Saegusa & Watanabe, 2016). In the current research, we examined the relationship between attractiveness judgments of isolated facial parts and the time taken for observers to make the attractiveness judgments. Whole facial area and facial parts (the eyes, the mouth, the nose) were cropped from 98 (58 females, 40 males) full-color frontal photographs, resulted in 392 stimuli. Each stimulus was presented on a monitor and observers rated attractiveness of each face or facial part with a 7-point scale by pressing the corresponding keys. Neither explicit time constraint nor instruction was given. Time elapsed from the stimulus onset to button pressing was taken as response time. The experiment was divided into 2 blocks for different face gender with 4 sub-blocks for the different facial parts (whole faces, the eyes, the mouth, the nose). We found significant positive correlations between the attractiveness judgment of facial parts and the response times. That is, the observers took longer with the attractive faces and facial parts. The correlation with the attractiveness judgment of the isolated eyes was as high as that of the whole faces. The present results suggest that, similar to whole faces, even isolated facial parts, particularly the eyes capture and/or hold our attention more when they are more attractive.

Perception of the old/young lady ambiguous figure is affected by own-age social biases

Michael Nicholls, Owen Churches & Tobias Loetscher

Although facial recognition is dependent on low-level neuronal process, it is also affected by seemingly incidental high-level social process. Faces from a social in-group, such as people of a similar age, receive more in-depth processing and are processed holistically compared to an out-group. To explore whether the social, own-age biases affect face detection at a subconscious level, we presented an ambiguous figure, which can either be perceived as a young or an old woman. Amazon Turk was used to sample a large group

of participants of varying ages from the USA and India. For the Americans, younger and older participants estimated the age of the image as younger and older, respectively. This own-age effect ties in with socio-cultural practices, which are less inclusive towards the elderly – causing the formation of age-related in- and out-groups. For the Indians, no effect of participant's age was found and this may reflect the more inclusive socio-cultural attitudes towards the elderly in this country. Participants were not aware the study was related to ageing and the stimulus was shown briefly for half a second. The results therefore support the conclusion that social group processes have a subconscious effect of the early stages of face processing.

Cultural differences in naturalistic face scanning

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Recent eye-tracking studies point to significant cultural differences in face scanning between Western Caucasian (WC) and Eastern Asian (EA) adults (e.g. Blais et al., 2008), challenging the notion of universality in face perception. However, previous studies have primarily presented static faces on screen; this raises the question of whether findings extend to real-world conditions, which are not only visually complex but also characterised by social presence. Using head-mounted eye-tracking, we adopted a face-to-face interaction paradigm to examine scanning behaviour in 20 WC and 20 EA dyads who introduced themselves and played story-telling games. We developed semi-automatic tools that track regions of interest (ROI; upper/lower face) and classify gaze points accordingly. Results revealed that both groups looked significantly more at the face when listening than when speaking. Cultural differences were observed during speaking, with increased face gaze at the listening partner in EA compared to WC participants. Contrary to predictions, no group differences were found for duration of upper face scanning or mutual gaze, questioning the notion of gaze avoidance in EA observers (Argyle et al., 1986). We also employed a data-driven approach whereby face regions and gaze points are mapped into a normalised space to generate difference maps of gaze density. Initial qualitative results revealed that EA observers showed more localised eye scanning, whereas WC observers exhibited greater gaze distribution. This replicates screen-based studies using emotionally expressive faces (Jack et al., 2009; Senju et al., 2013) and demonstrates cultural differences in naturalistic face scanning for the first time.

Familiarity enhances recognition of multiple facial identities from a single facial image

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When encountering families in everyday life, we often look for telltales of both parents' facial features in their children's faces. However, so far few studies have tested our ability to recognize multiple facial identities from a single face and how such ability is influenced by our familiarity with the target faces. To address these questions, we created a set of morphed faces by mixing three parent faces equally together. These 3-parent faces were created either out of a set of 10 female faces (female morphs), a set of 10 male faces (male morphs) or out of both sets together (mixed morphs). Each of the 30 3-parent faces was shown surrounded by the 20 original faces. Participants indicated which faces were represented in the test face by choosing a maximum of 3 original faces. To examine the influence of familiarity on the ability of recognizing multiple identities, we tested participants who were either familiar with the target faces (i.e., colleagues) or had never seen those faces before. Results indicate that familiar participants recognized more identities (M=2.3 faces, SEM = 0.10) than unfamiliar participants (1.8 faces, SEM = 0.05, P = .001) although the whole visual information is available during the task. Therefore, familiarity enhances our ability to extract multiple identity information from one face, and even for people familiar with the target faces, recognizing all three identities from one face remains challenging.

Flashed face distortion effect in pictorial faces

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When faces are shown in an eye-aligned, fast-paced presentation manner, they look grossly distorted. This is called flashed face distortion effect (FFD). Although the exact underlying mechanism is still unknown, it is believed that this optical illusion has something to do with checking the deviation-from-the-norm in our internal representation of faces, a process also involved in the creation of cartoon faces. We aimed to compare the strength of FFD between real and pictorial faces. A 4x2x2 (degree of realism x degree of familiarity x gender) mixed design experiment was conducted. The within participant variable is the faces' level of realism, for which we collected manga faces at three levels of realism in addition to a group of real faces. The first between participant variable is the participants' exposure to manga as an index to degree of familiarity to pictorial faces. The second between participant variable is the participants' gender. The results show a significant and systematic realism effect, there was significant difference between every adjacent group on the realistic rank order. We do not find significant effect in familiarity, gender, and interactions among the three variables. The results imply that certain room for abstraction or reduction in complexity is a necessary condition for FFD. The higher a stimulus is in realism, the more room available for it for reduction or abstraction, and thus stronger FFD it might induce.

Perceptual correlates of others' direction of gaze in anterior superior temporal sulcus

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Our ability to discriminate another person's gaze direction is remarkable, given that a single gaze direction can be conveyed by many different configurations of eye deviation and head position. Previous research by Carlin et al (2011) suggests activity in human anterior superior temporal sulcus

(STS) encodes gaze direction irrespective of how it is conveyed. However, it is unclear whether activity in anterior STS reflects stimulus differences in head and eye information that signal gaze direction or whether this region represents the perceptual "read out" of another's gaze. We addressed this question by measuring Blood Oxygenation Level Dependent (BOLD) responses to differences in perceived gaze direction while controlling for stimulus differences in eye and head information. We exploited a visual illusion known as the Wollaston illusion, which allowed us to create sets of stimuli that induced the perception of either direct or averted gaze while matching for eye deviation and head position across conditions. Consistent with previous studies, we found a cluster in the right anterior STS that showed significantly stronger activation when gaze was perceived as averted compared to direct. Because this result cannot be attributed to stimulus differences in eye deviation and head position, our findings suggest that anterior STS represents the perceived direction of another's gaze independent of how it is conveyed.

Induction of facial feature usage in naïve individuals reveals causal factors of face recognition ability.

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Université de Montréal

With the aim of going beyond the correlational techniques that have attempted to resolve the issue of variance in face recognition ability in the normal population, we experimentally induced two visual strategies in eighty naive participants and observed the effect of this treatment on their recognition abilities. We focused on two visual strategies that we knew correlated with better and worse performance at this task — the use of the right and left eye region, respectively (Faghel-Soubeyrand & Gosselin, 2016). Participants completed a three-phase procedure (pre-, during-, and post-induction) of face-sex recognition Bubbles task (Gosselin & Schyns, 2001). Individual Classification Images (CI) — least square regression planes between bubbles positions on each trial and a participant's accuracy — revealed idiosyncratic use of facial information for each experimental phase. Unsupervised clustering algorithm on pre-induction individual CI confirmed the existence of two sub-groups of individuals differing qualitatively in the information used for the task: a first group using the left eye region and a second group, which performed significantly better, using the right eye region. Most importantly, post-induction CIs shows that we successfully induced right-eye and left-eye usage in a sub-group of poor (left-eye users) and good (right-eye users) face-sex recognizers, respectively; while induction of right-eye usage significantly improved the unskilled group's performance on post-induction task sessions, left-eye usage yielded a significant decline in the skilled group's recognition ability. This is the first demonstration that the use of left and right eye region is causally linked to worse and better face recognition ability, respectively.

Mapping the earlier featural and holistic face processing of bad and good face recognizers

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We investigated the response profile of the face-specific N170 component of bad and good face recognizers by employing an adaptation procedure where adaptor and target stimuli were presented in rapid succession with a short interval inter-stimulus. Three different face categories, such as whole face, eyes, and mouth, were used as adaptors and targets. N170 amplitude reductions indicative of the adaptation effect were found for all types of face category in both groups of face recognizers, demonstrating that at a general level, this component reflects the activation of face-selective occipitotemporal area for both whole faces and facial features. Noteworthy, good recognizers showed a hemispheres dissociation with the right holistically coding for whole faces and left featurally coding for facial features (i.e. eyes and mouth); while bad face recognizers did not present such a processes encapsulation. However, they presented a mouth specificity on the right hemisphere. The pattern of lateralization in good face recognizers and the specific sensitivity for the mouth facial feature in bad recognizers suggest a distinct contribution of holistic and featural processes to face processing, which appears specifically tuned to individual differences in face recognition abilities. Overall, our results demonstrate that, during the early stage of face processing, different neural sources over the right and left hemispheres could generate the N170 component and that, importantly, these electrophysiological differences might rely on the specific face recognition ability presented by the participants. Together, the rapid adaptation procedure and the ERP technique provide a powerful tool to dissociate these sources.

Contrast discrimination near threshold at different spatial frequencies

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We measured contrast increment thresholds at different spatial frequencies (2, 4, 8 c/deg), with a focus on near-threshold pedestal contrasts where the discrimination function displays a facilitation effect, a decrease in increment thresholds (Legge, 1981). Sinewave gratings of same spatial frequency, with and without increment to a pedestal, were presented side-by-side in a 2AFC task, at seven pedestal contrasts ranging from 0 to 4.8%; observers (n=4) indicated the grating having higher contrast. Logistic psychometric functions were fitted to the proportion-correct data (Psignifit4), to obtain contrast increment thresholds and psychometric function slopes. Contrast increment threshold functions are dipper-shaped, decreasing with increasing log pedestal contrast to a minimum at 0.6% for the low frequencies, and increasing more steeply from there. The dip appears around the pedestal contrast corresponding to the detection threshold for all three spatial frequencies. At low pedestals, the thresholds are similar for 2 and 4 c/deg but clearly higher for 8 c/deg. As pedestal contrast increases, the increasing portions of the functions merge. The facilitation effect, manifesting itself by a threshold dip, is present in all three functions, but at 8 c/deg is shifted towards a higher pedestal,

indicating the transition from transient to sustained neural channels around 5 c/deg (Breitmeyer & Julesz, 1975). Psychometric function slopes are uniformly lower for 8 c/deg than for 2 and 4 c/deg, and for the latter are similar. Above pedestals where the dip occurs, slopes decrease and become more similar between the three cases.

Ekman's expression research revisited: Theoretically and empirically checking the current standards of emotion expression research

Ute Brütting & Claus-Christian Carbon

The predominant consensus in scientific publications is the assumption of the existence of six universal facial expressions, most prominently proposed by Paul Ekman. The universality hypothesis states that "basic emotions", mostly referring to joy, surprise, disgust, sadness, fear and anger, are represented in the same kind of mimic expressions in every culture. Consequentially, it is proposed that these facial expressions can be decoded free of cultural influences. We overview and critically reflect the universality hypothesis on a cross-cultural as well as on an individual level. It turns out that some classical research methods applied by Ekman and persistently cited are not suitable for critically testing the universality hypothesis as they presumably bias the result. Ekman's theory of microexpressions, emotions that appear only for a fraction of a second on the face, does not hold up a scientific examination, too. Main reasons are insufficient paradigms employed to study microexpressions and the inaccessibility of alleged scientific sources to which recursively is referred to. Highly problematic in this respect seems to be that, based on the theories of expression universality and microexpressions, a variety of very expensive training programs has already been launched around the world which focus on the detection of criminals. Proof of concept, however, is still missing. Essential parts of emotional research have therefore to be re-thought and newly theorized.

A neural evidence for the dissociation between mechanisms underlying detection and identification tasks

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In this study, the effect of context-dependent lightness on perceived contrast was investigated using psychophysical and fMRI methods. Previously, we measured appearance judgments of participants and demonstrated that context-dependent lightness of background influences the perceived contrast of rectified gratings (Pamir & Boyaci, 2016). Perceived contrast of gratings superimposed on equiluminant but perceptually lighter background is higher compared to ones on perceptually darker backgrounds. However, this pattern is valid only for incremental, not for decremental contrast. Literature indicates a significant difference between visual processing near and above threshold. Also, behaviorally it has been shown that appearance and discrimination tasks are mediated by different mechanisms. Therefore, here, we measured the effect of context-dependent lightness on contrast detection and discrimination thresholds using a 2-IFC procedure. Results indicate that both detection and discrimination thresholds are lower for the gratings superimposed on perceptually lighter backgrounds (N=9). Differently from the appearance results, the effect was observed both for incremental and decremental contrast. In an fMRI study, we investigated whether activity in any brain region correlates with lightness-dependent contrast. Although our stimulus was physically identical we observed difference in BOLD response in V1 reflecting the perceptual differences (N=3). Both for incremental and decremental contrast, activation was greater when the grating was superimposed on lighter background. Thus, variation in V1 activity with varying contrast closely linked with the detection and discrimination thresholds. Therefore, this study offers, for the first time, a neural evidence for dissociation between the mechanisms underlying detection (threshold) and identification (appearance) measures.

Eye movements to faces presented in the periphery

Stephan Brueggemann & Jeffrey Saunders

Studies of eye movements during face recognition have observed that the first fixation tends to be at a preferred location near the center of the face (e.g. Or, Peterson & Eckstein, 2015). In previous studies, faces were presented in the center, but in natural conditions faces can appear at different locations and the position of the preferred landing location is much less certain. We investigated first and second fixations when faces are presented peripherally. In Experiment 1, face stimuli for a famous vs. nonfamous task were presented 7° away from a central fixation cross in one of four quadrants. We found that first fixations were not centered on the face, but rather biased toward the starting fixation. For example, the first fixation on faces presented in the upper left quadrant tended to be on the right part of the chin. While first fixations depended on stimulus position, the second fixations converged toward the center of faces, consistent with a preferred location for performing recognition. In Experiment 2, we cued the position of face stimuli for a name-matching task by first presenting a blurred mean face for 1000ms, allowing subjects to move their gaze in preparation. Despite the absence of information about face identify, eye movements during the cueing period showed the same pattern of initial undershooting and converging to a central location. Our results suggest that peripheral targets may require a first fixation near the face to locate facial features and identify the preferred location for a second fixation.

Are low spatial frequencies (or high contrasts) the trigger of threat detection?

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Research in visual cognition has proposed that low spatial frequency (LSF) information could rapidly provide a coarse

visual cue for basic emotional response to a potential visual threat in the environment. This effect would be mediated by a large cerebral network involving fronto-parietal and temporal cortical areas, but also subcortical tecto-pulvinar regions. We report a series of behavioral, connectionist and neuroimaging studies in which we investigated the differential role of spatial frequency channels in response to visual danger and emotional facial expressions. Results show a better recognition of visual danger for LSF compared to HSF band-pass stimuli in human subjects but also artificial neural networks. However, our recent neuropsychological data (on Parkinson's disease and Tourette patients) but also magnetoencephalographic data suggest that contrast, more than spatial frequencies, plays a key role in triggering amygdala's response through a subcortical pathway. This suggests that the specific role of LSF information for fast recognition of a potential danger in the visual environment could actually be related to their high contrast inherent to the low spatial frequencies.

Effects of the shape of the cheek color blush on the perceived size of the face.

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It is well known that cosmetics enhance female facial attractiveness (e.g. Nash et al, 2006). Recently some research has reported that the visual illusions occur in face perception by means of cosmetics (e.g. Matsushita et al, 2015; Morikawa et al, 2015). We investigated whether the shape of cheek color blush influences the perceived size of a face. Stimuli were illustrated facial images with four kinds of cheek color blush (2 types of shape; circle and line x 2 types of direction; diagonal and straight). The color of the cheek color blush was pink. We used these four facial images with circle-diagonal, circle-straight, line-diagonal, or line-straight as standard stimuli. The comparison stimulus was an illustrated facial image without cheek color blush. The facial size of the comparison stimulus was sequentially changed from 80% to 110% of the original size (100%). A standard stimulus and a comparison stimulus were presented simultaneously side by side on a computer. Participants were instructed to manipulate a computer mouse and to stop the computer mouse when they judged that the facial size of the comparative stimulus was perceived to be the same as that of the standard stimulus by the up-and-down method. The results showed that the facial size of the standard stimuli with only line-straight was perceived to be smaller than that of the comparison stimulus. Our results raise a possibility that the color of cheek color blush, not the shape of that, might influence to perceive a smaller face.

Human classification of depicted materials in paintings

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Throughout art history, artists have discovered various techniques to create realistic depictions. The rendering of materials plays an important role in this development. Investigating this development may help understanding how humans perceive materials, because artists have (implicit) knowledge about the critical visual cues needed to communicate convincing material impressions. Although art works are potentially interesting, and increasingly more available via online collections, they are not readily suitable for scientific study because there is no useful 'metadata' about the depicted materials. To satisfy this need we started annotating material classes in (digitally reproduced) paintings. Despite that the results are too preliminary to make art historical inferences or to use for perception experiments, we already found an interesting effect. Labelling a material class (e.g. 'iron', or 'wood') seems to cause confusion between the object (the thing) and the material (stuff) it is made off. For example, what is the stuff that makes up an apple? In some cases there seems to be an inherent impossibility to disentangle the stuff from the thing. In other cases we find that responses vary across observers, some responding with the thing ('sword') and others with the stuff ('iron'). These findings both have practical and theoretical implications. To create access to a large body of depicted materials, it is important to develop a labelling system without object/material unambiguity. Furthermore, the question "what stuff is this thing made off?" is less trivial than expected, and likely needs object specific adaption.

The value of being real: Exploring how the reward value of genuine and posed emotional faces varies across development

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The impact of expressed emotions on the rewarding value of faces is well-known, but any contribution from the perceived authenticity of these signals remains unclear. Here we used an economic key-pressing paradigm (as an indicator of stimulus reward value) to analyse the relationship between expression genuine-ness (genuine, Posed), emotion (Anger, Happiness, Sadness) and motivated viewing behaviour across development (children, 6-12 years, n=256; adults, 18-40 years, n=168). Results revealed that all participants were willing to work to selectively increase their viewing time for happy faces and decrease it for angry and sad faces. Interestingly where this profile of reward-related behaviour was significantly modulated by the genuineness of these expressions in adults, the same was not true for children. Moreover crucially, children's failure to differentiate between genuine and posed expressions with their key-presses could not be simply explained with reference to attenuated perceptual sensitivity to these cues. When directly assessing participants' ability to identify facial expressions as posed or genuine (children, n=120, adults, n=62), we observed that children, as well as adults correctly rated angry and sad expressions for their genuine-ness. All happy expressions tended to be classified as genuine by both groups. Taken together these results show that while both adults and children can differentiate genuine vs. posed emotional content, it is only in adults that this distinction translates into differential reward value. This presents intriguing new evidence in the complex development of emotional processing and associated behaviour.

The content of visual working memory alters processing of visual input prior to conscious access: Evidence from pupillometry

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Visual working memory (VWM) allows for keeping relevant visual information available after termination of its sensory input. Storing information in VWM, however, affects concurrent conscious perception of visual input: initially suppressed visual input gains prioritized access to consciousness when it matches the content of VWM (Gayet et al., 2013). Recently, there has been a debate whether such modulations of conscious access operate prior to conscious perception or, rather, during a transition period from non-conscious to conscious perception. Here, we used pupil size measurements to track the influence of VWM on visual input continuously, and dissociate between these possibilities. Participants were sequentially presented with two shapes drawn from different shape categories (ellipses, rectangles, or triangles) and a retro-cue, indicating which of the two shapes should be remembered for subsequent recall. During the retention interval, participants were instructed to report whether a target shape, which either matched or mismatched the concurrently memorized item, was presented left or right of fixation. Critically, the target shape was initially suppressed from consciousness by continuous flash suppression, and could therefore only be responded to once it was consciously accessible. Analyses of pupil sizes revealed pupillary construction when visual input matched relative to when it mismatched the content of VWM. Importantly, this difference in pupil size emerged almost two seconds before participants could report the location of the target shape. We conclude that the content of VWM affects processing of visual input when it is not yet consciously accessible, thereby allowing it to reach prioritized conscious access.

Judgment of facial expression is modulated by the emotional congruency of task-irrelevant surrounded faces.

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We examined the hypothesis that the emotional congruency and the number of surrounding faces may affect on the perception of facial expression. The emotional faces attract attention more rapidly and strongly than neutral faces (Fox et al., 2000; Matsumoto, 2010). Recently, several studies reported that the perception of emotional facial expression was affected by affective contextual information (Hietanen & Astikaninen, 2012; Masuda et al., 2008). We manipulated the number of surrounding faces (set size; 1,2,4) and surrounding facial expression to test whether the context of task-irrelevant emotion affects on the perception of the target face emotion. Two types of emotional faces (happy and angry) and neutral faces were used for stimuli. The target face presented with surrounding faces; the surrounding faces consisted the same facial expressions of target face (congruent condition) or different facial expressions (incongruent condition). Participants (n= 40) were asked to judge the central target face's expressions with 10-point scale attached below stimuli faces, also, participants asked to ignore the surrounding faces that were not relevant to this task. Two-way ANOVA for angry target face indicated the significant interaction and main effect of number of faces. Post-hoc Tukey revealed perception of angry face significantly decreased when the emotion of surrounding faces were incongruent at largest set size. However, for happy face was affected by the angry faces even in the small set size. These results indicate that the incongruent negative surrounded faces more affected on judgment of target expressions.

Decoding control of sensory working memory

Thomas B. Christophel, Chang Yan, Lee Stopak, Stefan Hetzer & John-Dylan Haynes

Items held in visual working memory can be quickly updated, replaced, removed and even manipulated in accordance with current behavioral goals. Here, we use multivariate pattern analyses (MVPA) to identify fMRI activity patterns representing executive control processes supervising these flexible stores. In the task, subjects had to memorize two stimuli - one visual grating and one auditory tone that were sequentially presented. After an extensive delay, a cue stimulus instructed the subjects whether the first or the second stimulus should be used for a successive change discrimination task (at the same time also implying which stimulus could be forgotten). Multivariate decoding indicated that memory for the cued item persisted throughout the 30 second trial. In contrast, we found no representation of the item that wasn't cued after cue presentation. To identify areas involved in control, we used MVPA to identify activity patterns that are selectively carrying information regarding the instruction conveyed by the cue ('first stimulus' or 'second stimulus'). We found that transient neural activity in posterior parietal and superior temporal cortices carried information about what items should be retained during cue presentation. These selection-specific activity patterns generalized across both numerical and alphabetical selection cues. We found no such evidence in prefrontal cortex. Our results suggests that selection of memorized items can be controlled in a distributed and decentralized fashion and questions the notion of a prefrontal central executive supervising all memory function.

The contextual effect of colour preference on the perception of emotionally ambiguous faces

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Recent studies showed that colour, as an affective cue, might exert contextual influences on facial emotion percepts, particularly red context facilitating facial anger categorization (Young et al, 2013). Here, we focused on the effect of subjective colour preference and hypothesized that when emotionally ambiguous faces morphed between a positive and a negative emotion are presented on observers' favourable colour contexts, they would be more likely to be reported as positive than when they would be presented on various other

backgrounds. First, we generated an emotionally ambiguous dataset of morphed faces by combining two emotionally opponent faces (happy/sad; happy/disgust). We then found perceived ambiguity points by asking subjects (N=28) to rate the valence of computationally generated morphed faces with different morphing ratios of positive and negative emotions. In a second experiment, we used these perceptually ambiguous faces in order to test the contextual effect of subjective colour preference. Defined on Munsell colour space, we used 32 different background colours, which were composed of 8 hue categories and their differed saturation and luminance value categories. We found that participants (N=44) are likely to rate the valence of emotionally ambiguous faces as more positive when they are presented on colour contexts they rate as subjectively more preferred ($p = .01$). Control experiments showed that it is hue but not brightness or saturation that had the main effect on valence ratings, which indicate a relationship between contextual chromaticity and facial emotion reading.

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Effects of expectation on gaze fixation and pupil dilation during evaluative decision-making

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It has been well established in previous research that predictive information has a large impact on decision-making in a variety of cognitive paradigms. Less is known about how predictive cues influence the sensory and perceptual processes toward a subjective choice. Here, we designed an evaluative decision-making paradigm, with naturalistic food images as stimuli, using predictive cues to examine gaze fixation and pupil dilation during information processing toward a subjective rating. In each trial, we used a predictive cue to generate an expectation about the upcoming target image. The color of the cue indicated the predictive validity (either 100% or 50% reliability); the cue shape indicated the predicted valence of the target image (either appetitive or aversive). We also varied the length of the delay between the predictive cue and the target image (either 1s or 9s). The participants were asked to rate the target food images on a continuous scale from -10 to 10 using a joystick. The results showed a difference in pupil dilation in response to the predictive cue as a function of the predicted valence. There was also a notable difference in pupil dilation during the target image viewing as a function of the actual valence. Moreover, during the delay period we observed eye prepositioning to the positive or negative side of the evaluation bar as a function of the predicted valence. Taken together, the present data provide insights into the ways in which expectation influences the sensory and perceptual processing toward a subjective choice.

How the sequence of fixation times reveals the decoding strategy of emotional faces

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Recognizing emotional expressions from distinct facial features (e.g., eye, nose, mouth) is essential in a communicative environment. The content of facial expressions modulates the exploration strategy. The first two fixations are sufficient for identifying neutral faces, and they are located in the centre of the face (i.e., the nose), known as holistic processing. However, for the second fixation, when the task demanded that the participants judge a facial emotion, the fixation oriented to the preferential area on the face (e.g., smiley mouth), known as part-based processing. The nature of how humans decode facial expressions is still under debate. We used eye-tracking to investigate the successive fixation times across areas of interest (AOIs) for facial stimuli shown in sketches and photographs that expressed fear, anger, happiness, sadness and neutral expressions, based on the Radboud Faces Database. We were interested in which AOI attracted participants' visual attention to reach an accurate emotion recognition and compared the visual exploration patterns between sketches and counterpart photographs faces. Results indicate similar fixation patterns for both types of stimulus but not for emotion. Initial fixations on the nose area suggested an initial estimation of the emotional content of holistic processing. The second fixation varied with the emotion, suggesting a part-based processing targeted at the informative features. Residual fixations were mostly orientated into the eyes. This study exemplifies emotion recognition is determined by the presence of facial features, hence, the cooperation of holistic and part-based processing is required.

Effect of stimulus variance on neural representation of perceptual mean

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Statistical summary representation is a dimensionality reduction mechanism to deal with information overload by extracting a central tendency from a set of stimuli. Although behavioral evidence showed that humans are capable of estimating perceptual mean, its neural representation remains unclear. Inferred from the recently developed population-level object recognition model that explains irretrievable loss of information due to the increase in spatial pooling with eccentricity, we hypothesize that perceptual mean of a specific feature is a coarse-grained representation wherein high-dimensional neural population activity is projected onto low-dimensional subspace linearly spanned by the basis feature channels. To test this hypothesis, we used EEG and an inverted encoding model to examine representations of perceptual mean orientation as a function of stimulus variance during mean orientation computation. We presented eight sequential arrays of randomly oriented 36 Gabor patches with eight possible mean orientations and three possible standard deviations (0°, 10°, and 20°). Observers were instructed to compute the mean orientation of each array and

hold it for 600 800ms inter-array interval. We found that the spatially distributed pattern of low-frequency band activities (1 8 Hz) encoded mean orientation of an array of 36 Gabor patches. The reconstructed mean orientation response profile was maintained for inter-array interval. Mean orientation response selectivity decreased parametrically as the stimulus variance increased. These results demonstrate that the distributed pattern of low-frequency band activity across the scalp reflects the mean orientation of each array represented as a linear weighted combination of basis set of population tuning curves.

The effect of facial expression on contrast sensitivity

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According to the threat bias, fearful facial expressions are especially salient to the human visual system. Recent psychophysical explanations argue that the threat bias is driven by low-level factors, such as their spatial frequency content, rather than higher-level evaluation of the threat content in fearful faces (Gray et al., (2013), Emotion,12(3), 537). In particular, it has been suggested that the Fourier amplitude spectrum associated with fearful faces is different from that of other facial expressions, such that this is closely matched with the human contrast sensitivity function (Hedger, Adams & Garner., (2015), Journal of Experimental Psychology: Human Perception and Performance, 41(6), 1748) If it is the case that fearful faces gain prioritised access to processing via increased sensitivity to the information contained in their Fourier amplitude spectrum, then we might expect lower contrast thresholds for fearful compared to other expressions. In the present study, neutral, fearful, happy and angry faces were presented at varying contrast levels. In a 2AFC task, participants indicated whether the face stimulus appeared on the left or right of centre, and 75% detection thresholds were calculated for each facial expression. Results showed that contrast thresholds are not lower for fearful facial expressions, suggesting that the threat bias does not operate via the threshold contrast sensitivity function. This may be because the threat bias requires higher levels of stimulus contrast, instead of the lower level that is required for detection thresholds.

Timed action naming in Russian language

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Picture naming norms were collected in different countries as language specific factors have large effects on the performance in this task (Bates et al., 2003). The aim of this study was to acquire action naming norms for Russian. For this study, thirty native Russian speakers ranging from 18 to 22 years (20 female) named each of 275 black-and-white pictures of actions as quickly as possible. These pictures were taken from standard IPNP database set (Szekely et al., 2002). Dominant name, name agreement score, percent of valid and invalid answers as well as instances when a subject could not name the action were recorded for each picture. The mean naming times for dominant words and the general mean naming times for each picture were calculated. Naming speed of actions was significantly slower than naming speed of objects (Marchenko, 2015). Cross-cultural differences suggest that it is necessary to use action naming norms collected for Russian in studies with native Russian speaking participants. Supported by RFBR, 17-36-01131.

How does social impression transformation created on avatar faces affect face recognition performance and eye movement?

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Virtual reality technologies enable the manipulation of the impressions of synthesized 3D faces (M. Walker, 2009), but it remains unclear how that transformation affects the human recognition of them. We examined whether faces are recognized correctly when their apparent social impressions were slightly changed. As visual stimuli, we used a set of computer-generated faces provided by the Todorov Face Database, which includes impression-transformed faces in three different dimensions: trustworthy, dominant, and threatening. For each dimension, impression manipulation was made in three intensity levels: weakened, neutral, and strengthened. Subjective scrutiny of the perceived impressions of these stimuli has already been released (N. N. Oosterhof, 2008). We categorized the displacement of the impressions along each dimension into two semantic directions: positive and negative, depending on the assumed favorability of the transformed impressions for the observers. For example, strengthening trustworthiness was categorized in a positive direction, but weakening it was negative. All face images in the encoding phase were neutral without impression transformation; the participants memorized them. In the recognition phase, we conducted a seen-unseen test with the impression-transformed faces and novel faces as distractors. For the recognition performance, the observers generally failed to properly recognize the encoded faces as previously "seen" ones when their impressions were turned to semantically negative directions. In both the encoding and recognition phases, we also measured the observers' eye movement, which were unaffected by the dimension and semantical directions of the social impressions; they were mainly affected by personal differences in memory strategies.

The perception of apparent motion derived by subjective contours

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[Purpose] In the motion perception, real motion cannot be discriminated from apparent motion whose motion energy is not enough within the window of visibility in the spatiotemporal frequency domain. And it is necessary for the perception of apparent motion that corresponding features, generally defined by physical cues, such as luminance border to produce the motion energy, must exist between the successive frames. If the physical feature is not the only such corresponding information, the question of whether the subjective contours can resolve the corresponding problem and/or

produce the motion energy will arise. Previous studies by von Grunau (1979) and Omura (1981) demonstrated that apparent motion could be perceived by subjective contour stimuli. However, their stimuli unfortunately included inherent physical cues resolving the corresponding problem, and the original question is has still not be remainedsolved. To understand this issue, we tested whether it is possible to perceive the motion using the stimuli defined by only the subjective contours, excluding inherent physical cues. [Experiment] We measured probabilities of the perception in the two frame motion stimuli as functions of the inter-stimulus interval, duration, and distance of displacement between the frames. [Result and Discussion] We found the same performance of the motion detection in the subjective contour stimuli as those in the real contour. This result suggested that higher-order motion mechanisms not lower-order motion mechanisms extracting motion energy based on physical cues in the stimuli can be involved the apparent motion perception on basis of the subjective contour.

How a face becomes familiar? Episodic facial prototypes and representations are generated across the life-span

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Faces change massively over time. To be still able to reliably recognize familiar faces, we need a mental representation which is flexible enough to cope with the variety of outward appearances. In contrast to classical average models, so-called exemplar-based representation models (e.g. MINERVA-2) postulate that there is not necessarily a certain average prototype. Instead a mental representation consists of the entirety of all experienced objects and is updated periodically. Recent research revealed that learning a new face involves an abstraction of the variability of different images belonging to a person's face. Unfortunately, these models do not provide any information about how faces are mentally represented (e.g. average-based vs. exemplar-based) with respect to temporal dynamics. To simulate typical learning experiences, participants were exposed to a massive amount of learning trials through Repeated Evaluation Technique (RET) where face stimuli reflected single individuals across a time span of 30 years. By systematically varying exposition frequency we revealed facial representations which are in accord with exemplar-based theories but with an important new property: Faces of specific episodes in life clustered around such exemplars for which we coined the concept of episodic prototypes. In contrast to solely-frequency-based adaption, a representation was biased towards the most recent presentation of a face, independently how often it was experienced. Moreover, data suggests the presence of multiple prototypes of the very same person which are dynamically updated in correspondence to the temporal change of a face. Furthermore, episodic prototypes correspond to specific biographic and contextual information.

Subjective motion in one direction produced by objective motion in direction of left and right under semi-dark room conditions

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We report a phenomenon in which objective motion in the left and right directions is seen as motion in one direction. Stimuli in our demonstration were arrays of pairs of rectangles printed on a piece of black paper. Each rectangle of each pair had color different from the other rectangle. For example, one rectangle was red, and the other rectangle was green. The rectangle pairs were aligned in the left and right directions, and the space between the pairs was the same as the width of the rectangle. The combination of the colors given to the pairs was not changed in one array. Three conditions of color combination were adopted, namely, red-and-green, red-and-blue, and green-and-blue combinations. Observers in the demonstration held the paper in their hands in a semi-dark room, and moved the paper in the left and right directions. The amplitude of the motion was almost the same as one and the half of the width of the rectangle, and the frequency of the motion was approximately 4 Hz. The observers orally reported that they saw the rectangles moved in one direction for all color combinations. Such phenomenon implicated a mechanism related to the fluttering-heart illusion or the Fraser–Wilcox illusion.

The visual representation of facial expression revealed by face view adaptation

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Human can robustly and accurately recognize emotional expressions from different viewpoints. Little is, however, known about the neural mechanism underlying this powerful capacity of expression recognition. We examined whether there is a view-specific visual representation of emotion expression using face adaptation paradigm. In Experiment 1, the expression aftereffect is measured in within-view condition. Adaptation to a happy expression significantly biased the perception to an angry expression on the smiling and angry expression morphs from the same viewpoint. In Experiment 2, we systematically measured the expression aftereffect in across-view condition, gradually varying the angle between the views of adaptor and tests in step of 30 degrees. The magnitude of expression aftereffect firstly decreased when two adapting and test views differed, and then slightly increased when the test view reached to the mirror view of adaptor. Based on the results, we discussed the neural model of view-dependent expression recognition and competing theories of expression recognition.

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Explicit and implicit perceptual knowledge of free fall

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As demonstrated by Galileo, objects of the same shape and size fall to the ground with the same acceleration independently of their mass. In the current study, we explored people's explicit and implicit perceptual knowledge of free fall. In Experiment 1, we asked the participants to rate the perceived naturalness of the motion of a virtual sphere that fell to the ground from 2.30 m high. We manipulated the implied mass of the sphere (which could be "made" either of wood or of polystyrene), whether the sphere fell with uniformly accelerated motion or with constant velocity, and the module of acceleration (or velocity). The results revealed a poor explicit perceptual knowledge of free fall, as values of acceleration larger (lower) than the physically correct one (1g) were considered to be natural for the wooden (polystyrene) sphere. Moreover, we found no clear preference for the physically correct uniformly accelerated motion over constant velocity motion. In Experiment 2, the stimuli were the same as those in Experiment 1, except that we also manipulated the length of a rectangle occluding the last part of the fall. The participants were asked to press a key when they believed that the sphere would have touched the ground. The time to contact with the ground was largely overestimated, especially for the longer occluder and for the uniformly accelerated motion. Most importantly, the wooden sphere was predicted to touch the ground earlier than the polystyrene sphere.

Classical stereoscopic luster versus counter-modulation – evidence for different underlying mechanisms

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We investigated whether the binocular luster observed in the classical static stimulus and in a dynamic variant of it ['counter-modulation'; see Mausfeld, Wendt & Golz (2014). I-Perception, 5(1), 1-19] rely on similar mechanisms. In the static case the phenomenon is commonly attributed to a neuronal conflict due to reversed contrast polarities to the background in the fused stimulus (spatial 'inc-dec' pairings). In the dynamic case the perceived luster may be interpreted as a special case of gloss perception, because the temporal 'inc-dec' pairings in the counter-modulation stimulus resemble physical regularities occurring during binocular viewing of glossy surfaces. Our stimuli were haploscopically presented pairs of center-surround configurations with either static or temporally modulated centers. In the experiments, we varied the binocular color contrast between the two center patches and measured the effect on perceived luster. Additionally, we examined five color conditions (one achromatic, two equiluminant, two mixed conditions), in which the polarities of the contrast of the central patches to the common surround were either channel-wise identical or reversed. We found that compared to the static variant, the counter-modulation stimuli (I) evoked impressions of luster at markedly lower absolute contrasts, (II) appeared considerably steadier with barely noticeable binocular rivalry, and (III) were less dependent on the sign of the contrast polarities. These results suggest that the two phenomena are based on different mechanisms. A common finding was that vivid impressions of luster occurred only in stimuli containing luminance contrasts, with strength decreasing with polarity-pairing in the order 'inc-dec', 'inc-inc', 'dec-dec'.

Visual short-term memory for sequential coherent motion: A rTMS investigation

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Behavioral research in humans showed that different attributes of visual stimuli are stored in visual short-term memory (VSTM). In this study, we used repetitive transcranial magnetic stimulation (rTMS) to investigate the role of human visual motion area V5/MT in the VSTM for coherent motion. Four coherently moving patches (random dot kinematograms [RDKs], 0.15s each) having different motion directions were presented in rapid succession (memory sequence). After a retention interval of 3s, participants (N=10) judged whether a test RDK (0.15s) was included or not in the memory interval. rTMS (3 pulses at 10Hz) was delivered during the retention interval 0.2s after the offset of the last RDK of the memory sequence. The aim was to investigate the role of V5/MT in both the encoding and serial storing of the moving sequence. Under the stimulus conditions tested, we found that rTMS does not interfere with the encoding process, with no evident effect of rTMS on the latter serial positions in the motion sequence. However, rTMS interfered with the VSTM for the first RDK, suggesting a selective interference with the early maintenance of visual motion information. Further analyses did not report an effect of the serial position of the moving patches, excluding backward masking effects in the motion sequence. These results suggest that sequential moving objects are store independently in VSTM and when a high load serial memory task is used, VSTM is more susceptible to interference during the early maintenance of motion information.

High perceptual contrast caused by luminance gradients cannot explain simultaneous lightness contrast enhancement

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A small middle gray patch placed at the center of a white or black square is perceived darker or lighter than it really is, respectively. Agostini and Galmonte (2002) showed that this simultaneous lightness contrast (SLC) is enhanced when the white square is surrounded by luminance gradients from white (inner part) to black (outer part) or the black square with the reverse gradients. They interpreted this effect in terms of the albedo hypothesis. However, because a white area surrounded by such luminance gradients appears brighter (Tamura, Nakauchi, & Koida, 2016; Zavagno & Caputo, 2001, 2005), another explanation for SLC enhancement is possible; the perceptually higher contrast between the target patch and the brightened white area may cause enhanced SLC. If this "high perceptual contrast hypothesis"

is correct, then a central black area surrounded by luminance gradients from inner black to outer white should be perceived darker than it actually is. To test this hypothesis, we measured perceived luminance of both the central area surrounded by luminance gradients and the small patch embedded in it. Results showed that the central black area surrounded by luminance gradients from inner black to outer white appears lighter than that surrounded by homogeneous gray, even though the patch in the former was perceived lighter. Moreover, for a central white area surrounded by gradients from inner white to outer black, SLC enhancement was significant whereas the central white area was not perceived brighter. These results reject the high perceptual contrast hypothesis and support the albedo hypothesis.

The global motion perception depends on the spatial and temporal changes of the stimulus

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The motion perception is commonly assessed with tests of global motion integration using random dot kinematogram (RDK). It is clearly, that the different stimulus parameters are driving performance differences. The speed of dots in RDKs is parameter that is able to demonstrate a significant effect on the motion perception but the speed of a motion stimulus is calculated as the ratio Δx/Δt, where Δx is spatial offset, but Δt is temporal interval between animation frames. Changing the spatial and temporal offsets of the stimulus, to hold speed constant, differs the global motion perception (Ellemberg et al., 2010; Meier & Giaschi, 2014; Arena, Hutchinson & Shimozaki, 2012). Our purpose was to find this Δx/Δt value that shows more effective the power of global motion perception. We have studied how threshold values are influenced by different dot speeds (1deg/s, 2deg/s, 5deg/s, 8deg/s and 11deg/s) tested at five Δx/Δt values or at10 frames/s; 15frames/s; 20frames/s; 25frames/s and 30 frames/s. The thresholds values were obtained by test field with elliptical shape (r=6.2deg at 50cm) using adaptive staircase 4AFC psychophysical protocol. Global motion perception thresholds increase with increasing the speed of dots. When displacements increased, thresholds also increased. Changing the Δx/Δt values at dot speeds 5deg/s and 8deg/s showed higher influence on motion thresholds.

Why do LCD screens appear to glow?

Khushbu Patel, Leonard Palatnic & Richard Murray

York University

High-resolution LCD screens can depict realistic scenes, but even under restricted viewing conditions (e.g., monocular, stationary), we can usually tell that the surfaces and objects shown are not digital. One reason may be that we can tell the screen emits light instead of simply reflecting incident light. Here we investigated what cues allow observers to determine that a small patch of an LCD screen is light-emitting rather than reflective.

We cut a 3 x 3 grid of nine 3.2 cm square apertures in each of 27 black cardboard panels. Behind eight randomly selected apertures on each board we attached patches of gray and off-gray (e.g., beige) paper; we left the ninth aperture empty. The paper patches were picked randomly from twelve samples. On each trial, we put one board in front of a light-emitting LCD screen, and the observer judged which aperture contained the screen. In the luminance-match and colour-match conditions, the screen showed a gray region whose luminance or colour (i.e., CIE XYZ coordinates), respectively, were matched to a randomly chosen paper patch. In the luminance-texture-match and colour-texture-match conditions, the screen showed a luminance-calibrated and colour-calibrated photograph of a randomly chosen paper patch, respectively.

All observers (n=5) were well above chance performance in the luminance-match condition (83% correct), and luminance-texture-match (80%). Three were above chance in the color-match (20% correct) and colour-texture-match conditions (30%). We conclude that color is a driving cue for glow detection in this task.

Influence of different types of predictive signals on haptic exploration of soft material

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When estimating the softness of an object by active touch, people typically indent the object's surface several times with their finger. Thereby, people apply higher peak indentation forces when they expect to explore harder as compared to softer stimuli (Lezkan & Drewing, 2015). In the present experiment, we compared how different types of predictive signals differentially influence exploratory forces in softness discrimination. In each trial, participants successively explored two silicone stimuli which were either both relatively soft or both relatively hard and judged which of the two stimuli was softer. We measured peak indentation forces. In the control condition participants obtained no information about whether the upcoming stimulus pair would be from the hard or the soft category. In the three test conditions, participants received implicit (pairs from the same category were blocked), semantic (the words "soft" and "hard") or visual predictive information about softness category. Visual information was provided by displaying the (rendered) deformation of a compliant object with a probe (Paulun, Schmidt, van Assen, & Fleming, 2017). Estimated softness of the visual stimuli was carefully matched to that of the touched objects. We will discuss the influence of predictive information on exploratory forces and how these influences are modified by the type of predictive signal.

Influence of theta tACS on working memory performance

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Numerous studies have shown strong relationship between frontal midline theta (4-8 Hz) (FMT) activity and working memory (WM) performance. Activation of the cortical generators of FMT plays a key role in manipulation of information in WM. Transcranial alternating current stimulation

(tACS) is a non-invasive technique capable to induce long-term changes in oscillatory activity of the brain. The current study had initial goal to check the effect of tACS on accuracy in a set of match-to-sample WM tasks. Two types of tasks were used: with mental manipulations and just retention tasks. Fifteen (6 females, mean age = 25) healthy adults participated in two test sessions (after sham and tACS). The locations of stimulating electrodes were based on the results of a field distribution simulation performed in SimNIBS. tACS was applied for 20 min over Fpz and CPz at 6 Hz, 1 mA. No after-effects of tACS were observed in the stimulation sessions compared to sham. The data suggest that tACS delivered before the WM task is not able to produce any notable changes in WM performance. Prospective studies could apply simultaneous stimulation and EEG recording during maintenance of information in WM for better understanding of the theta tACS effects.

Statistic-based speech segmentation operates on an integrated audio-visual percept rather than on the auditory and visual modality taken independently

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Speech perception is a multimodal phenomenon. In particular, auditory and visual information can be integrated in a unified percept as it is the case in the Mc Gurk illusion. Mitchel et al.,(2014) showed that adults can segment the words of a continuous speech stream by computing Transitional Probabilities (TPs) between syllables on this unified audio-visual perception. This study demonstrates that word segmentation mechanism based on TPs can operate on an integrated audio-visual representation of speech. However, in this study no cue to word boundaries on the auditory and visual modality, taken independently, were available. This leaves unanswered the important question: in natural speech situation where TPs are available both on the auditory and visual information, are statistics computed on the auditory and visual modality independently? Or are they computed on the unified audio-visual percept? To disentangle between these possibilities we presented sixty-six adult French speaking participants with a virtual agent pronouncing an artificial language in which TPs cue should lead to segment different words, depending on the speech percept the participant actually rely on : (1) audio only, (2) visual only, (3) Audio-visual integrated. After familiarisation, three different groups of participants were each tested on their knowledge of the words obtained based on one of these three perceptions. Our results show that when speech is presented both through auditory and visual articulatory information, participants perform statistical word learning on an integrated audio-visual percept. Moreover, TPs information, available on the uni-sensory modalities does not seem to be exploited.

Visual working memory benefits from luminance-driven perceptual mechanisms in healthy controls, but not in patients with schizophrenia.

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Working memory (WM) impairment in schizophrenia has been reported alongside low-level visual deficits. Although perception and WM are closely linked, the relationship between the two is less clear. Luminance-driven mechanisms have been suggested to have an impact on higher cognitive processing and are also considered to be affected in schizophrenia. We investigated whether stimuli designed to engage luminance or cone-opponent chromatic mechanisms influence differentially WM performance in healthy subjects and schizophrenia patients. 12 patients and 12 controls performed a delayed match-to-sample task where they had to encode up to three abstract shapes while we recorded EEG. Three classes of shapes were defined along directions in cardinal colour space to stimulate luminance mechanism (L+M), or two chromatic mechanisms (L-M and S-(L+M)). Stimulus contrast was fixed at a suprathreshold level based on individual discrimination thresholds measured for each stimulus class. Colour vision, acuity and contrast sensitivity were measured using standardized CAD and Acuity+ tests. WM performance in controls was better in response to luminance than chromatic stimuli. Visual ERPs during encoding correlated with accuracy. Patients showed lower performance compared to matched controls. However, they remained equally accurate in response to luminance and colour-defined stimuli. Patients had also worse acuity and contrast sensitivity than controls. Results suggest that luminance signals provide an advantage over chromatic signals in WM processing in healthy controls, but not in patients with schizophrenia. We suggest that luminance processing might be affected in schizophrenia, with consequences for both perception and memory.

Limb or arm? A local body movement elicits a sense of agency but not a sense of ownership

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When moving one's hand, humans can sense that the hand is their own and control its movement unquestionably. This sense of self-body often refers to two sensations: a sense of ownership, which is a feeling that the observing body is one's own, and a sense of agency, which is a feeling of controlling the body. To examine the visual cues of hand movement that are responsible for eliciting these two sensations, we investigated the types of hand movement that could be critical for generating a sense of ownership and agency. A previous study found that hand movement such as waving a hand can elicit ownership and agency despite the shape of the object that follows the participant's hand movement differing from the human hand. We investigated whether relatively small movements such as repeatedly opening and closing hands elicit ownership and agency. The participants' task was to find a target consisting of hand-like or scattered dots that followed their hand movement on time or

with delay among distractors, and evaluate ownership and agency for the target through questionnaires. Behavioural results showed that search accuracy and reaction time were not altered by the target's shape. However, questionnaire responses revealed that the hand-like dots elicited agency but not ownership, whereas the scattered dots elicited neither. These results suggest that multisensory process of identifying 'global' hand position play a role in generating ownership, and process of matching multisensory feedback do in generating agency.

What can asymmetric confidence judgments tell us about visual working memory?

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The limits of visual working memory is a longstanding subject of debate. One difficulty in determining such limits is that the memory task artificially limits memory to details that the experimenter probes. In this study, we demonstrate how the typically used continuous report task does not reflect the richness of the stored memory. Participants remembered three colored circles and performed both a recall response on a randomly probed item and made confidence judgments separately in both directions of a circular color space. Reported uncertainty was correlated with observed uncertainty and the asymmetry in confidence judgments predicted the direction of the correct answer (60.6% of longer confidence intervals were toward the correct answer).

Why are participants producing meaningfully asymmetric confidence intervals? One possibility is that the asymmetric confidence intervals represent asymmetric belief distributions. Another possibility is that responses are not fully representative of participants' knowledge and asymmetric intervals correct for this—e.g., responses are samples from internal belief distributions (Vul & Pashler, 2008) and thus change over time. To distinguish between these possibilities, each participant repeated the same 20 displays 50 times to obtain error distributions for each display. These displays were chosen to have error distributions of high or low asymmetry (Brady & Alvarez, 2015). If asymmetric confidence intervals reflect asymmetric belief distributions, then a positive correlation should be observed between the asymmetry of confidence judgments and error distributions. However, no such correlation was found. We thus conclude that asymmetric confidence intervals reflect changing beliefs between the adjustment response and confidence reports.

Does learning an audiovisual association affect within-modal sensitivities?

Shutian Xue, Dorita H. F. Chang

Previous findings showing that synesthetes with innate and acquired synesthesia have differing capacities in discriminating visual hues have led to the suggestion of a mental resource equilibrium model, which proposes that a shared resource pool exists across sensory modalities and that a reallocation of resources across the modalities could be triggered through establishment of cross-modal associations (Ward, 2009). In this study, we examined this proposition by testing whether training that promoted the formation of cross-modal associations (between visual brightness and auditory pitch) would affect subjects' within-modal discrimination abilities for judging brightness and pitch. Participants were trained on either intuitive (i.e., positive correlation between the brightness of a uniform patch and pitch of a simultaneously presented sound stimulus), counterintuitive (i.e., negative correlation), or random brightness-pitch relationships, and tested before and after training on independent pitch and brightness discrimination tasks. We found that while training was successful in promoting the acquisition of the audiovisual correlations, it did not alter within- modal discrimination capacity for either brightness or pitch. Our data suggest that learned multimodal associations are not formed at a cost of altered within-modal sensitivities. We speculate that the strategies learned by subjects are likely more general in nature, and unlikely to be stimulus- or even modality-specific.

Continuous and categorical representations during color working memory

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Models of color working memory (WM) are typically based on continuous representations of hue. Recent evidence suggests that performance in color memory tasks is influenced by categorical representations akin to memory for color names ('green', 'blue', 'yellow'). Here, we tested a dual-content model of color memory where colors are memorized using color names or categories in addition to a continuous representation of hue. Following prior work, a delay estimation task was employed to estimate subjects' short-term memory of colors. In addition, subjects performed two categorical tasks to evaluate focal and boundary colors for a number of color categories. Behavioral results showed that color recall shows consistent biases suggesting an impact of categorization. To explain these findings, a mixture model combining visual and categorical mechanisms was employed based on prior work (Bae et al., 2015). This model predicts subjects' behavior more accurately than the commonly used single-content model and can replicate the biased delayed responses. Furthermore, it provides individualized estimates of the relative importance of categorical and continuous color representation. In summary, we provide further evidence for the concurrent storage of visual working memory in multiple representational substrates.

Visual and tactile perception of roughness in fractal surfaces

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Roughness is one of the most important dimensions in both the visual and haptic perception of material properties. While many studies have investigated roughness perception in vision and touch using a wide range of both natural and artificially produced surfaces, the difficulties remain in quantifying the physical properties on these materials and

their contribution to the perceived roughness in vision and touch. Here, we utilise a fractal scaling properties to parametrically manipulate physical surfaces and compare perception of their roughness in 'visual only', 'tactile only' and 'combined visoutactile' modalities. Our stimuli were created from synthetic two-dimensional textures with their amplitude spectra adjusted via Fourier transform to create a range of spectral fall-offs. Additionally, we examined the effect of Root Mean Square (RMS) contrast by creating equivalent sets of spectral slope variations at two different RMS contrast levels respectively. These synthetic textures were used to render three-dimensional solids which were then printed using 3D printing technology. Subjects were presented with textured surface solids one by one and asked to provide a numerical rating of surface roughness. We found that perceived roughness increased linearly with fractal scaling and this increase was equivalent across all modes of perception. Furthermore, high amplitude surfaces were perceived to be significantly rougher than low amplitude even when ratings were compared between-subjects. Our study provides an essential stepping-stone for future investigations of multisensory perception, offering a technique for potentially creating equivalent sensory experiences between touch and sight.

Effects of cognitive ageing on landmark detection and recognition

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Landmark recognition is essential for route learning. However, not every object is a useful landmark, be it due to repetitive occurrence or visual appearance. Salient objects (e.g. fire extinguishers) catching attention might be easier to memorize than non-salient objects, but if they appear more than once along a route (="non-unique"), they can't be used as reliable landmarks. Cognitive ageing affects executive functions and control of attention which could impact on choosing relevant objects as landmarks and therefore route memory. The aim of the presented study was to investigate how cognitive ageing affects people's ability to select unique objects as landmarks for place and route learning and how deficits in landmark selection might affect the navigation skills of older participants. To do so, participants were navigated passively through a virtual care home on short routes, each comprising four intersections each with two objects, of which some appeared twice on that route (="non-unique"). Learning performance and gaze behavior was recorded from young and old participants. The behavioral data showed that younger participants outperformed the older participants on learning the routes. The eye-movement data revealed a smaller saccade amplitude and lower saccade frequency for older participants compared to young participants. Further, saccade amplitude and frequency were reduced for incorrect responses compared to correct responses in both age groups. These results suggest an effect of cognitive ageing on the control of visual attention which, in turn, contributes to age-related deficits in route learning performance.

Visual and somatic adaptations to sloped floor

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While lying supine on the slanted floor without the presence of visual information, we may perceive the floor to be flat or to be less slanted than that we experienced earlier. This may be called a somatic adaptation after the visual adaptation to a tilted line (Gibson & Radner, 1937). This means that the trunk placed near the horizontal plane appears to rotate to the horizontal plane, which is norm along with the vertical plane in orientation perception. To compare the somatic and the visual normalization to sloped floor, we conducted three experiments that differed in exposure to the sloped floor in a period of 10 min. In the somatic condition, 23 observers were blindfolded and lay supine on each of the -6-, 0-, and +6-deg sloped floors. In the somatic and visual combination, 20 observers lay supine on each sloped floor while seeing the room that included the sloped floor. In the visual condition, 21 observers seated in a chair on the flat floor and saw the room that included each sloped floor. After exposure, the observers verbally judged different slopes of the floor that were around the exposed floor. For the exposure to the 6-deg sloped floor, the slope that was perceived to be horizontal was about 6 deg in the somatic condition (i.e., perfect normalization), about 2.5 deg in the visual condition, and about 4 deg in the visual and somatic combination. It is suggested that somatic orientation is much more normalized than visual orientation.

Pupil-linked arousal is driven by decision uncertainty and alters serial choice bias

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While judging their sensory environments, decision-makers seem to use the uncertainty about their choices to guide adjustments of their subsequent behaviour. One possible source of these behavioural adjustments is arousal: decision uncertainty might drive the brain's arousal systems, which control global brain state and might thereby shape subsequent decision-making. Here, we measure pupil diameter, a proxy for central arousal state, in human observers performing a perceptual choice task of varying difficulty. Pupil dilation, after choice but before external feedback, reflects three hallmark signatures of decision uncertainty derived from a computational model. This increase in pupil-linked arousal boosts observers' tendency to alternate their choice on the subsequent trial. We conclude that decision uncertainty drives rapid changes in pupil-linked arousal state, which shape the serial corre- lation structure of ongoing choice behaviour.

Time attracts space perception in young children

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Previous research demonstrates that vision is the most accurate sense for spatial perception (Alais & Burr 2004), whereas the auditory system is the most apt for temporal judgment (Burr et al. 2009). Few years ago, we showed that visual-auditory spatial integration occurs during development only after the age of 12 (Gori et al. 2012).

In the present study, we investigated the abilities of children aged between 11 and 13 years to estimate spatial and temporal cues during an auditory bisection task. Participants were asked to spatially bisect three consecutive sound sources. We simultaneously modulated temporal intervals and spatial distances between stimuli. We found that all children had a good performance when spatial distances and temporal intervals between sounds were coherent. However, when there was a conflict between spatial and temporal aspects of the stimuli, younger but not older subjects based their answers about space on temporal instead of spatial cues. Hence, younger children were more attracted towards temporal features of the stimulus.

Our data suggest that the temporal cue interferes with spatial estimation of distance in younger children. These findings are in line with recent results in blind people, and with our cross-sensory calibration theory (Gori et al. 2008), stating that the visual system is used to calibrate the auditory system for space perception. We hypothesize that this process is not complete before 12 years of age, and temporal coordinates are used to build a spatial metric within the auditory domain when visual-auditory integration is not mature.

Electrophysiological correlates of solving non-creative tasks by highly creative individuals

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The main aim of the current study was to reveal differences between electrophysiological patterns during solving non-creative tasks by high and low creative subjects. At the first stage of the experiment creative potential of 110 students was assessed by the Torrance test. After the creativity test 27 subjects (10 women, mean age = 19.9 ± 0,4 years) with the lowest and the highest creative potential were selected to the final sample. EEG of these subjects was recorded at 19 standard sites according to 10-20 system. The statistical analysis was applied to the EEG power in the rest state and during the verbal, imaginative, spatial cognitive tasks (visually presented) solving. There were no differences in performance of task solving between two groups. ANOVA RM showed no influence of creativity potential on power of EEG in non-creative tasks. However comparison of participants with the most prominent results in originality subscale (high-originality (HO) subjects) and low-originality (LO) subjects showed differences in EEG characteristics. Transition from the rest state to the task solving induced decreasing of alpha1 activity in the posterior area, widespread activation of beta2 in the HO group. At the same time LO group demonstrated suppressing of alpha1 activity in the frontal areas and decreasing of beta2. We assume that HO subjects choose insight way for solving non-creative tasks and their frontal cortex is not engaged in that process but have to maintain more widespread activation of small neural networks. The opposite is probably correct for LO subjects.

Eye-movement control with central and peripheral spatial-frequency filtering during object search and scene memorization

Anke Cajar, Ralf Engbert & Jochen Laubrock

Visual processing is spatially inhomogeneous with the central visual field being specialized in processing fine detail (high spatial frequencies) for object recognition and the peripheral visual field being specialized in processing coarse information (low spatial frequencies) for saccade target selection. Here we investigated the consequences of this functional segregation for eye-movement control during object search and scene memorization. Using eye tracking, high or low spatial frequencies were filtered in central or peripheral vision during the inspection of color or grayscale scenes. Data collection is still ongoing, but preliminary results suggest the following. Saccadic behavior is similar with scene memorization and search in color and grayscale scenes, as viewers avoid filtered scene regions as saccade targets. With both tasks, fixation durations increased more strongly with central high-pass and peripheral low-pass filtering than with central low-pass and peripheral high-pass filtering, suggesting that more processing time is invested when critical spatial frequencies are largely available. Task effects differed for color and grayscale scenes. In color scenes object search was faster with low-pass filtering than high-pass filtering, but search accuracy was better with peripheral than central filtering. In grayscale scenes search times and search accuracy for objects as well as scene memorization were better with central high-pass and peripheral low-pass filtering than with central low-pass and peripheral high-pass filtering. We conclude that, when eliminating color as a feature, object search and scene memorization are more efficient when critical spatial frequencies for foveal analysis and peripheral selection are still largely available.

Differential patterns of activity in V1 and MT for surround-suppression and surround-summation

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Behavioral experiments have demonstrated that observers' ability to discriminate the drift direction of a grating improves as its size gets bigger if the grating has a low contrast, and deteriorates if it has a high contrast (Tadin et al., 2003). It has been proposed that receptive field organization in middle temporal (MT) area underlies this counter-intuitive perceptual effect. Supporting evidence for this proposal has been provided in literature (e.g. Turkozer et al., 2016). However, previous studies have not unequivocally showed that MT is the sole area whose activity underlies the perceptual effect. Here, we investigate the role of primary visual cortex (V1), and MT for further elucidating the neural

mechanism involved in size-contrast interaction in motion perception. With this aim, we first replicated the findings in the literature with a behavioral experiment, where small or large (8.06° and 1.06°) drifting gratings with either low (2%) or high (99%) contrast levels were presented at the periphery (distance from fixation mark to the center of grating: 9.06°, N=10). Later, three observers participated in a blocked design fMRI study with the same spatial configuration and contrast levels. We found that at high contrast activity increased significantly with increasing size in V1, but remained unchanged in MT. However, at low contrast as size increased V1 activity remained largely unchanged, but MT activity increased. These findings show that center-surround interaction in V1 and MT are differentiated, and provide further evidence that the perceptual size-contrast interaction effect originates in MT.

Changeable texture image generation with anisotropic surface asperity and illumination features

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We perceive spatial configuration and surface asperity of the object by touching surface of the object, and get tactile texture information. We also perceive tactile texture of the object from the visual information of two-dimensional images, because shade and shadow made by asperity of surface and illumination are one of the important elements to perceive surface asperity information. Because the visual pattern of shade and shadow varies by the features of illumination such as light direction, diffuse light or parallel light, et al., it is possible to make completely dissimilar visual patterns made of shade and shadow from same asperity pattern of the surface. In this study, we generated various 3D texture models by the mathematical design of surface asperity and simulated the shade and shadow patterns on the surface changing illumination direction. As a result, we were able to confirm that anisotropic feature of surface asperity in 3D texture models made clear textural changes of the surface of objects with the change of illumination direction. Anisotropic feature of surface asperity might be one of the source of diversity and variability of natural images under illumination change in the passage of time.

Decision variables in visual gravity judgements: Evidence from simulating the decision process.

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It is assumed that humans interiorize value and direction of earth gravity and store it as an internal model. This internal model can be envisioned as a strong prior in the Bayesian sense (Jörges et al. 2017). As such, it serves to calibrate ambiguous information from the optic flow to guide motor actions such as interception. Through advanced technologies like augmented or virtual reality, humans may be exposed to arbitrary visual gravities which, for above reason, may prove problematic. The aim of the present study is thus to investigate and model the sensitivity of the human visual system to earth-discrepant gravities. We presented participants in a Two-Alternative Forced-Choice task with pairs of frontally approaching parabolas, one of which was governed by earth gravity, and the other by one of seven gravities from 0.7 g to 1.3g (steps of 0.1 g). Additionally, we manipulated underlying vertical (3.7 and 5.2 m/s) and horizontal (6 and 8.3 m/s) velocities. The task was to judge which parabola had the higher underlying gravity. Psychometric fittings revealed that most participants' performance was consistent with using the temporal rate of change of the elevation angle relative to the elevation angle as decision variable. We further analyzed the decision process via drift-diffusion processes (DDP), which allows to make predictions for different stimulus intensities based on parameters regarding neural variables, viewing time, rate of evidence accumulation amongst other. A fit of these predictions against performance data largely confirmed results from psychometric analysis. The discrepancies are addressed.

Modeling visual brain responses by image and word similarity judgments: Combining fMRI, MEG and deep neural networks

Kamila Maria Jozwik & Radoslaw Martin Cichy

Objects can be represented as images or as written words that depict object meaning. However, it is unclear whether images and words guide behaviour in a similar fashion and whether they support similar representations in the brain.

Here, we investigated the visual and word-related representations of similarity judgements based on images and written words, respectively. We determined how participants (N=15) judge the similarity of 118 object images and 118 words depicting these objects. Using Representational Similarity Analysis, we compared the similarity judgements of images and words to brain responses to images measured by fMRI and MEG; and activations in an artificial neural network (AlexNet) trained on object categorisation.

We show that images and words mean similarity judgements are highly correlated (r = 0.8450). Image similarity judgements correlated with image representations in both early and high level visual cortex. On the contrary, word similarity judgements correlated with image representations only in high level visual cortex, but not in early visual areas. Image similarity judgements explained more variance than word similarity judgements between 101 and 146 ms. Late layers of AlexNet predicted image and word similarity judgements despite not being trained on similarity judgements task.

In summary, our results indicate that similarity judgements of both images and words have shared components. However, image similarity judgements predict image representations in the brain earlier in the spatio-temporal processing cascade than word similarity judgements. This is consistent with the view that word similarity judgments are based on more abstract representations than image similarity judgments.

Increasing the realism of motion dazzle studies: Effects of flocking behaviour and speed oddity tasks

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It has been proposed that high contrast patterns (such as stripes) may cause disruptions in the speed or direction perception of an observer in a process known as 'motion dazzle', and that this phenomenon may explain some of the striking animal patterns seen in the natural world. We tested whether motion dazzle patterns lead to perceptual errors in human subjects in an ecologically-inspired tracking task. In the first experiment, participants attempted to track a pre-cued target amongst 49 identical distractors. The targets and distractors either interacted with each other, generating naturalistic emergent flocking behaviours (using "boids"-like rules) or did not. Results indicated that participants were less accurate at tracking targets in the flocking condition compared to the non-flocking condition, and were more accurate at tracking striped targets compared to camouflaged targets that matched the background. In the second experiment, we modified the participant's task, such that they had to attempt to find the slowest target in the group. This experiment may more closely resemble the natural situation, where a predator might aim to track the weakest member of the group. In this paradigm, the degree of clustering of targets did not affect accuracy, but pattern type did: participants were significantly less likely to choose the correct target in the striped and camouflaged conditions compared to a 'noise' pattern condition. These results suggest that choosing an appropriate task may be critical when evaluating the effectiveness of putative motion dazzle patterning.

Animate vs. inanimate selectivity in the ventral stream: Effects of spatial frequency, visual shape, and semantic category

Chenxi He & Olivia Cheung

Animacy is a major organizational dimension of the ventral visual stream. For instance, the lateral occipital (LO) cortex is more responsive to animals compared to tools, whereas the left middle temporal gyrus (LMTG) is more responsive to tools compared to animals. Here we examined whether these regions are sensitive to non-visual semantic information of animacy, by controlling for image differences of animals and tools. We also tested whether these effects may be modulated by spatial frequencies. Using fMRI, observers (N=18) saw round and elongated animals and tools in high or low spatial frequencies across different blocks - with image statistics being comparable across animals and tools. We defined animal-sensitive right LO and tool-selective LMTG in a separate localizer with animals and tools of naturally varied image statistics, then examined the activations in these regions with animal and tool images of comparable image statistics. Univariate results showed that the animate selectivity in LO persisted, with the selectivity being stronger for elongated than round shapes. In contrast, LMTG activity was only stronger for elongated than round shapes. No significant effects of spatial frequencies were observed. Importantly, using representational similarity analyses (RSA), we found differential response patterns for animals vs. tools in both LO and LMTG. The RSA performance did not significantly improve with the additional factors of shape or spatial frequency. Together, these results suggest that category-selective LO and LMTG not only are sensitive to shape differences, but also represent semantic information of animacy beyond physical differences of animate vs. inanimate categories.

Perceptual validation of the variational coupled Gaussian process dynamical model

Dmytro Velychko, Benjamin Knopp & Dominik Endres

A Coupled Gaussian Process Dynamical Model (CGPDM) describes the movement of each bodypart as latent dynamical model, which predict parts of the observations with a mapping drawn from a Gaussian process. The dynamical models are coupled in a product-of-experts fashion to allow a flexible adjustment of the coupling strength at run time. This makes it a modular Movement Primitive model with the possibility to exchange the dynamics of bodyparts after learning. The variational treatment of the CGPDM (vCGPDM) facilitates the use on large data sets. We investigate the number of Inducing Points (IPs) needed for perceptually plausible movements generated by a 2-part vCGPDM. To this end we conducted a Turing test of computergraphics: generated and natural movements were presented side-by-side to human observers (N=31), who had to decide which they perceived as more natural. Only a small number of IPs suffices to fool observers with the artificial movements. Furthermore, we could predict the performance of the subjects using the Evidence Lower Bound, a theoretical measure arising in the course of the variational treatment. This indicates that the model selection process on large databases of training movements for the model could possibly be automated.

Event-related potential effects of object repetition depend on spatial attention and view familiarity

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Are spatially unattended objects recognised, and if so, are the mental representations underlying unattended object recognition different from attended ones? We report behavioural and ERP effects elicited by attended and unattended objects in a short-lag repetition-priming paradigm in three studies. Repetition effects were measured for probe images (common every-day objects) as a function of whether a preceding prime object was shown as an intact image or slightly scrambled (split into two halves) and whether or not it had been attended (spatially cued) in the prime display. Behavioral priming effects were observed from both intact and split primes for attended objects, but only from intact (same view) objects when they were unattended. Similarly, ERP waveforms at occipital-temporal locations revealed more negative-going deflections for repeated items between 220 and 300 ms after probe onset (N250r). Attended intact images showed enhanced repetition effects over split images. Unattended images showed repetition effects only in an intact configuration (right-hemisphere electrodes). Repetition

effects in earlier (before 200 ms) time-windows were limited to attended conditions occipito-temporally (N1), while at central locations (P150) they were only found only for intact objects. A second study confirmed repetition effects for unattended objects and also showed that unattended split objects did not prime themselves – indicating that repetition effects from unattended objects were specifically holistic in nature. A third study showed that these holistic repetition effects extend to size-scaled images. These results demonstrate that view-generalisation under spatial attention is mediated by a combination of analytic (part-based) representations and automatic view-dependent representations.

Visuotactile sensory experience shared with others'

Wataru Teramoto

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Recent physiological and neuroimaging studies have demonstrated that there are visuotactile bimodal brain areas that respond not only to objects near one's own body parts but also to those near the corresponding body parts of another individual. This suggests that brain representations of one's peripersonal space can be shared with those of another person. The present study investigated this concept in terms of human behaviour, using a visuotactile detection task. A vibrotactile stimulator was attached to the tip of the participants' hand, which was placed on the table where visual stimuli (white circles) were projected. While a white circle was approaching towards or receding away from the participant's near or far space, the participants were instructed to detect a target stimulus (a vibrotactile stimulation, a colour change in the moving circle, or both) as soon as possible. In the condition where the participants performed this task alone, the approaching circle in the near space increased the speed of tactile detection performance. In contrast, in the condition where the participants performed the task with a partner, who was facing the participant across the table, the tactile target detection was facilitated not only when the circle approached the participants' hand in the near space, but also when the circle moved towards the partner's hand in the far (but partner's near) space. These results suggest that the human brain maps another's peripersonal space as if it were its own.

Semantic meaning informs high-level object perception

Rasha Abdel Rahman & Franziska Suess

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Object perception depends on bottom-up input from our physical environment and may be shaped by cognitive top-down influences. Whereas effects of factors such as attention or prior experience are well-established, little is known about potential semantic influences on perception. Yet, the meaning of object features is a source of information that may be used to form predictions about the physical input, its specific visual features and their configuration during perception. Here we examined the influence of semantic knowledge on object perception, using event-related brain potentials (ERPs) to localize semantic effects at high or low-level perceptual or post-perceptual stages. In a first part photographs of rare but existing objects were presented. Because the objects and their functions were unfamiliar and have not been seen before, perception proceeded without understanding (i.e., "naïve" perception). In a second part the same objects were shown directly after the presentation of keywords that correctly referred to the function of the object or not (i.e., semantically informed perception). The keywords directly related to the visual appearance, thus explaining the object's shapes and features. When correct key words were presented and participants understood the function of the object or had a strong assumption, perception was associated with an enhanced amplitude of the N1/N170, a component taken to reflect high-level object perception. Additionally, a subsequent N400 effect demonstrated successful object identification. These effects were replicated and extended in follow-up experiments, suggesting that abstract semantic information shapes online perception.

Crossmodal effects of dynamic visual information on beverage perception

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It is well-known that color of liquid and cup affects the flavor of the beverage. In this study, we measured the crossmodal effects of dynamic visual information, a virtual steam and a liquid motion with a modified viscosity, with respect to flavor perception of coffee and hydromel beverages by using an AR (Augmented Reality) system with an HMD and a small camera. The system detected the position of the cup by using an AR-marker. Then, the system manipulated the image in such ways that the virtual steam was added on the coffee in Expt.1 or liquid viscosity of hydromel was apparently increased in Expt.2. Finally, the system presented the modified image while drinking. The virtual steam was generated by synthesizing Perlin noises, and liquid viscosity modification was simulated by an image temporal processing in real time. Participants estimated the temperature, viscosity and flavor of the coffee before and after drinking. In Expt.1, results showed that dynamic visual information of the virtual steam increases apparent temperature and enhances flavor, and decreases the bitterness of the coffee. In Expt.2, results showed that slower liquid motion increases apparent viscosity and decreases sweetness of the hydromel. These results indicate that dynamic visual information modifies beverage perception and that the present AR-system works for such crossmodal researches.

Tilt detection influenced by both shape properties and task demands

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There are two major sources used to produce the tilt judgment of objects; the perceptual properties directly extracted from the shape and the information from the knowledge about the objects (e.g., the canonical position, direct memories). The relative importance of the sources when judging the tilt depends on task demands. In this study, we investigated how task demands call for differential weights for

the sources and hence produce different outcomes. In the experiment, observers were required to judge the tilt of a comparative stimulus that was shown after a standard stimulus disappeared. Standard and comparative stimuli were of the same shape but rotated differently. There were two response conditions: One was that the observers make tilt judgments by observing a comparative stimulus ignoring the standard stimulus, while in the other condition, they had to decide if standard - comparative stimulus pairs had the same tilt. Three types of figures were used that were different in terms of the straightness of the shapes including vertical / horizontal edges: one figure had an apparent canonical position. Judgment patterns of decisions, RT and eye movement data suggested that both knowledge about the object and shape properties influenced the tilt detectability.

Faces and voices in the brain: Is there a modality-general person-identity representation?

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Faces and voices can both trigger the recognition of a familiar person. A large body of research has separately explored the recognition of familiar faces and voices. However, it is unknown whether there is a consistent representation of person-identity that can be equally driven by a face or a voice. We wanted to determine whether the information from faces and voices is integrated in a modality-general representation of person identity in multimodal regions or, instead, whether person-identity is represented across unimodal brain regions that represent faces and voices separately. In an event-related fMRI experiment we measured brain activity patterns while participants either viewed the face or listened to the voice of a famous person. We localised multimodal, face-selective, and voice-selective brain regions. We used representational similarity analysis (RSA) to compare the representations of the famous people elicited by faces and voices within these regions of interest. Preliminary results (27 participants) do not show evidence of a modality-general representation in multimodal, face-selective, or voice-selective regions (i.e. there are no significant correlations between the similarity matrices for faces and voices). Furthermore, representations of the faces and voices in face-selective and voice-selective regions, respectively, appear to be stimulus-specific and do not generalise across different exemplars of the same identity. Finally, a region of the posterior superior temporal sulcus showed high correlations of the activity patterns within modality for both faces and voices, but not across modalities. These results shed light on how information from faces and voices is integrated in the brain.

Cortical plasticity in FHONDA – a new inherited visual system disorder

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The partial decussation of the retinal fibres at the optic chiasm is altered in congenital visual pathway abnormalities such as albinism. As a result, the visual cortex is organized as superimposed retinotopic maps of opposing hemi-fields with bilateral population receptive fields [1]. Here we studied a novel rare entity of congenital visual pathway disorders, the FHONDA syndrome [2], where in the absence of albinism, temporal retinal afferents abnormally cross to the contralateral hemisphere. We determined the organization of the visual cortex in FHONDA and its relationship to other chiasmal malformations. Using fMRI at 7 Tesla, we modeled the population receptive field (pRF) properties of the primary visual cortex for two affected individuals and two controls stimulating the dominant eye with moving bar apertures. Our findings indicate overlaid hemi-field representations confined to the contralateral hemispere and bilateral pRFs mirrored around vertical meridian. The results highlight the importance of melanin-synthesis independent components required for the development of the visual system and provide evidence for identical mechanisms shaping the organization of the visual cortex in different types of optic nerve misrouting. The similarity of the cortical organization in FHONDA and other congenital chiasmatic abnormalitites demonstrates the importance of intra-cortical plasticity in human visual system development. Funding: European Union's Horizon 2020 research and innovation programme under Marie Sklodowska-Curie grant agreement No 641805 and German Research Foundation (DFG HO2002/10-2) 1. Hoffmann & Dumoulin (2015). Trends Neurosci. 38(1): 55–65. 2. Poulter et al., (2013). Am J Hum Genet. 93(6): 1143–50.

Microstructure of V4 and visual word form area (VWFA) in synesthetes

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Synesthesia is a perceptual phenomenon in which one stimulation is concurred by a second unstimulated experience. The experience of color while seeing or thinking of graphemes (i.e. letters, digits and lexical symbols) is a common synesthetic combination. One theory of the origin of this grapheme-color synesthesia is an increased structural connectivity in the brain of synesthetes, especially in color processing area V4 and letter processing visual word form area (VWFA). The concurring experience is hence a direct result from cross activation between the stimulated and the unstimulated area. We investigate structural connectivity using diffusion weighted imaging in 17 synesthetes and 20 matched controls. Diffusion parameters as fractional anisotropy, mean and radial diffusivity are compared between the synesthete and the control group. For the synesthete group correlations between diffusion parameters and synesthetic qualities like consistency and vividness are calculated. Furthermore, we perform a fibre tracking emanating from VWFA to see if synesthetes show a different structural network for letter processing than controls. Preliminary results show slightly higher fractional anisotropy but lower diffusivity in V4 and VWFA for synesthetes. Correlation patterns hint at higher myelinisation as expressed by higher anisotropy but lower diffusivity in VWFA for synesthetes with

consistent and vivid color experience. This might reflect microstructural differences between synesthetes and controls in brain areas involved in synesthtetic experience.

A model that predicts where we grasp 3D objects

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Justus Liebig University Giessen

Vision is a powerful tool which, coupled with motor control, promotes our agency within the environment. Through finely coordinated arm, hand, and finger movements, humans can, for instance, grasp and manipulate objects of various shape and material. Visually selecting contact points on arbitrary 3D objects to execute successful grasps is a non-trivial task as most combinations of grasp points yield unstable or uncomfortable grips. Grasp point selection may be accomplished by searching for grasp configurations that minimize some penalty function that penalizes low-quality grasps. An array of grasp quality metrics has been developed to solve grasp point selection for robotic manipulators, yet whether humans employ similar strategies is unknown. We asked human participants to execute grasps to 3D objects of varying shape, weight and surface material properties. We compared recordings of human grasps to predicted grasp locations obtained from grasp quality metrics developed for robotic actuators. Certain computationally demanding grasp quality metrics based on object and grasp geometry only partially agree with human contact point selection. Conversely force closure, which is more readily computed, appears to be a necessary condition for all successful human grasps. Human participants appeared to take torque into account only under certain conditions. Constraints based on the kinematic properties of the arm and hand also play a significant role in human grasp planning. We employ these findings to build a zero-free parameter model that successfully predicts grasp locations across a range of novel objects, and which takes shape, mass distribution and friction into account.

Distinct patterns of deviation and reference frames in visuo-haptic and haptic-visual slant perception

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Real-world tasks can often involve multiple sensory inputs encoded in different reference frames and previous studies have suggested that the CNS avoids performing unnecessary coordinate transformations that add noise when a unimodal comparison is possible. However, the transformations between modalities are inevitable in cross-modal tasks. It is not clear how visual and kinesthetic information is processed in cross-modal matching tasks. In our experiment, participants were asked to haptically (H) or visually (V) adjust a test board to set it physically parallel to a reference board perceived visually or haptically in the three dimensional space. The experimental conditions were the combination of four slant angles of the reference board, three reference locations and five test locations in the midsagittal plane, as well as four modality conditions (target-response: VV, VH, HH, HV). Our data showed that the deviations from parallelity in VH and HH conditions were strongly correlated to the angle difference between reference and test locations, whereas those in VV and HV conditions were more affected by the reference slant angle. The patterns of deviation in VH and HV conditions were not mixtures of the patterns of unimodal tasks (HH and VV), but similar to that of the unimodal task with the same response modality. The result suggests that in VH and HV cross-modal tasks, target information may be transformed into the response modality without introducing prominent noise and the distinct patterns of deviation reflect different reference frames used for comparison in the two tasks, rather than a common reference frame.

Quiet eye and motor performance: The longer the better?

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In targeting tasks, the final fixation duration before movement initiation (i.e., Quiet Eye, QE) has been shown to be a valid predictor of the subsequent motor performance. However, the exact shape of the QE-performance relation is still unknown. Therefore, in the current series of studies, the QE duration was experimentally manipulated with the aim to evoke eight different QE-duration conditions ranging from 400 ms to 3200 ms. The participants' task was to throw a ball as accurately as possible at a virtual target disk. Motor performance (radial error, mm) and QE duration (ms) were assessed with a Vicon system (200 Hz) and an integrated eye tracker (EyeSeeCam, 220 Hz). While results showed successful QE-duration manipulations, participants denied to maximize their QE duration as intended to 3200 ms (min. 320 ms, max. 1785 ms). Likewise, significant main effects were found for radial error with on average inferior performance in short when compared to the long QE duration conditions (M = 165 mm vs. M = 140 mm) which, however, did not significantly differ from each other. On the one hand, these results emphasize the functional coupling between perception and action as the demands of the motor task restricted the intended maximization of the QE-duration manipulation. On the other hand, the relation between the QE and performance seems to be best described by an exponential function with performance deterioration in short but no further performance improvements the longer the QE duration.

Does corresponding visuospatial information facilitate learning to discriminate auditory pitches?

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When humans process sensory input from multiple sensory modalities, the input is rarely processed in isolation. For instance, researchers found that high and low auditory pitches

are associated with high and low visual elevations, respectively, leading to performance benefits for elevation judgements. Here, in a set of four experiments, we investigated whether humans can improve their ability to discriminate intervals between auditory pitches if interval learning is aided by corresponding visuospatial information. The experiments were divided in a test phase, followed by a training phase and another test phase. Across experiments and phases, the participants performed a five interval forced choice task for which they received performance feedback in the training phase but no performance feedback in the test phase. Moreover, the provided visual information for the training phase differed depending on the experiment. In the first two experiments, participants received visual information that corresponded to the pitch intervals (i.e., the jump height of a dot was proportional to the pitch interval). In a third experiment, the visual information did not correspond to the pitch interval, and in a fourth experiment, no visual information was provided. For the training phase, we found that participants receiving the corresponding visual information outperformed participants receiving the non-corresponding visual information or no information. However, we found no significant performance differences across experiments for the last test phase. Overall, results indicate that corresponding visuospatial information facilitates discriminating pitch intervals, yet this performance benefit does not lead to an immediate sustained pitch discrimination improvement.

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The essential role of optical flow in the peripheral visual field for stable quiet standing: Evidence from the use of a head-mounted display

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Vision has long been considered the most essential factor in maintaining stable quiet standing compared to other sources (i.e., vestibular and somatosensory inputs) of information. Specifically, several studies on postural control have shown evidence for the importance of the visual system, particularly peripheral vision rather than central vision, and optical flow. Nevertheless, no study to date has manipulated both visual field and optical flow concurrently. In our study, we experimentally manipulated both the visual field and the occurrence of optical flow during quiet standing, and examined the effects of the visual field and optical flow on postural sway measured in terms of the center of pressure. Random dot stimuli were presented exclusively in either the central or peripheral visual field, while the occurrence of optical flow was manipulated using a desktop (DTD) or a head-mounted (HMD) display. The optical flow that occurred while using the DTD was a function of the postural sway during quiet standing, while for the HMD, no optical flow occurred even when the body/head swayed during quiet standing. Our results show that the extent of postural sway was smaller when visual stimuli were presented in the peripheral visual field than that in the central visual field; however, this connection was only seen while using the DTD alone. No influence of peripheral vision on the extent of postural sway was found with the HMD. It is therefore suggested that the optical flow occurring in the peripheral visual field is essential for stable quiet standing.

Category learning by cortex-basal ganglia interactions: A neuro-computational approach.

Francesc Villagrasa, Javier Baladron, Julien Vitay, Henning Schroll & Fred H. Hamker

Category learning is more than just a simple sensory convergence, but a fundamental characteristic of sophisticated thought that structures the world into meaningful concepts (Seger & Miller, 2010). Extending our previous model of basal ganglia (Schroll et al, 2014), we present a new neuro-computational model in which basal ganglia (BG) train the acquisition of category representations in cortico-cortical projections.

The model reproduces a prototype distortion task carried out with monkeys (Antzoulatos & Miller, 2011). Specially, the model supports the view that BG teach prefrontal cortex (PFC) to acquire category representation by reproducing the monkey's data that upholds this view. Additionally, our model shows that the fast learning in BG alone is not optimal for correctly classifying a large number of stimuli whereas, the combination between fast and slow learning in PFC produces stable representations that can perfectly categorize even a larger number of exemplars.

Our model also adds novel predictions to be empirically tested. It predicts that thalamic activation correlates with the final category decision throughout the whole experiment. Specially, thalamus integrates both the PFC category decision and the BG category decision to emit a final category decision. In addition, our model predicts that the lost of striatum category selectivity is not associated to a decrease of the BG engagement in category decision and that a decrease of BG involvement in category decision is explained by the competition between PFC and BG for controlling thalamic activity. Finally, the model is robust enough to classify faces of two different people.

Neuro-dynamical model for the coupling of action perception and execution

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Action perception and action execution are intrinsically linked in the human brain, likely mediated by 'mirror circuits' in parietal and premotor cortex. We present a physiologically-inspired neural model that, based on physiologically plausible mechanisms, accounts for a variety of experiments testing the interaction of action perception and execution. METHODS: The model is based on coupled dynamic neural fields that encode action sequences. Each action is represented by a vision field and a motor field, which encode the perceived action and the associated motor program. Fields representing the same action are coupled in a way that supports synchronous traveling-pulse solutions, and fields encoding different actions inhibit each other. The model comprises a visual pathway that processes image sequences, and a motor pathway that produces joint angle sequences output. RESULTS: Using the same set of parameters, the model reproduces psychophysical and fMRI experiments on the influence of action execution on action perception and vice versa. It reproduces electrophysiogical data about

the population encoding of executed and perceived actions in mirror neurons in premotor cortex. In addition, it reproduces the spontaneous synchronization of motor behaviour when two agents observe each other. CONCLUSION: The model provides a unifying account for a multitude of experiments investigating the interaction between action perception and execution and makes specific predictions about the behavior of different neuron classes at the single-cell level.

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tACS modulates oscillatory frequencies relevant for detecting speed of change

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Occipital gamma oscillations are shown to predict the reaction time in a speed-of- change visual task. While little is known about the precise neural mechanism by which tACS affects the human cortex, current hypotheses suggest that tACS can either directly entrain brain oscillations and/or induce synaptic plasticity. Here, we use tACS to alter brain's oscillatory frequencies of 30 healthy subjects that are conducting a classical speed-of- change visual task with the goal of testing whether tACS in humans interferes with the ongoing oscillations that are relevant for task execution.

For that, thirty healthy subjects participated in a randomized, sham-controlled crossover study, where subjects were required to detect of a change in the speed of a circular moving-grating. 240 bursts of tACS (5 s each, Starstim, Neuroelectrics) at alpha (10Hz) and gamma (70Hz) frequencies were applied at occipital cortex using a multi-electrode optimized montage (Stimweaver) with 1.2mA intensity.

Our study analyses the impact of tACS in oscillatory activity, both ongoing and phase locked to stimulation, showing that tACS interferes with which oscillations are predict reaction time to the speed-of- change visual task.

Concurrent increases in spatial stability and temporal neural dynamics during perceptual decision making

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Recent work has shown that neural activity across the human brain stabilizes upon conscious perception. Such spatial stabilization possibly reflects attractor dynamics that draw network activity toward a low-energy decision state. It is unknown, however, whether this spatial stabilization (i) is either intra- or post-decisional; (ii) whether it can be modulated by level of decision certainty, and; (iii) how the underlying temporal neural dynamics behave during spatial stabilization.

We addressed these questions by quantifying the spatial and temporal variability of the EEG of 16 observers reporting faint target stimuli within a stream of non-targets. In different conditions, we encouraged observers to require either low or high certainty for reporting targets. We quantified spatial EEG variability by computing directional variance, which treats each sample across electrodes as a multi-dimensional vector and measures the directional dispersion of these vectors. We quantified concomitant changes in temporal variability by subtracting multi-scale entropy in pre- from post-target stimulus intervals.

We found that spatial stability increased in high vs. low certainty conditions. In line with an intra-decisional role, this increase occurred 0.5 s before report, but not after. Critically, heightened stabilization predicted individual differences in high versus low certainty increase (in behavior), suggesting that spatial stabilization reflects the level of certainty about a decision to report a target. Strikingly, within-electrode temporal entropy also increased around report across most time scales. The human brain thus appears to invoke a spatially stable, yet temporally dynamic regime during effective perceptual decision making.

The interaction of visual flow and perceptual load in the control of locomotion speed

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Visual flow is used to perceive and regulate the movement speed during locomotion. We assessed the extent to which variation in flow from the ground plane, arising from static visual textures, influences locomotion speed under conditions of concurrent perceptual load. Participants walked over a 12 m. projected walkway that consisted of stripes that were oriented orthogonal to the walking direction. During their walk, participants judged the average tilt of a sequence of noisy bars presented on the wall at the end of the walkway. In the critical conditions, the frequency of the floor stripes increased or decreased. We observed small, but consistent effects on walking speed, so that participants were walking slower when the frequency increased compared to when the frequency decreased. This basic effect suggests that participants interpreted the change in visual flow in these conditions as at least partly due to a change in their own movement speed, and counteracted such a change by speeding up or slowing down. Critically, these effects were magnified under conditions of low perceptual load (i.e. easier tilt discrimination). Our findings suggest that the contribution of vision in the control of ongoing locomotion is relatively fluid and dependent on ongoing perceptual (and perhaps more generally cognitive) task demands.

Variability in visuo-motor selection: Determinism and stochasticity

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Reaction time and accuracy vary greatly across trials even in the most basic orienting responses to highly salient visual stimuli. In all current computational models of sensorimotor decision, intra-individual variability in behaviour is captured by introducing sources of stochasticity, but these are often arbitrary. To better characterise variance in behaviour at short and longer time scales, we asked participants to quickly respond to a salient peripheral visual target appearing either left or right, every 3 seconds without breaks for 90 min. Targets were preceded by a central cue randomly indicating whether the required response was an eye-movement, a button press or both actions together. Our analyses suggest that only a small part of the overall variance can be accounted for by deterministic factors, and most of the variance unfolds at the time scale of one single trial. This variability therefore remains mostly unpredictable and can thus be qualified as stochastic. A small but clear part of the variance appears to be shared across modalities, consistent with the assumption of modality-specific decision modules.

The effects of luminance and color on vection

Keiko Shiozaki, Yasuhiro Seya & Hiroyuki Shinoda

When observers view a large visual stimulus that moves uniformly, they often perceive illusory self-motion (vection). In the present study, we investigated the effects of stimulus color on vection while varying the luminance of the stimulus and background. In two experiments, participants viewed moving random dots simulating optical flow during forward locomotion. The dots were presented on a black or white background in one of four equiluminant colors: white (or gray), red, green, or blue. In Experiment 1, participants pressed a key whenever they felt vection. After each trial, they also rated vection magnitude (from 0 to 100). In Experiment 2, participants rated the visibility of moving dots relative to their visibility in a standard stimulus presented before the experimental session. Results of Experiment 1 showed that, irrespective of dot luminance, single-colored dots enhanced vection more than did achromatic dots in the white background condition. Induced vection was stronger for red and green dots than for blue dots. In the black background condition, red and green dots inhibited vection, particularly when dot luminance was high, although blue dots enhanced vection. Results of Experiment 2 showed patterns similar to those in Experiment 1. These results suggest that vection can be modulated by stimulus color and that this modulation of vection is associated with stimulus visibility.

Fluctuations in sensory evidence dissociate choice accuracy and confidence

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Decision-making is often accompanied by a sense of confidence about the correctness of one's choice. In perceptual choice, the confidence observers report about their judgments is often closely related to the probability of making a correct choice. Yet, the exact nature of the transformations connecting sensory evidence and choice versus sensory evidence and subjective confidence remains unknown. To shed light on this issue, we collected simultaneous choice and confidence reports during a visual contrast discrimination task at different levels of fluctuations in contrast over time. Observers estimated the average contrast of ten consecutive contrast samples (the 'test' stimulus) and compared this to the contrast of a constant 'reference' stimulus presented at the start of each trial. Overall observers' choice accuracy and confidence reports were strongly correlated. However, choices were increasingly biased towards 'test larger' with increasing variance of the contrast samples. At the same time, and paradoxically, observers became increasingly more confident about their choices, even though the reliability of evidence became lower with increasing variance. A time-resolved analysis of psychophysical kernels for choice and confidence reports further dissociated the two: Fluctuations in evidence for the selected choice option (e.g., 'test larger') had a stronger impact on confidence than fluctuations in evidence for the non-selected option By contrast, both types of fluctuations had an equally big leverage on choice. In summary, subjective confidence reports deviated from concomitant choice in subtle, but systematic ways, that can guide future modeling of the transformations underlying both types of judgments.

Observational learning of surgical skills on the daVinci system

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The use of observational learning has established benefits for skill acquisition across a variety of domains, and is particularly crucial for learning skills where trial-and-error practice is not viable. Here, in the context of learning skills on the remotely-operated daVinci surgical system, we investigated what style of observed context could lead to the most robust skill gains.

150 medical students with no previous surgical experience were randomly assigned to one of five learning conditions: expert model, novice model, mixed novice/expert, 3D expert or control. The effect of observation on learning the primary task, retaining skills after a one-week interval and transferring learned skills to a novel task were assessed through time to completion, incidence of errors, and accelerometery data.

Significant improvements in time to completion and number of errors were seen across conditions, with learning on

the primary task related to changes in accelerometry measures (mean accelerations, entropy). Initial findings suggest that observing error-strewn and expert models provide similar benefits for learning and retention of surgical skills.

An eye-tracking investigation of the object handle orientation effect: Does handle-directed attention vary as a function of spatial compatibility between handle and response?

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In tasks requiring visual processing of manipulable objects, participants are reliably faster to respond with the hand that matches the task-irrelevant left/right orientation of the object's handle. This handle effect is thought to reflect processing of the handle as an affordance for action; however, abstract spatial compatibility between left/right responses and the asymmetrical handle might also contribute. Limited eye-tracking evidence suggests that objects handles are not inherently visually salient. Therefore it is possible that a spatial compatibility mechanism is driven by the use of lateralised responses, which might encourage an attentional bias to left/right handles. Accordingly, the current study determined whether attention to object handles varies with spatial compatibility between handle and response locations. Stimuli were colour images of manipulable objects with handles facing left or right. Participants made left- and right-handed key press responses to objects' kitchen or garage category while their eye movements were tracked. Stimulus location was varied on a central, vertical plane (upper, lower). Spatial compatibility between handle and response location was manipulated with the between-subjects factor of response configuration; hands were either in typical, left and right locations (horizontal) or oriented with one hand above another (vertical). Results demonstrated the effect of response configuration on a) response times and b) fixations to object handle. These results inform on attentional processes underlying the handle effect, and in turn, how affordance and spatial compatibility mechanisms contribute to the effect. The findings have implications for object affordance theories.

Dissociation between perception and action among tennis players revealed by using induced motion

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It is well known that perception and action rely on different visual information. To investigate the dissociation between perception and action, we measured induced motion (IM), i.e., illusory motion of a fixated object induced by background motion, of tennis players and novices using two tasks: adjustment and pointing. In two experiments, participants viewed a horizontally moving target within a vertically moving random-dot pattern. Velocity and direction of background motion were manipulated. In Experiment 1, participants adjusted a joystick to match their perceived direction of the target motion path during the stimulus presentation. In Experiment 2, participants pointed (by using an index finger of right hand), as soon and accurately as possible, to the last position of the target immediately after the target and background disappeared. The results of Experiment 1 showed a larger magnitude of IM in the tennis players than in the novices. IM magnitude became larger with increasing velocity of background motion. Experiment 2 showed accurate performance of pointing to the target's last position and no difference between the two groups. Pointing performance did not differ by the stimulus velocity. Reaction times, defined as the interval from the offset of target to the onset of pointing, also did not differ by the group or stimulus velocity. These results clearly support the notion that different visual information contributes to perception and action.

Schizophrenia and affordance perception

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Phenomenological psychopathologists conceptualize schizophrenia as a self-disorder involving profound distortions of selfhood. For James Gibson, "to perceive the world is to coperceive oneself." If the sense of self is disturbed in schizophrenia people, it would impair the ability to perceive oneself. Such impairment would then lead to disturbances in one's ability to perceive affordances, environmental properties taken with reference to the perceiver's action capabilities (. To test this hypothesis, we conducted three experiments. Participants were presented with a photo of a commonly used object on the computer and then asked to judge its secondary affordance (not the use it was originally designed for) in a two-choice reaction time task in Experiment 1 (26 schizophrenia patients and 23 healthy controls) and in a yes/no task in Experiment 2 (using a separate sample of 26 schizophrenia patients and 23 controls). Schizophrenia patients were less accurate and slower than controls in both experiments. In Experiment 3, the same participants as in Experiment 1 identified the same objects' physical properties (color, shape, material composition). Schizophrenia participants were as accurate as controls, and their reaction time was faster than in the previous experiments. Results demonstrated that the capacity to perceive affordances is likely impaired in people with schizophrenia, although the capacity to detect the object's physical properties is kept intact. Without being able to perceive affordances, functionally significant properties of the surrounding environment, schizophrenia people are detached from the world.

Eye-hand span at sight reading of the musical text by pianists

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Lomonosov Moscow State University

We studied eye movements at sight reading of the musical text by pianists which represents an example of multimodal profession practice. The musicians of approximately the same level of proficiency were asked to sight-read facing pages of two-line musical selections of three classical music pieces of various complexities. The study involved 16 students (9 males and 7 females at the age of 19-23) of Tchaikovsky Moscow State Conservatory who specialize in

piano performance. We recorded eye movements in conditions as close to the natural (free head and torso motions). We analyzed an eye-hand span (EHS) which represents the delay between the moment of reading the note and moment of its reproduction measured by musical signs number. EHS is dependent on the texture of performed musical piece. EHS value varies significantly both in relation to each musician as well as among the musicians from -3 to 14 symbols. This is consistent with the earlier data in experiments with professional musicians who read one-line music sheet. We revealed a direct correlation between an EHS and the tempo stability and also a reliable invert correlation between an EHS and the number of errors at sight reading - an objective criterion which characterizes the quality of playing at sight. While sight reading the easiest musical piece the EHS is maximal and on average constitutes 4-5 symbols, for the most difficult piece – 2-3 symbols. Therefore, EHS reflects the complexity of a music piece for sight-reading. Supported by RFH/RFBR (project №16-06-01082).

Knowing where is different from knowing what. Distinct response time profiles and accuracy effects for target location, orientation, and color probability.

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The effects of spatial and featural cuing are superficially similar. While they both improve detection, more detailed analyses find distinct temporal and accuracy profiles for the two different types of cues. Manipulations of probability often result in outcomes that resembles those of attentional cuing. By extension, are spatial and feature probability effects distinct? Our previous work using perceptual estimation tasks find that only featural probability improves perceptual precision, while spatial probability only improves detection. Here we ask if feature/spatial distinctions can be seen even within a detection paradigm. By using a continuous response measurement method, we demonstrate that response time benefits for spatial probability was restricted to the initiation times, whereas manipulations of feature probability affected both initiation and movement times. The purview of these probability effects were also distinct. Targets appearing at the probable location were reported more quickly and more accurately regardless of whether the report was based on orientation or colour. In contrast, when either colour probability or orientation probability was manipulated response time and accuracy improvements were specific for that probable feature dimension only. When task difficulty was increased, the two probability effects further diverged. Spatial probability disproportionally affected initiation times, while feature probability disproportionately affected accuracy. In conclusion, all manipulations of probability, whether spatial or featural, affect detection. However, only feature probability affects perceptual precision, and precision effects are specific to the probable attribute.

Priming of color and categorical information is independent from prime visibility in crowding

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When an object in the visual periphery is surrounded by flankers with similar features the identification of the object is impaired. This Crowding Effect can be experienced in everyday life and it can be used as a paradigm to study visual awareness and its role for information processing. Here we report two parallel experiments that were designed to examine the influence of crowding on the processing of color and categorical information. We employed a priming paradigm in which participants discriminated a foveal presented target stimulus in a speeded choice response task. A peripherally presented prime, which was crowded by surrounding flankers, preceded the target with various stimulus onset asynchronies (SOA). We manipulated prime visibility experimentally by varying flanker contrasts in three levels. Primes and targets were red and green letters and digits. We found that the congruency between primes and targets affected reaction times in the target discrimination task. This priming effect was larger for color compared to categorical discrimination and increased with longer SOA. Most importantly, however, priming effects were independent from prime visibility. Thus, although conscious perception of color and categorical information can be reduced by crowding, prime information is processed up to a degree that can affect motor behavior. We conclude that crowding influences conscious perception at a level of processing which occurs after the processing of color and categorical information.

Gender differences in interpersonal distances during interactions with avatars

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Social interactions with avatars in virtual environment are ruled by many aspects of avatar's appearance including their ethnicity, gender etc. We investigated the gender differences of participant's behavior during the interaction with avatars of different ethnic appearance. Forty participants (19M, 21F, 18-23) were tested. Three virtual scenes were constructed each represented a living room with a group of three avatars standing in the center. The scenes differed in ethnic appearance of avatars and were presented using the CAVE virtual reality system. The participants were asked to walk around avatars and remember its appearance details. During the execution participant's locations were recorded. Then participants answered the questions about details of avatar's appearance and filled out the questionnaires assessing their presence effect and ethnic attitudes. Behavioral characteristics were analyzed including average minimal and maximal interpersonal distances. The results showed the compensation effects in interpersonal distances: shorter - with avatars which appearance represented own subject's ethnic groups and longer - with avatars of other ethnic appearance. It was found that questionnaire's scores were in good agreement with behavioral characteristics. The gender differences of walking strategy while performing the task were revealed. Women preferred to maintain longer distances interacting

with avatars of other ethnic groups while men maintained shorter interpersonal distances interacting with avatars of other ethnic groups. Results may be useful for developing methods of testing the behavioral patterns during interactions with virtual partners. The research was supported by Russian Science Foundation, by the Grant 15-18-00109

It is more than just a decisional bias: High-level action adaptation aftereffects affect perception

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Visual adaptation is a powerful tool to behaviorally investigate the tuning properties of neural processes by temporarily impairing the neural processes of a perceptual-cognitive function. In a typical adaptation paradigm participants are asked to report their subjective impression about an ambiguous stimulus (e.g. morphed action between handshake and high-five) after they have been exposed for a prolonged amount of time to an adapting stimulus (e.g. handshake). It is typically found that participants report the ambiguous stimulus to look opposite to the adapted stimulus (i.e. a high-five). One fundamental objection to these adaptation effects, especially high-level adaptation effects, is that they might reflect a subjective bias on the decisional rather than perceptual level. Here we put this alternative interpretation to a test for action adaptation. 14 participants were adapted to an action and subsequently completed an adaptation task or an absolute identification task. Adaptation did not only impair the subjective report about an action in the adaptation task but also affected participants' objective ability to absolutely identify actions in the absolute identification task. Hence our results suggest that action adaptation takes effect on a perceptual rather than decisional level. We therefore suggest that high-level action adaptation complements other techniques that locally impair neural processes (e.g. TMS). Specifically, it seems that action adaptation is able to transiently change the response properties of neural processes underlying a certain visual function across the visual hierarchy.

The influence of global configuration on contextual cueing learning

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The repetition of displays may cause faster answers, this effect is known as implicit learning in contextual cueing. We try to understand how global processing influence contextual learning. In both experiments, we used contextual cueing paradigm (Chun, Jiang, 1998) with modified Navon's stimuli. We created eight unique composite figures looked like non-conventional shapes consisted of letters "T" rotated to 90 degrees left or right. The task was to find letter "L" between Ts.

In the first experiment, we tested the effect of distractors' similarity. In experimental group 1(EG1) all the distractors were rotated in one direction, the unique target's position for each figure hasn't changed. The same with the Experimental group 2(EG2), except that the orientation of the distractors changed randomly in each trial. In the control group, target's' position and distractors' orientation were randomly each trial. The reaction time of EG1 was lower than EG2 (both groups were faster than the group of control).

In the second experiment, one group learned on patterns increased in size, the other one on patterns decreased in size. On the transfer phase, both groups continue their search on the middle-sized patterns. The difference between groups in the second experiment wasn't found. The response speed was influenced only by the factor of pattern's predictivity. The results of the experiments demonstrate that the influence of the global configuration is preserved when the orientation of local distractors is changed and when the distance between local distractors is changed.

Cholinergic enhancement of short-term patching in healthy adults

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Short-term monocular deprivation strengthens the patched eye's contribution to binocular combination, resulting in a temporary form of adult visual plasticity. Acetylcholine (ACh) has been shown to modulate visual plasticity and augment the magnitude and specificity of visual perceptual learning. In the present study, we investigate whether pharmacologically boosting levels of synaptic ACh with the cholinesterase inhibitor donepezil (5mg, administered 1.5 hours before patching) influences the strength and duration of short-term ocular dominance plasticity after monocular deprivation.

We conducted a double-blind experiment where participants completed both a donepezil and placebo session on separate days. To measure the relative contributions of each eye to a cyclopean percept before and after 2 hours of patching, subjects were assessed using a well-known dichoptically-presented binocular phase combination task. Subjects completed this task before drug/placebo ingestion and again during five separate post-patching assessments that took place over the course of an hour. Our preliminary data suggest that cholinergic enhancement augments the effect of patching. Specifically, the patched eye contributed stronger to a binocular percept in the donepezil condition than in the placebo condition. This result implies that cholinergic potentiation may modulate adult ocular dominance plasticity.

Exploiting multisensory modalities for mathematics learning based on multimodal technology and serious games

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Università degli Studi di Genova

At school, the visual channel is often the most frequently exploited one for teaching, and the other channels are left a marginal role only. The visual signal, however, is not always the more powerful and effective channel for perception. Recent results from psychophysics and developmental psychology [1-5] show indeed that children have a preferential sensory channel to learn specific (spatial and/or temporal) concepts. In this work, we explore the possibility of developing

and evaluating a new methodology, supported by novel multisensory technologies, to teaching and learning arithmetic (time) and geometry (space). The main novelty of the proposed approach comes from a deeper understanding of the role of communication between sensory modalities during development, that is, that specific sensory systems have specific roles for learning specific concepts. Results suggest that it is possible to open a new teaching/learning channel, personalized for each student based on the child's sensory skills. Multisensory interactive technologies including a hardware and software platform to support this approach will be presented and discussed.

Prism adaptation as perceptual learning

Manfred Fahle, Klaudia Pochopien & Karoline Spang

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Adaptation to prisms shifting the visual world sideways seems to be quite straightforward. But in truth, evolution did not supply the brain with straightforward ways to handle prism-induced shifts of visual input hence the brain deals with the shift produced by the prisms using clever tricks derived from adaptations to every-day tasks such as keeping the (visual) world stationary while moving around. For more than one hundred years researchers investigated how the brain achieves this apparently simple task to compensate for the shift caused by prisms shifting the visually world sideways. The explanations offered range from adaptation of the perceived position of the hand/arm system based on modifications of proprioceptive input or else of the perceived position of objects to modifications of the motor output. We argue that several factors contribute to prism adaptation, starting with an unconscious rotation of the head that starts once the prisms are donned and that compensates for around half of the prism's optical effect. The remaining half of the adaptation required is to a large extend based on changes in proprioception of the hand/arm system and of the perceived position of objects in space. The exact amount of adaptation caused by each of arm/hand adaptation and visual adaptation (and maybe motor planning) depends on the exact experimental conditions, causing sometimes contradictory results in the literature. We will present selected psychophysical data collected over more than a decade with several hundred subjects to substantiate the claims outlined above.

A generic mechanism for perceptual organisation in the parietal cortex

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A common denominator in all vision tasks is scene segmentation: what is fore- and background, which visual components belong to the same or different entities? In prior studies we used a bi-stable stimulus that can either be perceived as separate local components or as a global Gestalt. fMRI and TMS showed that posterior parietal cortex (PPC) was selectively and causally involved in Gestalt perception. Here, we investigated the role of the PPC in resolving perceptual organization using three additional such asymmetric bistable stimuli. Importantly, all of these stimuli evoked a default low-level and a non-default high-level interpretation. The illusory interpretations involved high-level visual mechanisms like shape perception and motion integration. For all stimuli, we found an activity pattern that was highly similar for the contrast of default (simple) vs. non-default (complex) perceptual interpretations. It consistently and prominently involved posterior parietal cortex. We also found for all stimuli strong early visual cortex deactivations during high-level perceptual interpretations. Mid-level regions such as LOC or motion regions were differentially involved with each stimulus class and percept-type. Our results suggest that PPC is not merely involved in grouping items into global Gestalt, but instead more generally it is involved in generating the more complex, high-level perceptual interpretation of a given stimulus. The activation of the PPC and the concurrent deactivation of early visual areas during high-level perceptual interpretations are in line with predictive models of visual perception. Our findings suggest a generic mechanism for scene segmentation with the PPC as its anatomical substrate.

Figure-ground organisation and the neural response to visual symmetry: Symmetry has to be in the figure not just in the image.

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University of Liverpool

The human visual system is tuned to symmetry, as documented by behavioural and neurophysiological studies. Brain activation in extrastriate areas does not depend on the task and it is therefore an automatic response to an image property. Because of the key role of figure-ground segmentation in vision, we tested whether this activation is present for symmetry defined within a ground region. In this case symmetry is in the image but is not a shape (unidirectional contour ownership). We adapted the stimuli introduced by Kanizsa and Gerbino (1976) in which symmetry is present in a region perceived as figure, or in a region perceived as ground. In these stimuli figure-ground organisation depends on the powerful role of convexity. Two experiments measured event related potentials and specifically a sustained posterior negativity (SPN). Exp 1 confirmed a SPN when symmetry was a property of the figure. There was no SPN when symmetry was in the ground region, and, importantly, symmetry in groun was not different to symmetry absent (in figure or ground regions). Because Exp 1 relied on a difference in convexity, Exp 2 compared responses to convex and concave shapes (either figure or ground). Other things equal, a more negative wave was found for concave than convex shapes. This rules out the confounding role of convexity in Exp 1 (negativity associated with convex foreground). The results demonstrate that although the visual system automatically and efficiently responds to presence of symmetry in a stimulus, this response is dependent on figure-ground organisation.

Determining visual shape features for novel object classes

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Visual shape representations reduce a high-dimensional input to a smaller set of more informative features. These span a range of abstractions from 'shallow' features—based on simple image properties—to 'deep' features, related to the generative causes of the shapes. We examined the depth of visual shape representations by comparing human and model judgments of whether novel shapes appeared to belong to a common class. Each shape class was based on a unique 2D base shape. We generated novel samples by transforming the base shape's skeletal representation to produce new shapes with limbs that varied in length, width, position, and orientation relative to the base shape. Multiple related classes were derived from each base shape using different distributions of parameter values. On each trial, observers judged whether a target shape was in the same class as context shapes (samples from a particular shape class). Target shapes were samples taken from the same shape class as the context or one of the 5 related classes. We evaluated models based on shallow features (e.g., area, compactness, distance), and deep features (e.g., ideal and sub-optimal observers) and find that deeper models with ideal distributions for limb length, position, and orientation, but broader distributions for limb width, best account for the human data. These results show human vision represents some generative shape features precisely, suggesting that these features are more critical to inferring whether a shape belongs to a novel object class than simple shallow features.

Connecting visual objects reduces both perceived numerosity and density for sparse but not dense patterns

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Humans and other species have a capacity for rapid and effortless nonverbal estimation of numerosity. However, it is not clear whether number is sensed directly or derived from other stimulus features, such as texture density. We have recently suggested that the numerosity of sparse patterns is encoded directly by dedicated mechanisms, while at higher dot densities "texture-density" mechanisms come into play (Anobile et al., 2014). Here we studied the influence of item segmentation on numerosity and density perception at various stimulus densities by measuring the effect of connecting visual objects with thin lines. The results confirmed previous studies showing that connecting items robustly reduces the apparent numerosity of dot-patterns of moderate density. Furthermore, when subjects were required to judge apparent density rather than numerosity, the dot-patterns connected by lines were perceived as less dense, suggesting that density judgments were driven more by the apparent numerosity rather than physical density. However, both these effects were strongly reduced or inverted at higher numerosities. The results provide clear evidence for different perceptual regimes at various densities. In the low-to-moderate density range, numerosity mechanisms dominate the perception of both numerosity and density, and these mechanisms respond to the number of perceptually segmented items rather than to the physical structure of the stimulus. At higher densities, both numerosity and density are more veridical, driven mainly by the physical stimulus.

Visual representations can be bimodal

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Imagine a pile of black and white balls. This is easy, but what if the color of each ball is black half of the time and white otherwise? We have recently shown that during visual search observers encode relatively complex feature probability distributions, including bimodal ones (Chetverikov, Campana, Kristjansson, 2017). Following several trials with horizontal or vertical distractors, responses are slowed with vertical or horizontal targets compared to oblique ones. Those conclusions relied on aggregation over many learning-test sequences. We tested whether observers representations are bimodal rather than unimodal following individual learning "streaks".

In Experiment 1, observers performed an odd-one-out orientation search. Following learning streaks, on two test trials targets could correspond to the mean or mode of a previously learned bimodal distribution or come from outside the previous distribution. We replicated earlier results showing that search was slowest when a target corresponded to the mode of a preceding distractor distribution. Importantly, the speed-up between two trials was smallest if targets corresponded to different modes of a preceding bimodal distribution. In Experiment 2, observers looked for two odd targets on each trial. As in Experiment 1, RTs were slowest when the two targets corresponded to different modes of the primed distribution, compared to all other target combinations.

The results indicate that observers can have bimodal feature representations following exposure to bimodal distractor distributions. Although it may be difficult to imagine a half-time-black, half-time-white pile of balls, such feature distributions can be learned and used for attentional guidance.

Crowding asymmetries explained by a model of image segmentation

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In crowding, perception of a target deteriorates when neighboring flankers are presented. Flankers close to the fovea deteriorate performance less strongly than flankers presented peripherally, the well-known crowding asymmetries. For example, we presented a vernier at 4 degrees of eccentricity in the right visual field and observer discriminated its offset direction. Performance was better when the vernier was flanked by a square on the left and 8 long lines on the right

than the other way around. We recently showed that a version of the LAMINART model explains many effects in crowding well. The model comprises hundreds of thousands of spiking neurons mimicking early stages of vision (V1, V2 and V4). In addition, a segmentation network parses the visual stimulus in different segmentation layers. The segmentation process is started by a top-down segmentation signal. The precision of cortical segmentation signals follows cortical magnification and thus decreases with eccentricity. The model could well reproduce the results of the experiment described above, because the representation of the flankers close to the fovea is denser, which facilitates segmentation. For both conditions, the 8 lines span a large area that is easily caught by segmentation signals, independently of their position in the visual field. In contrast, the smaller square is more difficult to catch in the periphery than close to the fovea.

Modeling a nonlinear functional hierarchy of unconscious processing: A directed graph framework

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Numerous studies attempt to demonstrate the presence of absence of unconscious visual processing: the brain's ability to process and respond to stimuli that it has not consciously perceived. The results of these studies sometimes appear contradictory, but may be confounded by the experimenters' choice of masking technique (method used to render the stimulus invisible to consciousness) and criterion (dependent measure of unconscious processing). Previously-proposed linear "functional hierarchies" of unconscious processing seek to explain the variability in research findings, proposing that different masking techniques interfere with processing at different stages, and that different criteria rely on processing up to different stages.

We review the results of previously-published unconscious processing experiments across six different masking techniques and ten different criteria, and find that a linear hierarchy can account for some - but not all - of the findings in the literature, suggesting that if such a functional hierarchy exists, it is nonlinear. We propose a method, based on directed graph models of hierarchical processing, that can model the relationship between suppression techniques in a non-linear functional hierarchy. We demonstrate that our directed graph framework can be used to (1) derive all consistent models of a nonlinear hierarchy of suppression techniques, (2) generate testable predictions from any theory of unconscious processing that can be expressed as a directed graph, and (3) direct the choice of future unconscious processing experiments by quantifying the amount of information gained by each potential experimental combination of masking technique and criterion.

Local vs. global processing in early vision: The role of local features in fast discrimination of natural images

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It is widely believed that under fast viewing conditions the visual system summarizes complex scenes to extract a simplified "primal sketch", by using image primitives (edges, bars), physiologically encoded by specific receptive fields. A debated question is whether the reconstruction of images under these extreme conditions is driven mainly by the presence of specific local features, or by the global, large-scale structure of the image. To help answering this question, we investigated the following issue: can a bunch of randomly distributed, well-chosen tiny features (around 4' of arc) be visually more salient than a similar bunch of "less-significant" features, in the absence of any meaningful global arrangement? In our experiment we chose a specific set of local features, predicted by a constrained maximum-entropy model to be optimal information carriers, as candidate "significant" features. We measured the discriminability of these supposedly significant features in comparison to alternative, random features, in a 2AFC procedure, as a function of their number and contrast. Results show that these features are significantly more prominent than control features under fast viewing conditions, in spite of the lack of any clues coming from global structure. This suggests that those specific features get preferential treatment during fast image analysis, and participate in a reconstruction process that must be, at least partly, initiated at the local rather than global level.

Crowding impairs subitizing

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In crowding, nearby clutter hinders perception of a peripheral target. Identification or detection experiments with flanked targets have typically shown that discrimination is impaired while detection remains intact. Here, we investigated whether subjects actually perceived each element in a crowded stimulus by asking them to report the number of items (subitize). Observers were briefly shown 3-7 uniform, vertical lines to the left or right of a central fixation dot, and indicated the number of lines. Our results showed an underestimation of the number of lines in approximately half of the trials. Remarkably, in 70% of the trials with 3 lines, only 2 lines were reported. A two-line resolution task ensured that the results were not due to poor spatial resolution in the periphery. Next, we reduced crowding between the lines by presenting lines of alternating contrast polarity (black and white), and in another condition, horizontally jittered each line's location to break the regularity of the line array. The underestimation effect was strongly reduced, in particular when three lines were presented. Our results show that entire elements in crowded arrays can be prevented from reaching awareness, even when only very few items are presented. In sum, the perceptual vagueness and indeterminacy induced by crowding can affect not only the identification of a flanked target, but also how many items are perceived. Importantly, this strong diminishment of the stimulus would go unnoticed in standard identification paradigms.

Serial dependencies in perceiving body size

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Body size is a salient marker of physical health, with extremes implicated in a range of mental and physical health issues. It is therefore important to understand the mechanisms of perception of body-size of self and others. We report here a novel technique we term the bodyline, based on the numberline technique in numerosity studies. One hundred and three young females judged the apparent size of sequentially presented female body images by positioning a marker on a line, delineated with images of extreme sizes. Subjects performed this task easily and well, with average standard deviations less than 6% of the total scale. Despite their small variability, responses were consistently biased in two ways: a strong regression to the mean, and a consistent assimilative bias towards the size of the previously viewed body. The assimilative bias increased with the difference in size of past and present images, up to a maximum effect for a difference of one-third the scale, then fell off for larger size differences. This selectivity indicates a highly sophisticated system that assimilates across small but not large size differences. The magnitude of serial dependence, but not of regression to the mean, was well predicted by a simple Kalman-filter ideal –observer model, suggesting that the serial dependencies serve a functional role.

Mislocalization of visual stimuli – exploring the attentional repulsion effect

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The Attentional Repulsion Effect (ARE) is a bias in the perceived location of a visual stimulus away from a previously presented peripheral cue. This bias is typically attributed to a shift of attention towards the cue, which in turn distorts the spatial representation of the stimuli outside the focus of attention. Attentional repulsion is traditionally examined through a two-alternative forced choice task (2AFC), measuring the capacity of a cue to repel a stimulus across the vertical meridian. This is typically done by participants' judgement of a shift in a presented Vernier stimulus, with its two defining lines above and below fixation. Here, we compared the classic 2AFC task to a condition in which participants were asked to indicate the absolute perceived locations of the upper Vernier line by a computer mouse click. To further investigate how the ARE depends on the specific visual configuration typically used, we additionally compared the classic Vernier stimulus to a condition where we presented one single line above fixation. While all conditions revealed an ARE of similar magnitude, the mouse responses additionally exposed an unexpected tendency to overestimate the perceived horizontal eccentricity of the stimuli. The same tendency was revealed in a further condition in which no cues were presented, indicating a bias away from the vertical meridian independent of the cues presented. Further studies are envisaged to examine the robustness and nature of this horizontal eccentricity bias in the attentional repulsion paradigm and its dependence on stimulus presentation around the vertical meridian.

Orientation discrimination and orientation averaging in individuals high on the sensory processing sensitivity scale

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Sensory processing sensitivity (SPS) is a personality trait characterized by heightened sensitivity to internal and external stimuli of physical, emotional and social nature. It is commonly measured by the Highly Sensitive Person (HSP) questionnaire introduced by Aron and Aron (1997). Surprisingly little research has been conducted regarding one of the aspects often associated with this personality trait, sensitivity to sensory information. Therefore, in this study, we asked if and how sensory processing sensitivity could reveal itself in basic aspects of visual processing. We hypothesized that individuals scoring high on the HSP scale could either be more sensitive to small variations in stimuli, resulting in lower thresholds on standard signal detection tasks compared to typical controls. On the other hand, individuals scoring high on the HSP scale frequently report that sensory input is overwhelming. Thus, SPS could reveal itself also through a heightened sensitivity of added noise to a visual stimulus. To examine these hypotheses, we recruited individuals who scored high on the HSP scale and matched these with control participants on age, gender, and education. Participants performed two tasks; a simple 2AFC orientation discrimination task to assess sensitivity to subtle variations in a basic stimulus dimension and a voluntary orientation averaging task in which participants had to evaluate the average orientation of an ensemble of oriented grating elements. Our initial observations indicate that individuals high on the SPS scale score comparably on orientation discrimination, yet seem to be able to tolerate less orientation noise in the averaging task.

Comparative judgements of facial emotions are affected by semantic congruity not by SNARC

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Behavioural evidence based on speeded classification of centrally presented emotions suggests that the mental representation of affects is similar to number, with faster left-sided responses to negative emotions (anger) and faster right-sided responses for positive emotions (happiness), SNARC-Like Effect (SLE). However, it is not clear whether a similar effect would hold true using a One Interval Speed-Comparison Task (OIS-CT) between pairs of simultaneously displayed facial expressions (horizontally aligned), either fully-emotional (happy/angry) or half-emotional (neutral/happy-or-angry). In this case a Semantic Congruity Effect (SCE) might rise. Emotion comparison indeed requires judging greater or lesser, depending on whether the task involves detecting

the happiest or the angriest face. The speed of comparative judgements should thus be faster when the target image is emotional rather neutral irrespective from the response side relative to average valence, and/or the spatial congruency of image-pairs with the left-to-right mental format. This would produce standard vs reversed SLE for spatially congruent (angriest-left/happiest-right) vs incongruent displays. In particular, for incongruent displays, a positive right-to-left speed advantage for half-emotional displays with negative rather than positive average valence should be observed: vice-versa for congruent displays. We found a strong SCE, not a SLE, in two Experiments involving the same OIS-CT with (self-terminating stimulus, n=40) vs without foveation (stimulus presentation time=[190, 200] ms, n=40). Individual average speeds were fully accounted for by a model formalizing SCE: an lme-regression including the sum between global display and absolute target valence as the only covariate of speeds.

Controlling saccade rate in electrophysiological studies through experimental designs and pre-screening of participants

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Saccades constitute a major source of artifacts and confounds in electrophysiological studies. Specifically, the contraction of the extraocular muscles and the rotation of the corneo-retinal eye dipole are associated with artifacts in electrophysiological recordings, such as EEG and MEG. Even more problematic is the visual activity produced by retinal image displacement, which is indissociable from other sources of visual activity and can be depicted by all brain imaging methods. Whereas some artifacts can be removed by omitting segments of data, saccadic artifacts cannot be eliminated by this method because of their high occurrence rate (1-3 per second). Some saccadic artifacts can be alleviated by offline-correction algorithms, but these methods typically leave non-negligible residuals and cannot mitigate the saccade-related visual activity. In this study we propose a novel yet simple approach for diminishing saccadic artifacts and confounds through experimental design and pre-screening of participants. We suggest that choosing the right design and participants results in substantially less saccades, thereby enabling the omission of contaminated data segments. In two experiments we show that saccade-rate is reduced when a foveal rather than parafoveal task is used. This was demonstrated for simple visual stimuli (grating-patches) and for complex objects. We further demonstrate how the exclusion of a small percentage of participants, based on a short-but-reliable pre-test, leads to a cleaner dataset. We propose that combining foveal tasks and pre-screening of participants could substantially minimize saccade occurrences, and be a first step toward developing saccade-free experimental designs.

Apparent motion may shrink, but visual pattern masking enlarges the perceived distance between alternating stimuli

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Many visual illusions demonstrate the influence of motion on the perceived position of objects in the visual field. Here, I compared the effects of apparent motion and pattern masking on the perceived spacing between objects. On each trial, two pairs of bars were presented for a total duration of two seconds, one pair to the left, and one to the right from central fixation. Participants were asked to judge in which pair the two bars were further apart. The bars of a pair were either presented a) continuously, or b) alternating, giving the impression of one single object moving back and forth (apparent motion), or c) the bars were alternating, but a pattern mask presented during the inter-stimulus interval prevented a strong impression of apparent motion. In line with previous research, the interspace between the bars was underestimated when they were perceived as one moving object. Surprisingly, with masking, the distance between the two alternating bars was overestimated: Pitted against a continuously presented pair of bars, a strong and robust bias to report the distance between the masked bars as larger emerged. Thus, pattern masking does not only affect the visibility of an object and its features, but also its spatial representation. The observed bias was weaker, though, when the masked bars were compared to an apparent motion pair. Further experiments will examine the role of attention, stimulus duration and perceived transients.

Russian normative data for 552 ecological pictures from the Bank of Standardized Stimuli (BOSS)

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The databases of standardized stimuli are of a great importance in studies of visual cognition and language production. They provide valuable information about a range of psychological parameters (such as name agreement, visual complexity, familiarity, etc.) that can be controlled as confounding variables in various experiments. The present study provides Russian-language normative data for 552 pictures from the Bank of Standardized Stimuli (BOSS) (Brodeur et al., 2010). This database proposes high-quality pictures taken from photographs of real objects. All of the 552 pictures have been standardized for name agreement, category agreement, familiarity, and visual complexity. Pictures with the name agreement greater than 50% (326 items) have also been standardized for object agreement, viewpoint agreement, and manipulability. Stimuli from the database can be used as an ecological alternative to Snodgrass and Vanderwart (1980) set of black and white pictures.

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3D contextual cueing maintained to depth but not planar variation

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Human visual system is remarkably good at learning constant spatial regularities and further speed up visual search in everyday life (e.g., contextual cueing). Despite plentiful observations of contextual cueing in 2D visual search (Goujon, Didierjean, & Thorpe, 2015), previous studies rarely investigate contextual cueing in 3D layouts. On this ground, the current study carried out two experiments to investigate the role of depth information in a contextual-guided visual search task. The search items (consist of a 'T'-shaped target and eleven 'L'-shaped distractors) were presented in 3D layouts with half of them in the front and half in the back planes during early training session of both experiments. Note in the subsequent test session, the search items were either swapped between the front and back planes in Experiment 1or between the left and right halves in Experiment 2 of the displays, yielding comparable contextual changes from training to test along the Z- and X-axis, respectively. The results showed significant contextual learning facilitation during the training session, suggesting that spatial contexts spread in 3D space could be learned effectively to expedite visual search. Importantly, contextual cueing persisted following depth but not left-right changes in the test session. This result pattern suggests that planer, but not depth, variations affect effective contextual guidance. In other words, contextual learning depends to a large extent on intact and invariant 2D inter-item associations, while depth-defined spatial regularities are probably not encoded during contextual learning.

Creating peripheral shape metamers

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Spatial vision is often investigated with forced-choice methods in which observers respond from a (small) number of predefined response categories. For example, in crowding studies, where the deleterious influence of flankers on target perception is investigated, participants are often asked to identify a target letter or to indicate the target's orientation. Providing narrowly defined response categories, however, may lead to the loss of information, especially regarding target appearance. The same categorical response to a target can be based on clearly distinct target appearances. To get a better understanding of shape perception and crowding, we developed a method of adjustment with several degrees of freedom that enables precise capture of peripheral appearance by creation of shape metamers. We used eye tracking and gaze-contingent stimulus presentation to avoid eye movements to peripheral stimuli while allowing long presentation times and repeated observations. Our novel interface uses familiar touchpad gestures whereby subjects adjust the number, position, orientation, and length of line segments to modify a probe until it matches target appearance. The results of a peripheral shape matching task revealed several characteristics of peripheral appearance, such as the effect of flankers on target perception, and the omission and truncation of line segments in crowding (target diminishment). We discuss the advantages and disadvantages of our method compared to traditional methods, and suggest that peripheral shape adjustments are an important extension to investigations of shape perception and peripheral vision. We propose that our method is optimally suited to provide accurate shape metamers of peripheral vision.

Time error with long ISI

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In the most of past studies, time error has been described with the quantitative relationship between a pair of stimuli and their temporal arrangement of presentation. In the present study, a pair of circles was presented successively in a trial, and the same trial was repeated ten times with intervals of 5000ms. The ISI, the interval between two presentations in the trial, was varied in seven conditions including the 5000ms ISI. As the result, negative time error was observed in all of the ISI conditions. It must be notified, in the case of the 5000ms ISI, the same stimulus was presented twenty times with a constant interval. This phenomenon cannot be explained with the physical stimulus condition, in which no clue for segmentation of the pair of stimuli was included. In order to segment the two successive stimuli among the twenty stimuli monotonously exposed, some active function of the subject was necessary. According to the task of comparison, the subject must have prepared him/herself to perceive and compare the two circles which would appear in succession. The same active process should have worked in the other six conditions as well. Thus, the crucial factor in the appearance of time error depended not on the physical stimulus condition but on the active process of subjects who were instructed to compare the first circle and the second. Now we are collecting the data with over 5000ms ISI conditions.

Comparing an established and a new method for evaluating noise visibility

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Established psychophysical methods applicable for static stimuli can require a lot of time and effort in threshold experiments for dynamic stimuli. Spatiotemporal noise is a particularly interesting dynamic stimulus, because it can significantly decrease video quality. We therefore compared two different methods for evaluating noise perception. The experiment investigated the visibility of spatiotemporal noise with varying spatial frequencies. Noise of low to high frequency bands was added to both a homogeneous grey background and real video content. The first method is method of adjustment: To adjust the noise level we designed a Matlab program that communicates with a midi controller and displays the generated signals directly over a video-I/O. The observer can thereby adjust the noise level in real-time via slider. The second method is based on pre-rendered sequences showing 15 seconds of gradually increasing noise.

Numbers from 1 to 15 in the lower right corner of the frame indicate the current noise level. The sequences are played twice, and in the break the observers write the number at which they started seeing the noise. This method only requires a video display system without user interaction. The threshold curve measured with method of adjustment in comparison to the sequence-based method revealed slightly higher sensitivity. Apart from that, both methods in general produce similar results. Since real-time stimuli generation can require considerable effort and powerful hardware, especially if high end video specifications (4K, HDR, HFR) are considered the outlined sequence-based method might be a favorable alternative to established methods.

Conditioned fear lengthens perceived temporal duration without visual awareness

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IPCAS

Time perception of visual events is intertwined with conscious and emotional experience. Viewing stimuli of negative valence generally induces an overestimation of perceived temporal duration, yet it remains unknown whether such effect depends on the explicit awareness of emotional cues. To tackle this issue, conditioned fear was created by repetitively pairing aversive electrical shocks to one of two gratings with orthogonal orientations. Following the conditioning phase, two sets of counter-phase chromatic gratings with the conditioned (CS+) and the unconditioned (CS-) orientations, rendered indistinguishable through flickering at a frequency above the critical flicker fusion (CFF) threshold, were employed in a temporal duration discrimination task. While observers could not consciously discern the orientations of the gratings, the fear conditioned CS+ flicker was perceived significantly longer than the CS- flicker even when they were identical in duration. Furthermore, preliminary data from an intracranial electroencephalograph experiment showed that, in comparison with the CS- flicker, the unperceived CS+ flicker significantly enhanced the neural activity in amygdala, a key region for unconscious fear processing. These findings provide compelling evidence for a temporal dilation effect elicited by conditioned fear without awareness. Moreover, they suggest that the amygdala may play a crucial role in modulating the internal timing of unconscious fear.

Electrophysiological correlates of visual backward masking in first-episode psychosis

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Schizophrenia is a heterogeneous disorder and among other symptoms, patients have important visual impairments. Visual paradigms are therefore important tools to investigate the mechanisms of schizophrenia. We have previously shown that visual backward masking (VBM) is a very sensitive endophenotype of schizophrenia (Chkonia et al., 2010). Moreover, we found strongly reduced global field power (GFP) amplitudes for masked stimuli in schizophrenia patients (Plomp et al., 2013). In order to track the progress of the disease and its behavioral and electrophysiological correlates, we tested 11 patients with first-episode psychosis three times during one year in a longitudinal study. A vernier target (i.e. two vertical bars that are slightly offset in the horizontal direction), was presented and after the target, a mask followed. Task was to discriminate the offset direction by pushing a corresponding button. Two masking conditions (long and short inter-stimulus intervals (ISI)) were randomly presented along with target only and mask only conditions; in parallel the EEG was recorded. First-episode patients showed clear masking deficits and reduced amplitudes in the EEG compared to controls, but higher amplitudes compared to chronic schizophrenia patients. The amplitudes remained stable across the first year. Hence, masking deficits are present already at the very beginning of the disease. We suggest that visual backward masking is a very sensitive endophenotype of the schizophrenia spectrum.

Time duration changes with implied motion

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The aim of the present study was to investigate whether the perception of presentation durations of pictures of different subjects was distorted as a function of their implied motion (i.e. the fact that a still photograph of an object in motion may convey dynamic information about the position of the object immediately before and after the photograph was taken). In a time reproduction task participants were presented with images depicting subjects of four possible categories: (i) humans (ii) animals (iii) artifacts and (iv) natural scenes. For each category four pictures were presented, two with and two without implied motion. Each picture was presented four times for three durations (i.e. 0.7, 1.4 and 2.1 s), for a total of 192 trials. The results showed a general underestimation of presentation durations, which progressively increases for longer durations ($p<0.001$). More interestingly, temporal duration was judged longer for pictures with implied motion ($p<0.05$), regardless of category. These results challenge recent theories (e.g. Nather et al. 2011) suggesting a speed up of the internal clock with the embodied simulation of movements associated with body postures perceived in another person. A more conservative explanation is suggested, based on the visual analysis of motion, which is also engaged in processing implied dynamic information from static images.

Why psychopaths do not stand back: Understanding personal space violations

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Psychopathic traits are paired with interpersonal and affective deficits. This study examined the impact of psychopathy on interpersonal spatial behavior. To study spatial behavior under highly controlled conditions, participants were immersed in a virtual environment. In our first experiment, participants approached a virtual person (avatar) with angry or happy facial expression until a comfortable distance for conversation was reached (egocentric approach). In our second experiment, participants adjusted a comfortable distance between two avatars in the frontoparallel plane (exocentric approach). A student-sample was tested and we measured psychopathy via self-report. Our results suggest that regulation of interpersonal distance as a function of facial expression of the approached is impaired in psychopathy, although psychopathic individuals know how to regulate proper interpersonal distance in a dyad.

When more is more: Multisensory stimulation enhances performance improvement by temporal expectations

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Optimization is crucial to cope with the continuous stream of complex multisensory information we perceive every day. There is converging evidence for several optimization mechanisms instrumental in integrating incoming information, among them are multisensory interplay (MSI) and temporal attention (TE). However, how these two mechanisms interact is currently unknown. In a series of psychophysical experiments, we tested whether MSI-induced behavioural benefits interact with TE-induced benefits and how these effects are affected by distinct experimental contexts. In all experiments auditory (A) and/or visual (V) stimulus sequences were presented either alone or simultaneously. Participants always discriminated visual and/or auditory frequencies of deviant target stimuli (high/low) within each sequence. Temporal expectation about time-of-target-occurrence was manipulated block-wise (early vs. late occurrence). Task difficulty was altered by using speakers ('same location', Exp. 1 & 3) or headphones ('different location', Exp. 2 & 4), and by changing the predictability of target modality (predictable: Exp.1 & 2, unpredictable: Exp. 3 & 4). We observed a robust interaction of MSI and TE; with TE effects being enhanced for multisensory relative to unisensory stimulation whereas TE effects for unisensory stimuli even vanished under high spatial uncertainty. Accordingly, computational modelling indicated that TE, target and spatial uncertainty govern multisensory behavioural benefits. Finally, matching expectation information at trial n-1 selectively improved performance in the multisensory condition. Together, the result pattern indicates that multisensory stimulation has a protective and enhancing effect on generating temporal expectations especially in noisy environments, and allows for phasic as well as sustained information extraction to boost performance.

Visuospatial abilities in children with weakness in grammar understanding

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Objective: The goal of this research was to examine the hypothesis that Russian-speaking children with weakness in understanding grammatical structures have also a weakness in visuospatial perception. Participants and Methods: 25 children aged between 7 and 8 years were included in the experimental group with weakness in understanding grammatical structures, and 25 children were included in the control group. Children from both groups were assessed with visuospatial tasks from Luria's child neuropsychological assessment battery and with the Rey-Osterieth Complex Figure test. Results: One-way ANOVAs by group revealed significant differences ($p<.05$) between the groups for scores in the two visuospatial tasks (Constructional Praxis and Head Task) and for number of spatial errors in the Rey-Osterieth Complex Figure test. However, there were no significant differences ($p<.05$) in number of omission errors and needless details. The two groups differed also significantly ($p<.05$) in their use of coping strategies. The majority of children experimental group used immature analytic strategy. In contrast, the majority of children from control group used holistic strategy. Conclusions: Thus in view of the obtained results it can be assumed that children with weakness in understanding grammatical structures have also weakness in visuospatial abilities. Funding: The research was supported by Act 211 Government of the Russian Federation, agreement 02.A03.21.0006

Evoked potentials to visual apparent motion after auditory and visual time interval adaptation

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It is well known that the temporal information provided by audition can alter visual motion perception. Several studies have shown that not only concurrent presentation of sound timing (i.e., time interval) but also the previous experience acquired through a brief adaptation phase are also involved in shaping the perception of visual apparent motion. Here, we aimed to characterize the time interval aftereffects on the evoked activity to visual apparent motion. Accordingly, in our experiments, we adapted observers to different time intervals by using either brief sounds or visual flashes, and examined the evoked activity to the subsequently presented visual apparent motion. For both modalities, our results showed significant aftereffects of time intervals on the ERPs elicited by visual apparent motion. However, the changes in ERPs occurred in different time windows and were mostly centered over distinct scalp sites for auditory and visual adaptors. Compared to visual adaptors, the aftereffects induced by auditory stimuli were more salient and clustered over parietal and parieto-central regions. On the other hand, adapting observers to visual time intervals had relatively weaker effects on the ERPs and mostly occurred over occipital and parieto-occipital regions. Taken together, our findings within the context of visual motion indicate distinct changes in the spatiotemporal profile of the neural activity for auditory and visual adaptation, and highlight the

role of distributed sensory processes in sub-second time interval adaptation.

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How many factors are there in vision?

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Common factors are ubiquitous in cognition, audition, and somato-sensation. Surprisingly, there seems to be no common factor in vision, i.e., visual tasks correlate very weakly with each other. Here, we show that there are likely many very specific factors in vision. First, we have previously shown that the Ebbinghaus illusion correlates very little with other spatial illusions (except the Ponzo illusion). Here, we measured illusion strength in the classic Ebbinghaus illusion with disks and compared it with the illusion magnitude of 18 versions of the Ebbinghaus illusion, for example, having squares rather than disks or moving rather than static disks. In addition, we asked observers to compare the size of two single disks. All versions of the Ebbinghaus illusion strongly correlated with each other but not with the single disks comparison task, even though the tasks are the same. Second, we previously presented 10 illusions, each with 4 different luminance conditions, including 2 iso-luminant ones. For all 10 illusions, the luminance conditions correlated highly with each other. Here, we re-analyzed the data and found that there were almost no correlations between the 10 illusions, except for the vertical and horizontal bisection illusion, which correlated strongly with each other for all 4 luminance conditions. In both bisection illusions, there are likely different neurons, sensitive to vertical and horizontal orientations, involved. Hence, variations of an illusion correlate highly with each other, however, it seems that each illusion makes up its own factor.

The evaluation of naturalistic food images in self-paced versus time-controlled exposure conditions

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Previous research suggested a role of gaze bias in preference formation, not merely as an expression of preference, but also as a causal factor. According to this hypothesis, known as the "gaze cascade hypothesis," the longer a participant looks at an item, the more likely she is to develop a preference for the item. However, to date the connection between viewing and liking has been investigated predominately with self-paced viewing conditions. Here, we hypothesized that the connection between viewing and liking would break down under time-controlled conditions. To investigate the influences of exposure time, we examined the assessment process using naturalistic food images with a self-paced exposure condition, 'Self', versus a time-restricted exposure condition, 'Computer'. In the 'Computer' condition the exposure time was controlled randomly (from 1 to 8 seconds), and participants were able to indicate their evaluation only after the image exposure. In the 'Self' condition, participants were free to look at a picture as long as they wanted. Exposure time, rating score and reaction time were recorded. The 'Self' condition was characterized by a significant correlation between the exposure time and evaluation. In contrast, in the 'Computer' condition there was no significant influence of exposure time on the evaluation. Furthermore, with the increase of exposure time the reaction time significantly decreased, indicating that participants had formed their evaluation during the exposure. Taken together, the data provide evidence against a causal role for viewing time in the process of preference formation, particularly when participants have no control over the exposure duration.

Automatic detection of visual duration differences

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The perception of the passing of time is fundamental to conscious experience. The duration of a sensory stimulus is one of its defining attributes, but it is not clear how this is encoded in the brain. This work investigates if the duration of a visual stimulus is an attribute that the brain can adapt to and use to predict future stimulus durations automatically. Visual mismatch negativity is an ERP component elicited, even when the stimuli are unattended, when an 'unexpected' visual stimulus appears amongst a series of expected stimuli in an oddball paradigm. VMMN has been suggested to reflect automatic pattern detection over a sequence (Czigler, 2014). To date vMMN has only been measured in response to differences in visual duration in a single study, which involved static on/off stimuli, at the centre of the visual field (Chen et al., 2010). Our study measures vMMN to test whether duration is encoded automatically for static stimuli against a blank background and moving stimuli against a static background whilst attention is directed to a different spatial location using a continuous attentionally demanding task. We show that differences of duration in the absence of spatial attention are detected in the form of vMMN elicited in response to the shorter duration for both stimuli. For the motion stimulus a larger difference in duration was needed. We conclude that duration is encoded automatically early in the visual cortex and is an attribute that can be adapted to and form the basis of predictions.

Intentional binding of visual effects

Miriam Ruess, Roland Thomaschke & Andrea Kiesel

Albert-Ludwigs-Universität Freiburg Institut für Psychologie

When an action produces an effect, the action is perceived later in time compared to an action without following effect. Likewise, the effect is perceived earlier in time compared to a stimulus without preceding action. This temporal bias is called intentional binding (IB) and it serves as an important implicit measure for sense of agency. Typically,

IB is investigated by presenting a rotating clock to participants while they execute an action that produces a tone. They estimate the point in time of either their action, or the tone. These time estimates are compared to estimates from conditions where an action or a tone occurs alone. Studies on IB commonly use auditory effects, whereas we modified the traditional paradigm by presenting visual effects. Firstly, we observed IB also for visual effects, showing that also our visual perception is subject to this temporal bias. Secondly, IB depended on the delay between action and effect. It was strongest at delay ranges between 150 ms to 350 ms, whereas (almost) no IB was found for delay ranges larger than 450 ms. The results indicate that visual IB, that is, sense of agency for visual effects, might be maximal for different delays compared to auditory IB. This would have important implications for the design of human-machine interfaces.

How motor signals shape the estimation of time

Eckart Zimmermann

How we estimate the passage of time is still a mystery in current neuroscience. It has been suggested early on that motor structures might be acquired to tell time. In order to test the motor-hypothesis of subjective time I used a virtual reality setup. Hand motion was tracked online and rendered in the head mounted display. Subjects had to stop a moving ball with their hands as soon as it reached a landmark. In the adaptation condition the virtual hand was shown with a delay of 150 ms. Over the course of trials subjects adapted to the delay and performance increased again. Then, I tested how adaptation tranferred to estimations of time. In separate tasks subjects either had to reproduce a temporal interval or to judge the time of a ball reappearing behind a wall. In both task, temporal estimations were shifted after adaptation to the delay between motor action and its virtual presentation. These data provides clear evidence that motor structures shape our estimation of time.

Timing an action and being confident about it

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Accurate timing of a movement is essential for performing a successful action. However, perception of time is corrupted by uncertainty (Jazayeri & Shadlen, 2010) and humans have inaccurate representations of motor variability in time (Mamassian, 2008). The present study aimed at investigating how humans trade off different sources of uncertainty for the timing of an action and estimated confidence about their performance.

The task was to synchronise arm movement with a predictable visual stimulus presented on a horizontal plane. After two stimuli appeared consecutively, participant was to make a movement and point to a target third stimulus. The timing of the target could be estimated from the regular rhythm between the three stimuli. Additionally, after each trial the participant gave a binary estimation of confidence.

We independently varied sensory and motor noise across trials by varying the timing between the first two stimuli and the target size. In two additional experiments we assessed sensory and motor uncertainty independently.

In agreement with previous work, movement onset was mainly affected by the timing between events, while the target size affected movement duration. Furthermore, we found a preference for delaying onset and minimising movement duration. Interestingly, the bias towards a late onset was larger than predicted from measured uncertainty. Contrary to expectations, greater the deviation from the mean onset time, less confident participants were about their performance, while there were no correlation between movement time and confidence judgments. Altogether, our results suggest that people have only limited insight into movement time and variability.

Temporal attention improves visual feature integration

Bettina Rolke, Elisabeth Hein & Verena Carola Seibold

When attention is oriented towards the temporal occurrence of visual stimuli, their perception is improved (e.g., Rolke, 2008). In two experiments, we investigated whether temporal attention simply enhances the perception of individual stimulus features (e.g., color or form) or whether temporal attention also affects the integration of different features into a stable object representation. To estimate visual feature integration, we measured the number of assignment errors between form and color of different stimuli (illusory conjunctions) occurring in a shortly presented, masked visual display. The display consisted of one target letter and distractor letters of different colors. Target and distractors were presented either spatially predictable (Experiment 1) or spatially unpredictable (Experiment 2). In both experiments, temporal attention reduced the number of illusory conjunctions indicating that the binding of individual features into a stable object representation was improved. We assume that this processing benefit caused by temporal attention results from a prolonged availability of spatial feature maps in which the togetherness of form and color is identified along spatial coordinates.

Asymmetric temporal order tuning of the Ebbinghaus size illusion

Saki Takao & Katsumi Watanabe

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Perceived size of an object is influenced by the surrounding context. In the Ebbinghaus size illusion or the size contrast effect, a circle surrounded by smaller (larger) circles appears larger (smaller). This study examined the temporal tuning of the effect by manipulating the presentation timing between the surrounding circles (inducers) and the surrounded (target) circles. In the experiment, two identical circles were presented simultaneously on the left and right side of the

fixation for 50 ms. Two sets of inducers, one consisted of circles smaller than the target circles and the other consisted of larger circles, appeared for 50 ms with various timing, ranging between 3.2 second before and 1.6 second after the target circles. The inducer locations and the presentation timing were randomized. Participants reported which target circle was larger. The results showed that the temporal tuning of the Ebbinghaus size illusion was asymmetric. The effect was observed even when the inducers preceded the target 1.6 second. However, the contrast effect became much conspicuous when the inducers appeared less than 200 ms before the target. The effect was not observed when the inducers appeared 100 ms after the target. A subsequent experiment revealed a more precipitous and symmetric function for temporal order judgment between the inducers and the target circles, suggesting the asymmetric tuning of the effect is not due to perceived relative timing between the stimuli. These results indicate that neither physical nor perceived simultaneity is prerequisite for the Ebbinghaus size illusion.

Short-term adaptation effects on perceived duration in Random Dot Kinematograms (RDKs) and drifting gratings

Inci Ayhan & Doga Gulhan

Bogazici University

Apparent duration can be manipulated in a local region of visual field by long-term adaptation to motion or flicker (Johnston et al., 2006). These effects show narrow spatial tuning (Ayhan et al., 2009), as well as retinotopic position dependency (Bruno et al., 2010), supporting early locus in the visual pathway. Here we introduce a novel effect, where a rather short-term adaptor (RDK pattern, 700ms, 2.5°/s or 9°/s) induced a significant subjective duration compression (10%) on a subsequently presented test stimulus (RDK pattern, 2.5°/s or 9°/s) only for global motion patterns drifting at 50% motion coherence but not for those at 0% coherence, suggesting a higher-level area as a source of origin. In order to investigate the direction specifity, we conducted another experiment using plaids as adaptor (600ms, 2.5°/s) and gratings as tests. In blocked trials of 2-AFC tasks using method of constants, participants compared the duration of a comparison grating (300-1200ms, 2.5°/s drift) to the duration of a standard grating (600ms, 2.5°/s drift) following adaptation. A significant duration compression was only visible when the plaid adaptor and the upcoming standard test moved in the same direction. Direction specific adaptation effects being non-significant for plaid's component directions indicate a locus where global motion is processed. Further experiments showed that the duration effects cannot be explained by adaptation-induced changes in perceived speed, perceived onset-and-offset and attentional resource allocation, implying separate mechanisms mediating duration effects in higher-level motion areas.

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Aesthetic judgment of high and low-ranking Western and Eastern buildings: The influence of architectural system and physical properties of the stimuli

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In a previous study (Vannucci, Gori, Kojima, 2011, ECVP; 2014, Cog.Neurosci) we investigated the aesthetic judgment for high- and low-ranking Western buildings in Italian and Japanese participants and we examined the effects of differences in cultural expertise and power spectrum of the stimuli. We found that irrespective of cultural expertise, high-ranking buildings and their relative random-phase versions received higher aesthetic judgments than low-ranking buildings and their random-phase versions. Here we aimed to go a step further, by extending the examination of the aesthetic judgments of the Eastern (Japanese) architectural system. To this aim we asked twenty Japanese undergraduate students with normal or corrected-to normal vision to perform two aesthetic judgment tasks: one with line drawings of high- and low-ranking Western and Eastern (Japanese) buildings and one with their random-phase versions (an image with the exact power spectrum of the original one but non-recognizable anymore). With both Western and Eastern buildings, high-ranking buildings received higher aesthetic judgments than low-ranking buildings. The same pattern was found for the random-phase version of the buildings. These findings confirm the results of our previous study and extend them to the Eastern architectural system, providing a stronger evidence for a role of low-level visual processes in the aesthetic judgment of buildings.

The Ebbinghaus illusion in time: Temporal context affects visual and auditory duration discrimination

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We investigated whether the perceived duration of a visual or auditory stimulus depends on the duration of distractor stimuli presented before and after a test stimulus. In a visual and auditory experiment two samples of participants (N=12) discriminated between the duration of a standard and test stimulus in a 2IFC task. In randomly intermixed trials we varied the context and the duration of the test stimuli. In each trial a participant perceived several short distractors or a single long distractor before and after the test stimulus. The test stimulus varied around a standard of 500ms, ranging from 300 to 700ms in steps of 50ms. In both modalities participants systematically overestimated the duration of the test stimuli in the context of the short distractors and underestimated duration of the test stimuli in the context of the long distractors. The average difference between the point of subjective equality for the condition with short and long distractors was 115ms in the visual ($t(11)=4.28$, $p=0.001$; 95% CI [56, 174]) and 240ms in the auditory domain ($t(11)= 3.75$, $p=0.003$; 95% CI [99, 381]). We confirmed both results using general linear mixed models. These hierarchical models take into account individual variability when comparing conditions at group level. The robust effects in the visual and auditory domain suggest an "Ebbinghaus illusion" for time perception that is different from the "temporal oddball effect" and exceeds sensory adaptation effects.

Exploring network connectivity during visual aesthetic experiences

Ilkay Isik & Edward Vessel

Max Planck Institute for Empirical Aesthetics

Whether it is a painting or a natural scene, human beings consistently favor interactions with aesthetically pleasing objects. However, the mechanisms supporting aesthetically pleasing experiences remain to be discovered. Previous research found that the ventral visual pathway and the default-mode network (DMN), large-scale brain networks that are typically anti-correlated, become simultaneously active during moving aesthetic experiences, suggesting that such experiences are correlated with a change in the dynamics of large scale brain networks. We measured BOLD fMRI as eighteen participants made aesthetic judgments about landscapes, architecture and paintings (including portraits), and tested the hypothesis that ventral visual regions would show functional connectivity (fc) with nodes of the DMN and that this fc would be content specific and modulated by preference. Core regions of the DMN and category-selective visual regions in ventral occipito-temporal cortex (e.g. PPA, FFA, OFA) were identified for each individual using a rest scan and a visual localizer scan. We found that the three aesthetic domains differentially activated regions in ventral occipito-temporal cortex: FFA was most activated by art and PPA was most activated by architecture. The caudate and DMN were also modulated by aesthetic preference. A measure of dynamic fc (multiplication of temporal derivatives; MTD) revealed fc between category selective ventral visual regions and several nodes of the DMN, but that fc was not content specific nor modulated by preference. These results suggest that aesthetic appreciation may not be directly mediated by connections between content-specific brain regions and the DMN.

Monday August 28th Oral presentations

Looking into the future when grasping

Dimitris Voudouris[1], Jeroen BJ Smeets[2], Katja Fiehler[1] & Eli Brenner[2]

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Humans usually direct their gaze near their index finger's contact point when grasping objects between their thumb and index finger, but when the object is at eye height they sometimes fixate near their thumb's contact point. To better understand gaze when grasping, we previously conducted experiments in which we manipulated various aspects of the grasping movement while the objects were below eye height. Although many aspects influenced gaze to some extent, participants generally fixated near their index finger's contact point. Recently, we compared gaze when grasping a glass placed below and at eye height. Participants had to pour its content into another glass on their left, rather than just to lift it as in our previous experiments. Surprisingly, for objects below eye height, participants now looked near their thumb's contact point. For objects at eye height, they looked below the endpoints altogether. We therefore now examined whether gaze was biased towards where the hand would subsequently move, rather than towards a specific digit, by having participants move a glass or pour its contents into a second glass to their left or right. When grasping, gaze was modestly biased towards where participants performed the subsequent action. Thus, the direction of gaze when grasping an object is influenced by where one is going to act with the object after grasping it. Although this is certainly not the only factor that influences where humans look when grasping, it might contribute substantially to the biases found in previous studies.

On the nature of correlation perception in scatterplots

Ronald A Rensink

University of British Columbia

The perception of correlation in scatterplots can be described by two laws: a linear one for discrimination and a logarithmic one for perceived correlation magnitude (Rensink & Baldridge, 2010). To determine the underlying mechanisms, JNDs and perceived magnitudes were measured for 20 observers, for each of four conditions. The first tested scatterplots of 100 points with a bivariate gaussian distribution of equal variance in both dimensions. The second used 25 points, the third compressed the scatterplot by a factor of 2, and the fourth used a uniform distribution of dots. For all conditions, the same laws were found: JND was proportional to $u = 1\text{-}br$, with bias b such that $0<b<1$; perceived correlation was proportional to log(u).

This generality—together with the finding that similar laws exist when properties other than spatial position are used (Rensink, VSS 2015) can be explained by three proposals: (i) observers can infer probability distributions in an abstract two-dimensional parameter space, (ii) observers can perceive the width of this distribution, and (iii) this reflects the perception of the entropy of the distribution inferred from the dots, with perceived correlation proportional to its information entropy. This example illustrates that the visualization of information can be studied rigorously, and can help us uncover new insights into the nature of our visual intelligence.

Seeing colour where there is none: Decoding the implied colour of grey-scale objects using MEG

Lina Teichmann, Tijl Grootswagers, Thomas Carlson & Anina Rich

Natural objects in our environment often have canonical colours that influence our recognition and decision-making. For example, the colour of a strawberry is useful when deciding whether it is ripe and edible. In the current study, we asked participants to do a simple target-detection task when looking at either isoluminant red and green shapes or grey-scale luminance-matched pictures of fruits and vegetables that in 'real life' would be red (e.g., strawberry) or green (e.g., cucumber). We recorded brain activity using Magnetoencephalography (MEG) to investigate (1) the temporal dynamics of real colour processing, (2) whether grey-scale pictures of red and green fruits and vegetables can be classified into

their colour category, and (3) whether there are commonalities in the processing of real colour and implied object-colour. Applying Multi Voxel Pattern Analysis (MVPA) to our time-series neuroimaging data, we were able to successfully classify the real colour objects into red and green categories early in the signal. Similarly, we could classify trials showing grey-scale pictures of fruits and vegetables into their natural colour categories. Finally, we were able to decode implied object-colour when the classifier is trained on distinguishing real colour, but this cross-classification was only possible using time-generalisation methods showing that there are temporal asynchronies in processing real colour and implied colour. Together, these results demonstrate that there are similarities in brain representation of real and implied colour but that object colour knowledge is accessed later than real colour.

Confidence in visual discrimination decisions is based on evidence and stimulus visibility

Manuel Rausch & Michael Zehetleitner

Katholische Universität Eichstätt-Ingolstadt

What is the mechanism that determines confidence in visual discrimination decisions? We propose a new model of confidence in visual discrimination decisions, according to which confidence is determined by weighting sensory evidence and visibility on a trial-to-trial basis. Visibility can be seen as an estimation of the physical quality of the stimulus. In a backwards-masked orientation discrimination task with varying stimulus-onset asynchrony (SOA), a model based on evidence and visibility provided a superior fit to the data compared to signal detection models, post-decisional accumulation models, parallel models, or drift diffusion models. Specifically, only the weighted evidence and visibility model was able to account for the observed positive correlation between SOA and confidence in incorrect decisions. All the other models implied that the correlation between SOA and confidence in incorrect decisions should have been negative. The same results were obtained in experiments where the task was speeded and unspeeded, and independent of whether confidence was recorded at the same time as the discrimination response, or afterwards. It is argued that a complete theory of confidence in visual discrimination decisions should not only involve sensory evidence, but also encompass visibility.

Perceptual continua in material depictions

Maarten Wijntjes

Delft University of Technology

Studies on visual material perception often focus on properties than span perceptual continua. Similar to our ability to discriminate several shades of grey, we can discriminate between various levels of gloss, for example. In the current study, we wondered whether these continua also exist in visual representations of materials, in this case (oil) paintings.

Depictions of body armor are beloved examples to illustrate the relationship between highlights and local surface curvature. Furthermore, at first sight they seem to show various levels of 'shininess'. We used 10 painting fragments in an online experiment where participants performed pairwise shininess judgments (900 trials divided over about 200 participants). Using a variation of Thurstonian scaling analysis, we reconstructed the perceived scale of these 10 samples. Subsequent analysis revealed that shininess judgments span a space of about 4/5 JNDs (75% criterion).

These results indicate that at least one perceptual continuum exists within a selection of (painterly) material depictions. It appears to be a promising direction of future studies on the relation between material perception and various ways of depicting material properties.

The moon illusion revisited: New insights by employing the moon diary app in the field

Claus-Christian Carbon

Otto-Friedrich-Universität Bamberg

The moon illusion shows a drastic change of the perceived moon size within one lunar day. Typically, data about the moon illusion originate from research in the lab or the planetarium. In the present study, we developed an Android-app which provides easy access for observers of the moon in the field. Participants had to assess the perceived size, the degree of perceived details of the moon and the perceived distance to the moon; furthermore, they were asked to provide information about environmental factors such as the density of clouds and the amount of perceived stars. GPS-location was used to calculate astro-physical data on the moon addressed by common moon illusion theories. Out of the 403 observations, we obtained 235 data sets that were accompanied by valid GPS-location. For the set of variables assessed by the participants, perceived distance was the best predictor in a multiple regression for perceived size, followed by the degree of perceived details of the moon and the density of clouds at the sky. Importantly our data partly contradicts common theories as perceived distance was inversely related to the perceived size of the moon ($R=-.459$, $p<.0001$); other typical relationships could be replicated, most prominently that a lower moon is typically also perceived bigger ($R=-.403$, $p<.0001$), but this relationship was only obtainable for relative low altitudes, e.g. 0-30°. The paper discusses the results by employing a complementing theory of direct perception versus indirect perceptual measurement potentially reconciling the revealed contradictory finding.

Awareness of action outcome and action intention

Andrei Gorea[1], Lionel Granjon[1] & Dov Sagi[2]

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How much do humans know about the outcome of their own actions? Participants performed a speeded pointing task, moving their index finger to a random location briefly marked by a visual target (T), with and without visual feedback. They then estimated (E) their landing location (L) using the same finger with no time limit. Overall, L and E precisions (1/SD) are very similar and are highly correlated across participants. This similarity argues against a Bayesian account of the results inasmuch as L and E distributions are taken to represent the prior and the posterior. L and E locations are

systematically but idiosyncratically shifted away from T and L locations, respectively, suggesting participant specific errors in the sensorimotor transformation from the visual localization of T to the joint-based motor command. Trial-by-trial L-E correlations reveal an E bias away from L and toward the T of 20%/36% in the presence/absence of visual feedback, respectively. The data are well accounted for by a model rooted in the general principles of the forward internal models. It posits that participants do not know the outcome of their pointing movements and, when asked to introspect, refer to their planned rather than actual landing locations. The end product of both action (landing) and introspection (estimation) is the noisy planned action outcome to which motor execution and introspection add independent, participant specific noises.

Differential predictive processing for "good" and "bad" Gestalts in the early visual cortex

Thiago Leiros Costa[1], Kimberley Orsten-Hooge[2], Gabriel Rêgo[3], Johan Wagemans[1], James Pomerantz[2] & Paulo Boggio[3]

[1]KU Leuven - University of Leuven; [2]Rice University; [3]Universidade Presbiteriana Mackenzie

Our understanding of perceptual organization processing steps at the early visual cortex is limited, but a growing body of evidence (and predictive coding models) suggests that perceptual organization and expectations can modulate early visual cortex activity. Given this, we assessed whether predictable vs. unpredictable stimuli and "good" vs. "bad" Gestalts could have a differential effect on early temporal and hierarchical stages of visual processing. We measured the C1 EEG component (the earliest event-related potential generated at the early visual cortex) during an odd-quadrant visual search task using stimuli that yielded a configural superiority effect ("good Gestalts") and their relevant constituent parts isolated or organized in a way that did not lead to configural superiority ("bad Gestalts"). Each block had one stimulus type that was likely (80% of the trials) and another that was unlikely (20%). We tested all stimulus combinations, manipulating the predictions for good and bad Gestalts in different blocks. Results showed that in general, likely stimuli led to lower C1 voltages, suggesting a suppression of early visual cortex activity in accordance with current predictive coding models. Surprisingly, when comparing good vs. bad Gestalts in the 80% likely conditions, we observed that suppression of activity was significantly stronger for bad than for good Gestalts. In fact, it seemed absent for the good Gestalt stimuli. These results suggest a differential effect of predictive processing for good vs. bad Gestalts present in a very early time window and hierarchical processing step, while both supporting and challenging expectations of predictive coding models.

Memory effects, central tendency, serial dependency or just task bias? An investigation using illumination hue discrimination

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Holding perceptual estimates of surface and illumination colour in memory induces a bias toward the mean of recently viewed colours (Olkkonen et al. 2014, Aston et al. 2017). In the task, observers see a reference illumination and, after a delay, indicate if a test is "bluer or yellower" than the reference. There are three blocks of five references, some references appearing in multiple blocks, bluer than the average in one block but yellower in another. The hue value of the point of subjective equality (PSE) for a reference that is bluer than the mean block reference is yellower than the true colour (quantified by hue value). It is suggested that this effect is caused by central tendency or serial dependency, observers averaging over multiple reference presentations to minimise the uncertainty added by the task's memory requirement. We suggest that when the reference and test become indiscriminable, observers respond with the colour term that describes the appearance of the test, biasing the PSE in the opposing direction. We show that eliminating the naming element from the task (response not tied to "bluer/yellower") reduces bias magnitude. The remaining bias may still be due to categorisation effects if colours are encoded in memory by assignment to colour categories, although it might alternatively be a compensatory effect to account for deterioration of the reference hue in memory, pulling the PSE towards the observer's prior. It remains to be determined whether semantic categorisation effects influence the bias observed in similar experimental paradigms.

Hidden layers in perceptual learning

Daphna Weinshall & Gad Cohen

The Hebrew University of Jerusalem

Performance in relatively simple perceptual tasks is known to be affected by practice. When investigating human perceptual learning, one of the most striking results has been the repeated observation that many of the acquired skills are specific to low level properties of the stimuli, and do not transfer. These and other results were used to direct and constrain computational modeling of human perceptual learning. Here we revisit these computational studies in the context of recent advances in deep learning, and specifically model the learner by a generic Convolution Neural Network (CNN) whose original architecture was inspired by the visual system. We first replicated the results of representative perceptual learning experiments by training shallow CNNs to perform the relevant tasks. These networks qualitatively showed most of the characteristic behavior observed in perceptual learning, including the hallmark phenomena of specificity and its various manifestations in the forms of transfer and learning enabling. We next analyzed the dynamics of weight modifications in the networks, identifying patterns which appeared to be instrumental for the transfer (or generalization) of learned skills from one task to another in the simulated networks. Our main contribution with respect to previous modeling work lies in the use of a generic model, which resembles the visual system in its pipeline hierarchical structure, in order to replicate most of the observed perceptual learning phenomena. Unlike previous models, for learning enabling our model does not require any top-down learning, but relies instead on the amplification of weights throughout the whole network.

Classification images for understanding lightness perception

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Lightness constancy is the ability to maintain a stable perception of surface lightness across lighting changes. Typical lightness experiments involve making perceptual matches or measuring thresholds (PSEs); here we measured classification images (Murray, 2011) to understand which image features contribute to lightness perception.

Different theories of lightness perception emphasize different image features. Adelson (1993) emphasizes X-junctions (Beck, Prazdny & Ivry, 1984) for forming lighting boundaries; Shapiro and Lu (2011)'s high-pass filter emphasize isotropic surrounds; Blakeslee and McCourt's (1999) oriented difference-of-Gaussians (ODOG) emphasize oriented filters. We expected classification images to discriminate between model predictions.

We used the argyle illusion (Adelson, 1993) as our test stimulus. In this illusion, some patches appear lighter than others though they are of the same physical luminance. We chose this illusion because it is one of the strongest known lightness illusions and has also consistently resisted explanations by low-level models. We implemented three models: the high-pass filter model, the ODOG model, and an X-junction model (after Adelson, 1993). We measured PSEs and classification images for human and model observers.

Human observers' classification images showed a role of local contrast that depended on the lighting region shape (Gilchrist et al., 1999), which all models failed to show. Even the X-junction model failed, suggesting that X-junctions may help form lighting boundaries but are not used to compute lightness.

Overall, we found that classification images complement PSEs for understanding lightness perception, and our results demonstrate the importance of understanding lighting frameworks for developing a theory of lightness perception.

Ecological valence theory and football club colour preferences

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Ecological Valence Theory (EVT) suggests that people learn their colour preferences through interactions with coloured objects/entities (Palmer & Schloss, 2010). Previous research has correlated specific colour preferences with "school spirit" (Berkeley/Stanford: Schloss et al, 2011) and political party allegience (Democrat/Republican: Schloss & Palmer, 2014), but the associations were relatively weak. Some individuals develop strong affiliations with specific football club colours at an early age, so EVT predicts that the strength of the affiliation with the football club should be related to colour preferences. We asked 61 Scottish students (30 male) to rate 43 different 3x3deg coloured patches (either single colours or two-colour combinations) on a scale from -100 (hate) to +100 (love). Participants were also asked to answer a number of questions, including which of the two main local football clubs they supported and how much they were interested in football (on a scale from 1-9). Ratings of the Greens and Oranges associated with one local club (Glasgow Celtic) were much higher than those for the Blues and Reds of their rival team, Glasgow Rangers, from Celtic supporters, and strongly correlated with interest in football. Rangers supporters showed the opposite preference pattern. The differential effects were even stronger when the club colours were presented in typical combinations, with highly significant positive correlations of 0.718 and 0.496 and negative correlations of -0.705 and -0.607 for the most well known combinations. These data provide strong support for Ecological Valence Theory in the context of colour preference.

Optimal decision making in a rapid reaching task

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Studies using visuomotor tasks (e.g., reaching, throwing, eye-movements) come to inconsistent conclusions regarding the optimality of decisions. When participants execute rapid reaching movements under uncertainty, they select optimal movement paths that accurately reflect the probability of the final target location (spatial averaging). In contrast, humans rarely employ optimal strategies when deciding whether to pursue two goals simultaneously or select one goal over another. Here, participants performed reaching movements to two potential targets presented in front of them at either side of the midline (6, 12, 48 cm) - with the final target location only being specified after movement onset. One group performed the task without strict time limits (slow condition) while a second group had to adhere to strict time limits (fast condition) selected such that an averaging strategy would inevitably cause a timeout of the trial before reaching the final target. Participants' movement paths in the slow condition reflected the two available target choices (spatial averaging) before the trajectory was corrected in-flight to the specified location. In contrast, participants in the fast condition tended to pre-select one of the two possible target locations, resulting in fast, straight trajectories that successfully reached the target location in about 50% of the trials. Overall, both groups employed different strategies that were optimal under the given task constraints. We conclude that in contrast to slower deliberate decisions, participants are able to flexibly adapt their behaviour to maximise success during rapid reaching under time pressure.

Early spatio-temporal processing shapes approximate numerical representation.

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Numerosity perception involves a complex cascade of processing stages, including an early stage representing a size-independent code of item locations, followed by a later stage representing the conceptual meaning of numerical values. While much attention has been dedicated to investigating the later processing stage at both behavioral and neural level, the functional properties of the early stage remain poorly understood. For example, it is unknown whether the early processing stage of numerosity interacts with other perceptual systems or integrates information over time to influence the conceptual representation of numerosity at

later stages. Here, by having participants judge numerosity of dynamically presented dot arrays, we demonstrate evidence that the early stage of numerosity processing receives feedback from higher-level areas and integrates signals over space and time and across different formats (simultaneous and sequential). First, participants judged a dot array in which a subset of dots randomly changed positions over time to be more numerous than a static dot array, suggesting that activity elicited by stimuli appearing in new positions is integrated over time. However, this overestimation effect was much reduced when participants judged numerosity of an array in which dots moved in smooth trajectories, suggesting that motion integration alleviates this bias. These overestimation effects did not change using physically-equiluminant stimuli, suggesting a role for feedback from color-sensitive areas, and involved an integration of both simultaneous (dots) and sequential (events) information. Overall, our results demonstrate the spatio-temporal properties of the early stage of numerosity processing, which critically shapes the higher-level numerical representation.

The McCollough effect is enhanced in anomalous trichromats: Nonlinear contrast coding and post-receptoral compensation

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The orientation-contingent color aftereffect (McCollough effect) depends on the cortical representation of color. Because of a pigment swap, protanomalous and deuteranomalous observers suffer reduced effective chromatic contrast at the photoreceptor level, and they are accordingly less sensitive to external red/green contrast. We find, however, that they show orientation-contingent color aftereffects of many times the normal magnitude. Subjects adapted to red and green pairs of mutually orthogonal isoluminant gratings of different saturations. Aftereffect strength was assessed using a nulling technique. In normal trichromats, halving the inducing saturation of the gratings reduced the aftereffect strength only slightly. This suggests a compressively nonlinear neural response to chromatic contrast. This compressively nonlinear representation of chromatic contrast can partially explain the larger than normal McCollough effect of the anomalous trichromats. In anomalous trichromats the cone contrast between red and green is greatly reduced, but the induced aftereffect is only slightly reduced, because of the contrast non-linearity; in order to null the resulting aftereffect, the color-deficiency of the retina must be overcome by adding significantly more color to the null than a normal subject would require. In the above account, anomalous observers differ from normal only by their pigment swap, and are post-receptorally normal. But the quantitative data allow us to reject this simple model as a complete explanation of their enhanced McCollough effect. Instead our evidence suggests that the neural representation of color in anomalous trichromats is post-receptorally enhanced, in partial compensation for the losses that originate from the photoreceptor pigment swap.

Are human neurometric signals consistent with sequential sampling models of speeded choice?

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In sequential sampling models, perceptual decisions are made by accumulating sensory evidence until a decision threshold is reached. Although these models are based on behavioural data, the build-up of evidence or Decision Variable (DV) may be reflected in several neural signals in man. We explored these potential neural substrates of the DV in the context of the Speed Accuracy trade-off (SAT). Participants completed perceptual decision making tasks while we tracked their neural signals using either electroencephalographic ERPs or TMS-evoked MEPs. We manipulated the strength of sensory evidence, as well as the speed/accuracy focus, and compared the resulting neurometric patterns. As predicted, the build-up of both signals was steeper in easy compared to hard trials, supporting the role of these signals as a neural substrate of the DV.

Sequential sampling models also (typically) explain the behavioural SAT through an adjustment of the decision threshold. We therefore expected an amplitude difference in the neural signals, to reflect this criterion adjustment. Neither signal displayed this difference. However, sequential sampling models are non-identifiable unless one parameter is fixed. When fixing the threshold parameter, the SAT can be explained by other changes that can collectively be characterised as a change in gain (or urgency). Our neurometric data were more consistent with such an account, and we therefore speculate that sensory evidence may indeed build in the brain as predicted by sequential sampling models, but with strategic changes implemented via an increase in neural gain that affects both signal and noise.

The role of race in perception of face lightness: Modeling the joint contributions of race and luminance for lightness perception of upright and inverted faces

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African American faces are judged to be darker than Caucasian faces even when the faces are matched for overall luminance and contrast (Levin & Benaji, 2006), and the effect holds even when faces are blurred (Firestone & Scholl, 2015), suggesting that low-level visual features drive the effect to some degree. Maximum likelihood conjoint measurement (MLCM) was used to measure the joint contribution of (1) overall mean luminance and contrast and (2) race for perceived face lightness for upright and inverted faces. Thirteen African American faces ranging in mean luminance and contrast and 13 Caucasian faces, matched to the African American faces in mean luminance and contrast, were tested (Levin & Banaji, 2006). All pairs of the 26 faces (either upright or inverted, in separate runs) were presented straddling fixation for 250 msec, followed immediately by a noise mask (with replications, 1,800 total judgments for each observer). Conjoint measurement requires that participants only choose

which member of a pair appears lighter, ameliorating concern about demand characteristics (e.g. Firestone & School, 2015). For 8 of the 9 observers, race had a significant effect on lightness judgments of upright faces ($p < 0.001$) in the direction of a fixed decrement in perceived lightness for each African American face. Furthermore, the magnitude of this effect was greater for upright than inverted faces for 7 of the 9 observers ($p < 0.05$). The greater effect of race with upright than inverted faces shows that perception of face lightness depends on race beyond just low-level features.

The window shapes of building facades strongly modulate the amplitude EEG signal in parietal and occipital lobes

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Recently the impacts of visual elements in building facades are considered by some art and architectural researchers. Physical features of building facades greatly influence the human's perception and feelings (Askari,Binti Dola,2009). One of the most important features is the geometry of windows that strongly affect human's perception. The 16 pictures of window building facades were simulated by 3d max software and the EEG signals were collected by ANT Neuro data acquisition system (32 channel electrodes) from 9 human subjects participate in the experiments (male & female, 18- 37 years old). After collecting data, a Butterworth notch filter (50 Hz), the band pass (0.1-60 Hz), and finite impulse response were employed to remove the artifacts. Grand mean ERPs were averaged across subjects and the peaks of P300 and N100 components and the amplitudes of signals were measured through the cortical lobes. The grand mean ERPs were investigated by presenting the different geometrical window shapes of building façade which the windows shapes were distinguished as pleasant and unpleasant by subjects. These results demonstrate a significant difference in the ERP signal amplitudes between right and left hemispheres for the pleasant (Mean; right hemisphere= 8.055, left hemisphere= 7.135; $p<0.001$) and the unpleasant pictures (Mean; right hemisphere= 8.955, left hemisphere=7.089; $p<0.001$, Sing Rank test). The unpleasant window shapes show a significant high amplitude than pleasant ones in parietal cortex (Mean amplitude for pleasant pictures = 7.811 and Mean amplitude for unpleasant pictures= 8.960, $p<0.05$, Rank Sum test).

The effects of predictability and higher task-control upon perception and action

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A central characteristic of human perception and action is variability. If we are repeatedly presented with the same stimulus, we may fail to perceive it occasionally. When we do perceive it, the time needed to respond to the stimulus will be different on each instance – and even if the action is very simple, we may sometimes make an error. Previous behavioural, clinical, and neurological studies have suggested that attention is an important contributor to this variability. If one's attention is lapsing, one may be more likely to have a long response time or to make an error. In the current study, we examined whether participants could improve their performance and reduce their variability when they were given control over the timing of the trials. On each trial, a stimulus would appear either on the left or the right side of the screen. Performance on a 'self-paced' condition (in which participants had to start each trial manually whenever they felt ready) was compared to three 'automatic' conditions (in which trials either appeared on a regular or irregular fixed timing). Results showed that when the stimulus had a high contrast, participants were faster but less accurate on the self-paced condition compared to the irregularly-timed automatic conditions, but not compared to the regularly-timed automatic condition. These findings suggest that people adjust their response-strategy when the timing of a trial is predictable, but that there is no extra benefit in having control over these timings.

Humans treat unreliable filled-in percepts as more real than veridical ones

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Humans often evaluate sensory signals according to their reliability for optimal decision-making. However, how do we evaluate percepts generated in the absence of direct input that are, therefore, completely unreliable? Here, we utilize the phenomenon of filling-in occurring at the physiological blind-spots to compare partially inferred with veridical percepts. In multiple experiments, subjects chose between stimuli that elicit filling-in, and perceptually equivalent ones presented outside the blind-spots, looking for a Gabor stimulus without a small orthogonal inset. In ambiguous conditions, when the stimuli were physically identical and the inset was absent in both, subjects behaved opposite to optimal, preferring the blind-spot stimulus as the better example of a collinear stimulus, even though no relevant veridical information was available. Thus, a percept that is partially inferred is paradoxically considered more reliable than a percept based on external input. In other words: Humans treat filled-in inferred percepts as more real than veridical ones.

The relative contribution of color and material to object identification

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Object properties — such as color, material or shape — all contribute to object identification. We developed a method that quantifies the relative importance of one property type (e.g. color) relative to another (e.g. material) in object identification. On each experimental trial, observers viewed three identical rendered scenes, each containing a blob-shaped object: one target and two tests. The tests were equal in shape to the target, but differed in either color (along a blue-green axis) or material (along a glossy-matte axis). Across trials, observers viewed the target with all pairwise comparisons of six color-vary and six material-vary tests and selected the test that was more similar to the target. To analyze the data, we developed a model that implements a

two-dimensional variant of the maximum-likelihood difference scaling method. The model assumes that the target and tests all lie in a two-dimensional color-material perceptual space. On each trial, the observer chooses the test whose representation, which is on each trial perturbed by perceptual noise, is closest to the target representation. A model parameter determines the relative weight given to the two underlying perceptual dimensions. For each observer, the model recovers the color-material weight —which reflects the importance color information plays in identification relative to material— as well as the underlying positions of the color-vary and material-vary tests in the perceptual space (in units of the perceptual noise on each dimension). Our results provide first quantification of color-material weighting in object identification and reveal large individual differences in weights across observers.

Potential downside of high initial visual acuity

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Studies of children who were treated for congenital cataracts have yielded an intriguing finding: when tested on face-individuation several years after treatment, they exhibit impairments in configural processing relative to children with normal visual development. One difference between these groups is that newborns go through a period of low visual acuity, while subjects with late sight-onset experience high visual acuity immediately after cataract removal. While this has been explained in terms of a face-specific critical period, we propose a more parsimonious account according to which deficits in configural-processing result from abnormally high initial acuity (HIA). By this account, the initial period of low acuity characteristic of newborns' visual development facilitates configural processing by inducing larger areas of spatial integration. To test this, we conducted computational simulations to probe how early training with either low- or high-resolution information may impact the performance and receptive fields in a convolutional neural network. We found that training with low-resolution images creates receptive fields that integrate information across larger image areas than high-resolution training, and leads to better generalization across a range of resolutions. Our findings support the counter-intuitive idea that training a visual system on optimal (high-resolution) input may actually be detrimental to the development of face individuation, because it does not force the visual system to integrate information over large receptive fields, a prerequisite for configural processing. Our findings suggest an adaptive function for the acuity trajectory in normal development, and provide a scheme for improving the performance of computational face recognition systems.

Impact of ADHD treatment on retinal background noise: A neuronal correlate

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Impulsivity and inattention are well-known among the key symptoms of the still poorly understodd attention-deficit/hyperactivity disorder (ADHD). Meanwhile, there is growing evidence for an elevated background noise, or non-stimulus driven neural activity, as neurobiological correlate in ADHD. In electrophysiological signals the retina we found an elevated level of background noise at a very early stage in the visual system in untreated patients with ADHD. We hypothesized that this neuropathology may reflect an essential neurobiological correlate in ADHD. In order to test this hypothesis further, we performed a new study and compared the background noise in patients with ADHD both before and after therapy. Method: 20 patients with the diagnosis of ADHD were tested both before and after treatment with methylphenidate (MPH). The control group consisted of 21 healthy subjects. In both groups, the retinal background noise was assessed using the pattern electroretinogram (PERG). The PERGs were recorded in a steady state mode in response to checkerboard stimuli of 12 reversals/s. ADHD severity was assessed by interview and questionnaire. Results: Patients with ADHD before treatment again presented with elevated background noise (higher by 127%) compared to the control group. After treatment, the elevated noise normalized in the patients and it did not differ from that of the control group. Retinal background noise correlated highly with the severity of the ADHD symptoms. Conclusion: The data provide further evidence to the hypothesis that elevated background noise is linked to ADHD and narrow down the neuronal correlate for ADHD.

Sensitivity and aesthetic preference in dynamic naturalistic stimuli varying in their spatiotemporal amplitude spectra

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We have previously shown that humans display a consistent preference across various static images with fractal-like statistics and that observers' preference is related to their sensitivity for such patterns. However, this relationship has been studied almost exclusively in the spatial domain and little is known about sensitivity and aesthetic preference for these statistical properties in the temporal domain. It is unknown whether sensitivity and aesthetic preference would be highest in response to a natural distribution of temporal frequencies and whether they closely match across a range of slopes. To address this, we measure sensitivity and preference with dynamic synthetic noise patterns across a wide range of spatial (-2.25, -1.25, -0.25,) and temporal slopes (-2.25, -1.75, -1.25, -0.75 and -0.25). In both tasks, there was a significant effect of temporal slope variations such that observers were less sensitive to and also preferred less the dynamic synthetic noise patterns with steep spatiotemporal slopes. Furthermore we find strong correlation between sensitivity for the dynamic spatiotemporal patterns and the visual preference in individual observers. Like with the static patterns with fractal-like scaling properties, these findings

suggest a strong relationship between visual sensitivity and preference for simple visual patterns, supporting assertions that there is a close relationship between aesthetic experience and the sensory coding of natural stimuli.

Eyes and fingers are already on the goal: Grasp-specific anticipatory remapping of peripersonal space

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Our minds constantly plan the next step leading to our current goal. In object manipulation the very first segment is always the grasping of the object of interest. In this case the eyes are mostly anchored at the future index finger location, triggering an anticipatory remapping of the peripersonal space around the hand. We conducted a cross-modal congruency experiment to determine whether this remapping is grasp-specific and starts even before the hand moves toward the object. In a dual-task paradigm, participants were asked to perform a grasp-and-place task, while reporting which fingertip (thumb or index) received a vibro-tactile stimulation. This was administered at different times (before, at, after motion onset) concurrently with a visual distractor on either side (left or right) of the object to be grasped. The target was a bottle presented upright or upside down so to induce a thumb-up or thumb-down grasp, hence inverting the congruency between the side of the distractor and the final position of the fingers. Response times show a strong congruency effect when side of the distractor and landing position of the stimulated finger overlap. Eye-tracking measures show how the eyes inform and support the sensory-motor control of the hand, while also integrating bottom-up visual capture, driving the gaze to the distractor, and top-down haptic capture, shifting to the side of the stimulated finger. These results show that visuotactile interactions in peripersonal space play a fundamental role in motor planning and control, acting as an anticipative sensory-motor interface for successful object interaction.

Crowding and binding: Not all feature-dimensions behave equally

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Background. Crowding refers to the failure to identify a peripheral item in clutter. The nature of crowding and the stage at which it occurs are still debated. We use a novel quantitative approach to characterize crowding errors across different feature dimensions and their interdependency.

Methods. Observers estimated the orientation and color of a "T" (Exp.1) or the orientation and spatial frequency (SF) of a Gabor (Exp.2) via two reports. In the crowding conditions, two distractors flanked the target (7° eccentricity), each with unique features. We compared two probabilistic models – standard mixture and swap mixture– to characterize the error distributions for each feature-dimensions independently and with respect to the other dimension.

Results. The swap model characterized color and orientation error distributions better than the standard model, indicating switch between target and distractor. However, the standard model better characterized SF errors, indicating averaging across target and distractors. Whereas color and orientation swapped independently from each other, SF and orientation errors were interdependent; the probability to swap orientation with a given distractor was independent of the direction of the color error, but higher when SF error was toward that distractor. A population coding model fitting supported these results.

Conclusion. Crowding operates differently across feature-dimensions. It confuses between the colors and orientations of target and distractor but averages across their SFs. Crowding unbound color and orientation, but not SF and orientation, suggesting that crowding occurs before color and orientation are bound together but after SF and orientation are jointly represented.

Which image characteristics yield striking individual differences in perceived colour?

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#thedress provided an unprecedented case of striking individual differences in colour perception: some observers see it white-gold while others see it blue-black. Here, we investigated which properties of a photo are responsible for the individual differences. We manipulated the hue and the shape of the colour distribution of #thedress, and we examined other images with similar hues as #thedress. We tested whether individual variation in colour perception of those stimuli were correlated with those for the original #thedress and with assumptions about the illumination of scene in the images. Results showed that images with other objects, but similar hues as #thedress, yielded strong individual differences that were highly correlated with those for #thedress. This was the case even when compressing the variation of hue in the colour distribution and when objects were shown on a plain white background. Individual differences and the link to assumptions about the illumination decreased with increasing hue rotation of the colour distribution of #the dress. The detrimental effect of hue rotations on individual differences was stronger when only the hues of the dress, but not of the background were rotated. However, the individual differences were still correlated with #thedress for rotations of 90 degrees in the red and in the green hue direction. These findings suggest that the individual differences depend on the alignment between object and illumination hue and are maximal when object colours can be confused with shadows. We use these insights to create objects that have similar properties as the dress.

How early can we predict the outcome of a throwing action?

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Intercepting or avoiding a moving object, whether it be to catch a ball, snatch one's prey, or avoid the path of a predator, is a skill that has been acquired by almost every species throughout evolution. This requires processing early visual cues in order to program anticipatory motor responses tuned to the forthcoming event. Here, we consider the role of early predictions in intercepting fast balls. We explored (i) how early it is possible to predict the direction of the ball's trajectory based on the throwing kinematics, and (ii) which body segments provide the most informative cues for successful predictions. Whole-body kinematics was recorded for 20 non-expert subjects throwing at four different targets. The data-set shows large variability in individual throwing styles. Using a combination of dimensionality reduction and classification techniques, we found that for most subjects it is possible to predict the region where the ball will land, with an accuracy above 80%, as early as 300ms before ball release. Interestingly, the body parts that provide the most informative cues vary with throwing style and across the action time-course. Not surprisingly, at the very end of the action, the throwing arm is the most informative body segment. However, predictions earlier than 200ms before release are typically better informed by other body segments (legs and trunk), with a strong dependence on the throwing style. Future analysis will explore the correlation between throwing styles and the spatiotemporal structure of outcome predictability in terms of whole-body kinematics.

Size constancy affects the perception and parietal neural representation of object size

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Humans and animals rely on accurate object size perception to guide behavior. Object size is judged from visual input, but the relationship between an object's retinal size and its real-world size varies with distance. Humans underestimate changes in an object's retinal size. This size constancy is thought to bias perception towards likely real world size, compensating for the variable relationship between retinal size and real world size using the context of recently seen sizes. We therefore hypothesized that perceived object size may be attracting towards recently viewed sizes. We demonstrate two systematic effects: a central tendency attracting perceived size towards the average size across all trials, and a serial dependence attracting perceived size towards the size presented on the previous trial. Early visual cortex's spatial representation is closely linked to retinal input, so is unlikely to change with object size context. However, we recently described topographic object size maps in human parietal cortex (Harvey et al., PNAS, 2015). We therefore hypothesized that neural representations of object size here would be attracted towards recently-viewed sizes. Using 7T fMRI and population receptive field modelling, we compare object size representations measured with small (0.05-1.4°diameter) and larger objects sizes (0.1-2.8°). Parietal object size preferences and tuning widths follow this presented range, but change less than presented object sizes. Therefore, perception and neural representation of object size are attracted towards recently viewed sizes. This context-dependence reveals effects on neural response preferences that may underlie serial dependence.

#thedress reveals general "chromotypes" in colour constancy

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Do different observers see colours differently? In the case of #thedress the answer is yes: some see it white-gold, others blue-black. To investigate whether these striking individual differences are a general feature of human colour vision, we compared individual differences in two colour constancy tasks to #thedress. To measure the perceived colours of #thedress, observers adjusted the colour of a disk to match the colour they saw on the body and the lace of the dress, respectively. In the first colour constancy task, a scene was shown under a yellowish and a bluish daylight illumination, and observers adjusted the colour of a patch in one of the scenes to match the respective patch in the other scene (asymmetric matching). This was done with 15 different surface colours. The asymmetric matches were correlated to the perceived dress colours. Correlations were highest for blue, grey and yellow surface colours that were close to the daylight locus. In a second colour constancy task, we embedded a colorimetrically grey test patch in a scene that was rendered under illuminations in 40 hue directions. For each illumination, we measured the perceived colour of the test patch through colour naming. #thedress was correlated with the strong individual variation of the blue-purple boundary. This boundary corresponds to the purple blue colours that are induced under yellow illumination. These findings suggest that #thedress exposes general "chromotypes", ie. types of observers that differ in the way they perceive surface colours under changing illuminations, in particular along the daylight locus.

Looking, moving, touching: The role of exploration in multimodal perception

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When faced with a novel object, we explore it to understand its shape. This way we combine information coming from different senses, as touch, proprioception and vision, together with the motor information embedded in our motor execution plan. The exploration process provides a structure and constrains this rich flow of inputs, supporting the formation of a unified percept. However, how the exploration strategies are planned is still an open question. We investigate how the availability of different sensory inputs, the possibility to move the object and the complexity of the spatial representation required affect the exploration procedures. To this aim, we use iCube, a sensorized cube which measures its orientation in space and the location of the contacts on its faces. Participants were required to explore the cube faces where little pins were positioned in varying number. In different conditions subjects could either only touch the static cube, move and touch it or move, touch and look at it. The spatial complexity of the task was manipulated: i) by requiring subjects to find the face containing a specific number of pins, ii) by asking to compare different faces or iii) by asking to count the total number of pins. The results show that the exploratory strategy changes significantly as a function

of the sensorimotor modalities available and of task requirements. These findings are discussed in light of the possibility of a systematic modeling of natural visuo-haptic exploration strategies, to enable early detection of anomalies in explorative behaviors during development.

Filling-in and contour interpolation in Kanizsa configurations

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To explore the mechanisms of object integration in the human visual system, this study investigated how the completion of illusory contours and surfaces in Kanizsa figures modulates the sensitivity of detecting a target probe. In three experiments, observers determined whether a briefly presented dot probe was located inside or outside of a region as demarcated by pacmen that induce an illusory Kanizsa figure. Performance in this dot-localization task was then used to determine psychometric functions, with their slope characterizing the detection sensitivity. Experiment 1 showed that sensitivity is systematically modulated by the amount of surface and contour completions present in a given configuration, with surfaces depicting a higher sensitivity than contours. This gradual variation in sensitivity indicates that both surface and contour processing contributes to Kanizsa shape completion. Moreover, Experiment 2 indicated that performance was in general reduced for stimuli that encompass object occlusion, with a sensitivity modulation occurring specifically for surface (but not contour) variations. Experiment 3 was then performed to rule out an account where the performance modulation simply results from variable distances between the target and the pacmen. Collectively, these data provide evidence for a dissociation between surface and contour processing, supporting a multistage model of object integration, where completion is instantiated by feedforward and feedback processing loops to render surface filling-in and contour interpolation.

Unique hues are not mediated by two perceptually opponent mechanisms

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Colour vision starts in the retina where light is absorbed in three different cone classes, sensitive to long-, medium-, and short-wavelength light. The cone signals then feed into three post-receptoral channels, a luminance channel and two cone-opponent chromatic -channels. Behavioural experiments have shown that these two cone-opponent chromatic channels do not correspond to perceptually salient colour mechanisms (unique red, green, yellow, blue).

The putative red-green mechanism, which is at equilibrium for unique yellow and blue, is approximately linear in cone space. On the other hand, the putative yellow-blue mechanism, which is at equilibrium for unique red and unique green, is known to be non-linear.

If unique yellow and unique blue are indeed generated by a single red-green mechanism, then one would predict that the individual differences in the unique yellow and unique blue settings are correlated; similarly for unique red and green. We tested this hypothesis by analysing the unique hue settings at different saturation and lightness levels for a large sample of observers (n=185). Our results show that the individual hue angles for unique red and unique green are not correlated; the same lack of correlation was observed for unique yellow and unique blue. We have confirmed the robustness of this result by analysing the data in different colour spaces (cone space, u'v').

Our results are inconsistent with the hypothesis that the unique hues are generated by two perceptually opponent mechanisms; at least four mechanisms must underlie the perception of unique hues.

Who's up for some heavy lifting? How three-dimensional shape and material properties determine precision grip grasp locations

Lina Katharina Klein, Guido Maiello, Vivian C. Paulun & Roland W. Fleming

Justus-Liebig University Giessen

Successfully handling objects requires selecting appropriate grasp locations. Of the many possible grasp points, only a small subset yield stable, comfortable grasps. To identify these, humans must take object shape, material properties, and the desired action into account. As previous experiments have generally investigated simple geometries, the computations underlying visually guided grasp point selection for three-dimensional objects of non-uniform materials remain unclear. We tested how an object's visually perceived three-dimensional shape and material properties (mass distribution and surface friction) affect grasp locations. We created objects composed of 10 cubes (side length 2.5 cm) in various configurations. Individual cubes were made of either wood or brass. Objects were composed either entirely of wooden or brass cubes, or of 5 cubes of each material. By reordering the locations of wood and brass cubes we shifted the location of each shape's center of mass (COM). Human participants were asked to pick up each object with only index finger and thumb and place it nearby on an elevated plate. Movement trajectories and grip point locations were recorded with an Optotrak system. We find that grasp locations are affected by object orientation, the location of the object's COM, partial object occlusions by the subject's hand, and shape properties such as the presence of obvious handles. Durations of movement planning and execution also varied across objects. We used these findings as fundamental constraints for a generalized contact point selection model for three-dimensional objects. The correspondence between the model's predictions and human grasp locations is striking.

Contour integration in multiple feature dimensions explained in a recurrent network model

Axel Grzymisch[1], Alina Schiffer[1], Günter Meinhardt[2], Malte Persike[2] & Udo Ernst[1]

[1]Universität Bremen; [2]Johannes-Gutenberg-Universität Mainz

Contour integration is a basic process in feature integration to extract the shape of objects from visual scenes. Its study usually focuses on orientation alignment as the primary means for contour definition. However, recent experimental work has shown that other features such as spatial frequency (SF) strongly interact with contour integration, having dramatic effects on contour visibility. Here we identify putative neural mechanisms that provide a unifying account for contour integration in multiple feature dimensions.

Specifically, we constructed a structurally simplistic cortical model including SF as a second cue for contour integration. We applied the model to stimuli consisting of oriented Gabor patches with different orientations and spatial frequencies, into which contours of aligned and/or SF-homogeneous patches were embedded. Feature integration in the model is performed by recurrent interactions between populations with receptive fields (RFs) selectively tuned to orientation and SF of localized stimulus patches. Our key assumption is that interaction strengths exponentially decrease with increasing SF difference. Excitatory connections realize an association field with strong links between collinear and co-circularly aligned RFs. Inhibitory interactions provide medium-range normalization and are independent of orientation preference.

By quantitatively reproducing the results of multiple experimental studies we are able to provide an explanation of the psychophysics and dynamics of contour integration in different stimulation paradigms. Our model suggests a novel mechanism involved in feature integration, namely spatial-frequency dependent interactions, which accounts for previously unexplained findings, helping to create a more comprehensive understanding of computation in the visual system.

The colours of natural scenes are perceived as beautiful

Sérgio M. C. Nascimento[1], Anke Marit Albers[2] & Karl R. Gegenfurtner[2]

[1]University of Minho; [2]Justus-Liebig-Universität Giessen

Several spatial and chromatic properties of paintings mimic natural scene statistics but it is unclear how the perception of naturalness and beauty are related. To address this question in the colour domain, we carried out an experiment where observers judged naturalness and beauty for images of natural scenes. To vary the degree of naturalness and beauty, the colour gamut of the images was rotated in CIELAB from -100º to +100º. Participants performed pairwise comparisons on images of the same scene but with different gamut angles. Using maximum likelihood difference scaling we derived aesthetic preference and naturalness curves as a function of the angle of gamut rotation. The scenes were presented either in their original form or were spatially manipulated using a modified version of the 'eidolon factory' (Koenderink et al, 2017, Journal of Vision, 17(1):22, 1–35) to look like abstract paintings deprived of semantic content, but preserving the original colour statistics. Four observers were tested with four natural scenes. Naturalness and preference curves for the same scene had a considerable degree of similarity. For all conditions the maxima were close (on average within 20º) to the original image. The degree of overlap of the curves for each scene was, on average, 79% for the original images and 73% for the altered images. For scenes with vegetation the similarities were stronger than for scenes of urban images with artificial elements. These results suggest that aesthetic preference is related to how natural the colours are perceived.

Monday August 28th Symposia presentations

Uncertainty-dependent History Bias through Accumulation of Internal Decision Variables

Tobias H. Donner

University Medical Center Hamburg-Eppendorf

Perceptual decision-making under uncertainty is biased by previous events, including preceding choices. I will present recent work from my lab indicating that such sequential biases result from the across-trial accumulation of action-independent, internal decision variables. In several experiments, human observers performed visual motion discrimination tasks around psychophysical threshold. When perceptual choices and motor responses were decoupled on a trial-by-trial basis, the impact of previous choices on sequential bias largely outweighed the impact of previous motor responses. When observers performed the task in 'biased environments' (containing predominantly stimulus repetitions or alternations, respectively) and in the absence of external feedback about choice outcome, observers adapted their sequential biases to the environmental statistics. This adaptation indicated active memory for previous choices and was beneficial for performance. These observations indicate that sequential choice biases result from the accumulation of the internal decision variables that drive within-trial choices. Neural representations of decision variables do not only encode categorical choices, but also the uncertainty associated with them. In line with this, we found that both observers' intrinsic sequential biases (in the face of random stimulus sequences), as well as their adaptation to biased environmental statistics, were reduced by decision uncertainty. Finally, we determined how sequential choice biases shape decision dynamics, by fitting the drift-diffusion model to a variety of data sets. Previous choice consistently biased the (within-trial) accumulation of sensory evidence, rather than the starting point of that accumulation. Taken together, our results constrain the candidate neural sources of sequential choice biases in perceptual decision-making.

Serial dependence in perceptual decision-making

Floris De Lange

Radboud University

Sensory signals are highly structured in both space and time. These regularities allow expectations about future stimulation to be formed, thereby facilitating decisions about upcoming visual features and objects. One such regularity is that the world is generally stable over short time scales. Temporal context could be exploited by the brain in two opposite ways. On the one hand, biasing of current stimuli towards the past could be beneficial in terms of promoting visual stability (Fischer & Whitney 2014). On the other hand, repulsion of

current stimuli away from the past can boost sensitivity of the visual system to changes in the physical environment (Muller et al 1999). In my talk I will discuss recent psychophysical data from my lab that both processes occur: while perception is repelled away from the past, post-perceptual decision processes are attracted towards the past (Fritsche, Mostert & de Lange 2017). These opposite biases on perceptual and post-perceptual processes may imbue the nervous system with an optimal balance between sensitivity and stability that is required to operate successfully in the environment. Moreover, I will discuss how temporal context may change sensory computations in the primary visual cortex via feedback processes (St John Saaltink et al 2016).

Asymmetric adaptability of choice history biases in human perceptual decisions

Justin Gardner

Stanford University

Humans are known to be biased by the history of their previous choices even when this behavior is disadvantageous. This suggests an inability to adapt choice history strategies appropriately. We therefore asked whether changing trial order statistics to strongly favor different choice history biases would cause humans to change their choice history behavior. First, we used a standard two-alternative visual detection task and replicated previous observations that humans tended to switch choices after a failure and repeat choices after successes, even though this leads to demonstrably poorer psychophysical performance. These choice history biases were apparent in observers tested in three different countries. We next arranged trial order statistics to promote different choice history biases. We found that adaptability was strong when trial statistics promoted choice history biases that confirmed subject's default biases, but weak when they contradicted those default biases. We conclude that humans can adapt choice history biases but that this adaptability is asymmetric. Our results suggest a form of confirmation bias in which existing choice history biases are easier to reinforce than to change.

Rats Show Flexible History-dependent Choice Biases in a 2AFC Auditory Task.

Jaime De La Rocha

IDIBAPS

Animal decisions not only reflect current sensory information but are also influenced by recent experience. To understand the mechanisms of this influence we used rats in a novel two-alternative forced choice (2AFC) auditory discrimination task, in which the probability to repeat the previous stimulus category was varied in blocks of trials. Rats capitalized on the serial correlations of the stimulus sequence by showing a bias towards repeating the same response built up after correct repetitions, and towards alternating after correct alternations. A GLM analysis revealed that rats decisions relied the current sensory stimulus and at least on three different history terms: (1) a negative term biasing choices away from the acoustic content of up to the ten previous stimuli; (2) a lateral bias towards (away from) the side of recently rewarded (unrewarded) responses, i.e. win-stay-lose-switch strategy; (3) a novel and strong transition bias that reinforces recent correct transitions (repetitions vs. alternations). Intriguingly and in contrast to the lateral bias, the transition bias had no impact on choice after error trials. The value of the bias was not reset but simply ignored after an error, and it was recovered after the first subsequent correct trial. Thus, the weight of the history-dependent transition bias could be flexibly and transiently put aside after error choices when possibly the reliability of the internal model was questioned. Overall, we show that history-dependent biases in rodent decisions reflect a variety of processes going from outcome independent low level sensory repulsion to flexible high level expectation biases.

Can Serial Dependencies in Choices and Neural Activity Explain Choice Probabilities?

Hendrikje Nienborg

University of Tübingen

During perceptual decisions the activity of sensory neurons co-varies with choice, a co-variation often quantified as "choice-probability". Moreover, choices are influenced by a subject's previous choice (serial dependence) and neuronal activity often shows temporal correlations on long (seconds) timescales. Here, we test whether these findings are linked. Using generalized linear models we analyze simultaneous measurements of behavior and V2 neural activity in macaques performing a visual discrimination task. Both decisions and spiking activity show substantial temporal correlations and cross-correlations but reflect two mostly separate processes: Removing history effects using semi-partial correlation analysis leaves choice probabilities largely unchanged. The serial dependencies in choices and neural activity therefore cannot explain the observed choice probability. Rather, serial dependencies in choices and spiking activity reflect two predominantly parallel processes, which are correlated by instantaneous co-variations between choices and activity. These findings provide important constraints for computational models of perceptual decision-making that include feedback signals.

Cleverer than you think: Understanding Human Idiosyncrasies as Statistically Optimal Learning and Decision-Making

Angela Yu

University of California

Across a variety of behavioral settings, humans have been noted to act irrationally or sub-optimally. Using a combination of theoretical and experimental tools, we have found that such behavior may sometimes reflect statistically optimal learning and decision-making, whereby the human subjects are continually tracking statistical regularities in the environment based on data, and altering their decision policies in response to evolving beliefs. In this talk, I will describe how this theoretical framework can explain experimental results in perception, active sensing, cognitive control, and reward learning.

Psychophysical bases of anomalous perceptual experiences

Szabolcs Kéri

Budapest University of Technology and Economics

Anomalous perceptual experiences, including blurred vision, partial seeing, visual hypersensitivity, and dysmorphopsia, are often present in patients with schizophrenia and non-clinical individuals with high schizotypal traits. However, the psychophysical correlates of these anomalous visual experiences are not clear. In the present study, we administered a battery of psychophysical tests to a large group of patients with chronic schizophrenia receiving antipsychotic medications (n = 105), individuals with an ultra high-risk for psychosis (n = 35), and non-clinical volunteers (n = 280). Tasks included lateral masking and achromatic luminance contrast sensitivity (steady- and pulsed-pedestal at low and high spatial frequencies). Anomalous perceptual experiences were evaluated with the Bonn Scale for the Assessment of Basic Symptoms. Results revealed that patients with schizophrenia exhibited a reduced facilitation of contrast detection by lateral masks (flankers) and a globally decreased contrast sensitivity relative to non-clinical individuals. In high-risk individuals, lateral facilitation was also reduced, but these individuals were characterized by an increased steady-pedestal/low spatial frequency contrast sensitivity (a putative magnocellular function). Reduced lateral facilitation was associated with a higher prevalence of anomalous perceptual experiences in all three groups, with a particular reference to dysmorphopsia. In the high-risk group, heightened contrast sensitivity was linked to visual irritation and intrusive perception. In the non-clinical sample, individuals with anomalous perceptual experiences and reduced lateral facilitation were characterized by higher schizotypal traits. These results indicate that reduced lateral facilitation in early visual areas might be the strongest correlate of schizophrenia-related anomalous visual experiences.

Sense of time continuity: patients with schizophrenia show the way

Anne Giersch, Nicolas Franck, Brice Martin & Laurence Lalanne

University Hospital of Strasbourg

At a clinical level patients with schizophrenia display a fragmented thought flow that reflects also in perception, leading us to question the mechanisms of the sense of time continuity. Experimentally, patients are impaired in explicitly discriminating stimuli in time and in judging order at the subsecond level. Despite these impairments, we showed that patients do distinguish events in time at an automatic level, even when unaware of any asynchrony. We will present new results suggesting that patients have difficulties at predicting/following sequences of visual events. To that aim we explored sequential effects during a simultaneity/asynchrony discrimination task. Two stimuli are displayed on each trial with a stimulus onset asynchrony (SOA) varying from 0 to 137 ms. Subjects decide whether the stimuli are simultaneous or asynchronous and press one among two response-keys accordingly. The results show that when two consecutive trials share the same SOA, healthy controls benefit from a direction change between trials, with more responses 'asynchronous'. These results are interpreted as evidence for predicting mechanisms allowing us to smoothly follow visual events over time. Patients do not benefit from a direction change when the SOA remains identical across trials, despite being sensitive to small changes in SOAs. The results in patients are correlated with a scale designed to explore the minimal self, i.e. the feeling of being one and continuous self. We will discuss to which amount these results reveal mechanisms by which we are tuned to the external world, and experience it as a continuous, stable environment.

Sensitivity and Specificity of Eye Movement Abnormalities in Major Adult Psychiatric Disorders

Philip J Benson[1], Sara A Beedie[2], Dan Rujescu[3], Eva Nouzová[2], Joji Kuriakose[4], Nick Walker[5], Lucia Suhanyiova[1], Allen Shand[4], Mugdha Kulkarni[4], Elizabeth Shephard[1], Ina Giegling[3], Suresh Bheemaraddi[4], David St Clair[2], Arndis Simonsen[6], Ole Mors[6], Hailong Lyu[7] & Jingping Zhao[7]

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The heterogeneity of clinical symptoms and cognitive dysfunction in schizophrenia poses difficulties for the design of a behavioural trait marker for the illness. Patients' oculomotor performance in laboratory tests is generally degraded relative to neurodevelopmentally normal assays. However, elicited eye movement abnormalities are task-dependent, not all patients perform badly on a given task, not all controls perform well, and distributions of performance measures are rarely Gaussian. A 40 minute test battery involving smooth pursuit, saccadic, steady fixation and picture viewing tasks, engaging cortical and subcortical processes, was used in an attempt to detect as many patients as possible. A machine learning classifer delineated schizophrenia cases from controls with better than 95% sensitivity. Using the same protocol this result was replicated in Faroese and Chinese samples by independent researchers. Patients diagnosed with bipolar and unipolar depression also undertook the eye tracking tasks, and various classifiers built to examine the specificity of the eye movement phenotype in each illness. Although a statistical description of each phenotype subtly differs according to the groups against which it is compared, average specificity was also around 95%. Use of eye tracking tasks to both challenge and objectively validate current diagnostic labels will be discussed. Funding: Royal Society of London, Chief Scientist Office (CZB/4/734), Tenovus Scotland (G12/31), Millar-MacKenzie Trust, FP6 (SGENE), Funds for Women Graduates, Lundbeck Foundation (R102-A9118, R155-2014-1724), Ministry of Health of the People's Republic of China (National R&D Special Fund for Health Profession, No. 201002003)

Neural oscillations in visual cortices in schizophrenia indicated a disturbance in excitation/inhibition parameters

Peter Uhlhass

Background: A considerable body of work over the last 10 years combining noninvasive electrophysiology in patient populations with preclinical research has contributed to the conceptualization of schizophrenia (ScZ) as a disorder associated with aberrant neural dynamics and disturbances in excitation/inhibition (E/I) balance. In the presentation, I will provide an update on this hypothesis through a summary of data that we have obtained with Magnetoencephalography (MEG) and Magnetic Resonances Spectroscopy (MRS) of GABA-and Glutamate levels across different illness-stages.

Predictive coding and psychosis

Katharina Schmack, Heiner Stuke & Philipp Sterzer

Charité Universitätsmedizin Berlin

How we perceive the world determines what we learn, and what we learn shapes how we will perceive the world. This reciprocal interaction between inference and learning can be elegantly described within the framework of predictive coding. Predictive coding states that learned predictions are combined with incoming signals into an inference about the current state of the world, and, that the mismatch between predictions and incoming signals constitutes a prediction error that drives the learning of predictions for future inferences. In our work, we investigate the idea that psychotic symptoms can be viewed as maladaptive perceptual inferences that result from alteration of the predictive mechanisms of the brain. Two cohorts of healthy individuals with varying degrees of psychosis-proneness and of patients with schizophrenia performed several perceptual tasks that tap into the predictive mechanisms of the brain. We found that psychosis-proneness was associated with a decreased influence of low-level predictions but an increased impact of high-level predictions during perceptual inference. Furthermore, a novel reinforcement learning model revealed that altered inference in psychosis-proneness was related to excessive learning from irrelevant prediction errors. Taken together, we suggest that dysfunctional learning might result in maladaptive perceptual inferences that lie at the core of psychosis.

The impact of Yarbus' work on Active Vision

Benjamin W. Tatler

University of Aberdeen

In the final chapter of his book, Yarbus presented a wealth of eye tracking data, describing how people view images of complex scenes and faces. The observations in this chapter illustrate the active nature of sampling by the eye and previewed many of the debates and research themes that have underpinned subsequent eye movement research. A key question raised by the active sampling illustrated by Yarbus is the extent to which high-level information is processed in the peripheral retina and used to select the next target for fixation. Successful selection of information that is important for the current task raises the possibility of simultaneous processing of multiple peripheral targets to sufficient levels to extract semantic properties and discern their task relevance. In this talk I will review evidence for peripheral processing of semantic information in scene viewing and how this work relates to Yarbus' original observations of cognitive influences on inspection behavior. Evidence will be discussed from studies of natural behavior and from static scene viewing paradigms, including how inconsistencies in the locations at which objects are placed, or in whether they should be found in a particular scene context, influence visual search. I will also discuss the relative contributions of low- and high-level factors to eye guidance during scene viewing and how these contributions may change over time. These themes echo the elegant illustrations and insightful comments that Yarbus drew attention to 50 years ago.

Eye movements and peripheral vision before Yarbus

Nicholas J. Wade

University of Dundee

The translation of Alfred Yarbus's Eye Movements and Vision by Basil Haigh 50 years ago marked a new phase in eye movement research. Yarbus introduced greater precision in recording how the eyes moved, either when attempts were made to keep them stationary or when scanning pictures. In relating eye movements and peripheral vision he was returning to two topics with long and interrelated histories. The superiority of central vision for spatial resolution was known to the ancients and movements of the eyes to different features of the visual world were later remarked upon. Some experimental studies were undertaken, initially by Ptolemy and later by Ibn al-Haytham (Alhazen); both constructed boards on which peripheral targets could be placed and Ibn al-Haytham examined reading with increasingly eccentric words. Surprisingly little equipment is required to determine how the eyes move and a surprisingly long time was taken to appreciate this, largely because subjective feelings of ocular movements were taken as the index. Afterimages are the key and they have been known about for millennia. Comparison of the relative movement between afterimages and real images provide evidence of image instability during fixation and of discontinuous eye movements as Wells demonstrated in 1792. Yarbus touched briefly on this history and his research provided detailed support for the older findings. Purkinje added elements of refinement to the measurement of peripheral resolution and colour perception with his perimeter.

Is there a single functional channel at the edge of the retina?

John D. Mollon

University of Cambridge

The array of photoreceptors in the fovea is sampled by at least 25 different types of ganglion cell, and the traditional challenge for the psychophysicist is to choose a stimulus, and a regime of adaptation, that isolate a single neural channel. The region of the retina near the ora serrata – a region that

corresponds to vision at 90 degrees from the line of sight – offers a tempting study to the psychophysicist, since it can be argued that here there is only a single neural channel, or at least, a small number of channels of a similar type. Polyak observes that near the ora serrata the multiple layers of ganglion cells seen in the fovea are reduced to one. Moreover, ganglion cells occur in small clumps with large spaces between them. What do we know of the corresponding functional channel? Psychophysically, there appear to be four sub-types of motion-sensitive detector, mapping approximately on to the four cardinal directions (To, Regan, Wood and Mollon, 2011, Vision Research, 51, 203). These detectors have their peak sensitivity at a very low spatial frequency and they appear to be insensitive to stationary stimuli. A plausible hypothesis would be that they correspond to four types of ON-OFF directionally-selective ganglion cell: such cells are widely found in the mammalian retina and the four subtypes, corresponding to different cardinal directions, are thought to be genetically pre-specified (for a short review see Morrie and Feller, 2016, Current Opinion in Neurobiology, 40, 45).

Theoretical analysis and practical implications of human photoreceptor densities to the far periphery

Christopher W. Tyler

City University of London/ Smith-Kettlewell Eye Research Institute San Francisco

In designing next-generation visual displays and in the management of visual deficits, it is important to have a good understanding of the full capabilities of human visual processing. There is a widespread misconception, even among vision scientists, that the peak cone density in the fovea implies that cone function and color vision is largely restricted to the fovea, and conversely that the high density of peripheral rods implies that they mediate peripheral motion processing and that the periphery a lacks color vision. None of these statements is correct, and a proper understanding of retinal function requires a full specification of photoreceptor density distributions, which I provide in the form of analytic equations incorporating the principles of an inverse cube law of cone resolution, cone density compensation for the effective reduction in retinal luminance with eccentricity, and the secondary occupation of remaining retinal space by rods. The consequences of these principles of photoreceptor population growth dynamics are an appreciable cone density out to the far periphery with undiminished color sensitivity, peripheral temporal resolution up to 100 Hz at high luminance, and photopic motion sensitivity of up to10,000 deg/s. These factors imply a spatiotemporal bandwidth for human vision of about a terabyte/s for full virtual reality and a high sensitivity to brief changes throughout the retina for guiding eye movements to peripheral targets.

Far peripheral vision and pattern recognition

Hans Strasburger

Ludwig-Maximilians-Universität München/Georg-August-Universität Göttingen

Peripheral vision has been studied quantitatively for over a century yet relatively little is known about the far periphery. Ironically, many current textbooks give values of the lateral extent that are too small, below 90°, even though correct values of around 110° (due to refraction of the lateral rays) were reported by Hueck in 1840. Eccentricity dependencies for visual performance measures like MAR, letter contrast sensitivity, critical crowding distance etc. vary widely between functions but their study typically stops at the mid periphery, 60° at most. Only studies from the perimetry tradition, like Zigler et al. (1930) or Collier (1931), studied the full visual field for form vision. Yet with the introduction of intraocular lenses the far periphery has regained interest because patients often experience strange shadows at their visual field border, termed negative dysphotopsias. Here I review knowledge on peripheral vision, on peripheral form recognition, and crowding, with an emphasis on large eccentricities.

Mysteries of the blind zone at the extreme periphery of the human retina

Galina Rozhkova, Petr Nikolaev, Alexander Belokopytov & Maria Gracheva

Institute for Information Transmission Problems (Kharkevich Institute) Russian Academy of Sciences (IITP RAS)

Proceeding from his psychophysical investigations, A.Yarbus tried to formulate the basic principles of retinal image processing in the visual system. The key idea of A.Yarbus has been to explain the whole variety of color sensations and the phenomena of color constancy taking into account the signals from the so-called blind retina (BR) – the extreme retinal periphery where optical formation of images is supposedly impossible and only diffused light is present. The incomplete perceptual model developed by A.Yarbus has implied that the role of BR is to estimate the ambient light in order to correct the perceived colors of visible objects. Our retrospective analysis of the Yarbus's concept revealed some intrinsic contradictions and restrictions that make it insufficient regarding elaboration of a universal comprehensive model. However, the experimental achievements and general ideas of A.Yarbus are principally interesting and his hypothesis regarding BR deserves more thorough appreciation. In fact, the functions of BR and other parts of the extreme retinal periphery remain unclarified until now though this area has attracted attention of scientists since XIX century. Our aim was to summarize, compare, and analyze all the data accessible that has been obtained by various techniques including natural and diascleral stimulation of BR and adjacent regions, and to verify some predictions in own experiments. As a result, principal conclusions have been gained about the nature of blindness in BR, asymmetry of the nasal and temporal BR and the influence of diascleral stimulation of BR on the visible scenes. Supported by RFBR grant 16-04-01421a

Tuesday August 29th Poster presentations

Neural oscillations during breaking continuous flash suppression

Magdalena del Rio, Marlene Tahedl, Mark W. Greenlee & Gregor Volberg

University of Regensburg

The present study investigates the response-locked EEG correlates of unconscious visual processing using the popular breaking continuous flash suppression (bCFS) paradigm. In this technique, a mask consisting of high contrast dynamic patterns is presented to one eye, predominating over a target stimulus presented to the other eye. The time needed for this stimulus to overcome the suppression is thought to reflect the transition from unconscious to conscious perception. As potent suppression occurs primarily during trials with slow reactions, trials were sorted as slow and fast according to the median reaction time for each experimental condition and each subject. Preliminary results show an interaction between slow and fast trials in bCFS and a control condition in which the target stimulus was presented binocularly on top of the masks. Only in slow bCFS trials does gamma power increase contralaterally to the mask presentation approximately 250 ms prior to the response. This neural activity may be related to the emergence of a dichoptically integrated percept, as the incongruous visual inputs from each eye are combined.

Binocular rivalry transitions predict inattention symptom severity in adult ADHD

Aiste Jusyte[1], Natalia Zaretskaya[2], Nina Maria Höhnle[3], Andreas Bartels[2] & Michael Schönenberg[3]

[1]LEAD Graduate School & Research Network, University of Tübingen; [2]Werner Reichardt Center for Integrative Neuroscience; Max Planck Institute for Biological Cybernetics; [3]University of Tübingen

Attention deficit and hyperactivity disorder (ADHD) is a pediatric disorder which is often maintained throughout the development and persists into adulthood. Established etiology models suggest that deficient inhibition underlies the core ADHD symptoms of inattention, hyperactivity and impulsivity. While impaired motor inhibition has been documented by numerous studies, little is known about the sensory inhibition processes, their changes throughout the development, and the relationship to ADHD symptoms. For this purpose, we employed the well-established binocular rivalry (BR) paradigm to investigate for the very first time the inhibitory processes related to visual perception in adults with ADHD. In BR, perception alternates between two dichoptically presented images throughout the viewing period, with shorter dominant percept durations and longer transition periods indicating poorer suppression/inhibition. Healthy controls (N=28) and patients with ADHD (N=32) were presented with two dissimilar images (orthogonal gratings) separately to each eye through a mirror stereoscope and asked to report their perceptual experiences. There were no differences between groups in any of the BR markers. Instead, we observed a strong association between symptom severity and the duration of transition periods in the ADHD group only; further exploratory regression analyses indicated that particularly symptoms of inattention were the best predictor of longer transition durations in adults with ADHD. The lack of impairments to sensory inhibition in adult, but not pediatric ADHD, may reflect compensatory changes associated with development, while the correlation between inhibition and inattention symptoms reveals an invariant core of the disorder.

Abnormal visual plasticity in obese subjects

Claudia Lunghi, Giuseppe Daniele, Paola Binda, Angela Dardano, Ciccarone Annamaria, Ferruccio Santini, Giovanni Ceccarini, Laura Giusti, Stefano Del Prato & Maria Concetta Morrone

University of Pisa

Obesity is associated with cognitive impairment, increased liability to neurodegenerative disorders, neuroinflammation, impaired memory and learning and reduced hippocampal plasticity (Guillemot-Legris & Muccioli, TINS 2017). Here we asked whether the impact of obesity extends to affecting plasticity in the sensory cortex. Recent studies have found that short-term monocular deprivation shifts ocular dominance in favor of the deprived eye, reflecting homeostatic plasticity (Lunghi et al 2011). We measured this effect in adult volunteers, normal-weight or obese (N=39, age: 19-55 years; BMI: 19-53), testing binocular rivalry between orthogonal gratings (size: 2°, contrast: 50%, SF: 2cpd) before and after 2h of monocular deprivation. In normal subjects (BMI=21.17±0.5 kg/m2), the plasticity index (variation of ocular dominance after deprivation) is equal to 0.13±0.01. However, we found that it declines sharply for BMI>40 (the threshold for the diagnosis of severe obesity, class III), where no changes in ocular dominance were seen after deprivation (p=0.57). Moreover, we found a negative correlation (rho=-0.45, p=0.004) between BMI and the psychophysical plasticity index. A subset of severely obese patients (n=7) underwent bariatric surgery (gastric bypass). In these patients, we tested visual plasticity for up to 6 months following surgery; when BMI was 36.7±1.6 kg/m2, the plasticity index increased from -0.03±0.03 to 0.06±0.05, approaching normal values. We conclude that the metabolic abnormalities associated with obesity impair plasticity in the early visual cortex and that this impairment can be reversed by weight-loss following bariatric surgery.

Observation on the changes of perceptual eye position, fine and rough stereopsis before and after surgery in children with intermittent exotropia

Wei Shi[1], Hang Chu[2] & Li Yan[2]

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Methods: From June 2015 to June 2016, 80 cases of intermittent exotropia were selected in the clinical data. They were divided into group A (4-6 years old) and B (6 years older) . Pre- and post-operation strabismus deviation were measured by prism-covering method. The perceptual eye position was examined by human- computer interaction visual perception method on the basis of binocular dichoptic state. Furthermore, a fine and rough random point stereoscopic biological model software which used matlab algorithm was established to measure binocular visual function

of these cases. Retrospectively analyzed the changes and correlations of these relevant parameters.

Results: All cases in group A and B ,the degree of strabismus deviation and perceptual eye position were significantly improved after surgery compared with those preoperation(p=0.000). Preoperative strabismus deviation and perceptual eye position (horizontal and vertical) are statistically related before surgery(r=0.451), while no correlation between them after surgery(r=0.017). Either fine or rough stereopsis was improved in both groups of children after surgery, of which fine stereoscopic improvement was statistically significant only in group A(p=0.001),and rough stereoscopic improvement only in group B(p=0.000).

Conclusion: Early surgery is helpful for the repairing of fine stereopsis in intermittent exotropia. Strabismus deviation and perceptual eye position are quantified on the different basis of binocular correlations, not a simple linear correlation; The perceptual eye position and different energy thresholds stereopsis are important for the reconstruction of binocular vision in children with postoperative orthostatic position.

Classification of EEG responses reveals dynamics of disparity judgements in parietal and visual cortices.

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UNIVERSITY OF CAMBRIDGE

Accurate categorical judgements rely on the coordinated activity of interconnected brain regions. However, the contribution of individual brain regions will depend on the specific demands of the task. Here, we recorded neural activity using electroencephalography (EEG) while 17 observers made categorical judgements about the position in depth of a 3D target stimulus. Decision demand was manipulated by varying either the difference between the target point and reference location (feature difference task, FD), or by varying the coherence of the dot positions across space (signal in noise task, SN). To quantify the task-relevance of neural activity, we used the amplitude of the evoked EEG responses across time. In particular, we trained a classifier algorithm to discriminate whether the participant had viewed a stimulus with a near or far depth position for each presentation. For the signal-in-noise task, significant classification accuracy was reached at both occipital and parietal sites within 300ms, and was sustained at comparable levels in the pre-response window. For the FD task, however, classification accuracy was strongest at parietal electrodes, with weak classification at occipital sites. The behavioural relevance of these signals was tested by measuring the generalisation of the classifier across matched levels of task difficulty. A classifier trained on easy trials generalised to more difficult trials, but with reduced overall accuracy, consistent with behaviour. Together, these results suggest that resolving a depth judgement in noise relies on parallel occipito-parietal activity, but accurate fine discrimination shows a more serial dependence on occipital and parietal cortices.

Surface smoothness and surface discontinuity bias the perception of stereoscopic depth

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Random dot stereograms (RDSs) containing smooth gradations in binocular disparity are perceived as having less depth than surfaces with sharp disparity changes (Cammack & Harris, 2016). This has been explained in terms of both disparity averaging and good continuation processes. We examined this effect in stimuli where surface smoothness and discontinuity were both manipulated. Participants were presented with pairs of RDSs in a 2IFC procedure, each defining a curved plane in depth. Participants judged which interval contained the greater edge-to-edge change in depth. Surface smoothness was varied by manipulating the standard deviation of the cumulative Gaussian function that defined the curved plane in depth. Surface discontinuities were added by replacing sections of each curve with a frontoparallel plane, or by shifting each half of the curve laterally or in depth. Perceived depth was measured by manipulating the edge-to-edge change in disparity to find the point of subjective equality (PSE) compared to a standard continuous curved plane in depth. Increased surface smoothness led to a shift in PSE consistent with a decrease in perceived depth. Effects of discontinuity were, however, dependent upon the specific discontinuity structure used. Depth discontinuities in the opposite direction to the overall change in disparity were perceived as having less depth than continuous surfaces, while there was no effect for stimuli containing lateral discontinuities. These results are consistent with neither the good continuation nor disparity averaging arguments, but are accounted for by a model that encodes surface structure by linking local measurements of relative disparity.

Convolutional sparse coding in binocular vision systems predicts tuning for point- and higher-order disparities

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Stereo vision in biological systems is based on disparity-tuned cortical neurons integrating visual information from the left and the right eye. Biological stereo systems do not react exclusively to position-defined point disparities, but also to intensity differences between the two half-images of a stereogram. Indeed, Bülthoff & Mallot (JOSA A 1988) and Lappin (Frontiers in Psychology 2014) argue that human stereo vision is not adequately described by calculating a list of feature-disparities from solutions of the correspondence problem, but that intensity-based disparities and higher order shape descriptors play an important role. In psychophysics, effects like global stereopsis, the Venetian blind illusion, or intensity-based stereo have been interpreted in this sense.

What are the primitives of stereo vision? As one possible access to this problem, we study the joint statistics of stereoscopic image pairs, using sparse coding through the biologically inspired Locally Competitive Algorithm (LCA) (Rozell et al., Neural Computation 2008). The findings are compared to

literature data on disparity-tuned simple cells in V1. The network reproduces the phase- and position shifts of respective Gabor-like functions. Simulated sqtereo kernels also show specificities for higher order disparities. Examples include differences in spatial frequency which are sensitive to surface slant and anti-correlated basis functions which could contribute to the binocular luster effect.

Early neural correlates of visual consciousness show the oblique effect: A binocular rivalry and event-related potential study

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During binocular rivalry, different images presented one to each eye alternate in visual consciousness. Recently, binocular rivalry has been used to study brain processes that correlate with visual consciousness. Such studies have used various types of images, but the most popular have been gratings: sets of bright and dark lines of opposite orientations shown one to each eye. We studied whether using cardinal rival gratings (vertical, 0°, and horizontal, 90°) versus oblique rival gratings (left-oblique, –45°, and right-oblique, 45°) influences early neural correlates of visual consciousness, because of the oblique effect: the tendency for visual performance to be greater for cardinal gratings than for oblique gratings. Participants viewed rival gratings and pressed keys indicating which of the two gratings they perceived, was dominant. Next, we changed one of the gratings to match the grating shown to the other eye, yielding binocular fusion. Participants perceived the rivalry-to-fusion change to the dominant grating and not to the other, suppressed grating. Using event-related potentials, we found a neural correlate of visual consciousness 100 ms after the change (the P1) for both sets of gratings, and we found a neural correlate of the oblique effect 170 ms after the change (the N1), but only for perceived gratings. We conclude that the P1 is the earliest neural correlate of visual consciousness and that visual consciousness is necessary to elicit the oblique effect.

Stereoscopic depth perception is differentially affected by adaptation to binocularly correlated versus binocularly anti-correlated noise

Frederick Kingdom, Keith May & Paul B Hibbard

McGill University

Li and Atick (1994) proposed a theory in which disparity-sensitive neurons are constructed from two independently gain-controlled binocular summation (BS) and binocular differencing (BD) channels; the gains on the BS and BD channels determine the disparity selectivity of each binocular neuron. We hypothesised that adaptation to correlated versus anti-correlated noise should alter perceived stereoscopic depth as these adaptors selectively attenuate the BS and BD channels, respectively. Test stimuli were fractal noise random-dot-stereograms with rectangular flat-plane targets. Adaptors were binocularly correlated and binocularly anti-correlated fractal noise patterns with equal energy at each orientation. We found that correlated adaptation significantly increased perceived depth while anti-correlated adaptation significantly reduced perceived depth. These results are consistent with Li and Atick's theory of encoding if disparity is later decoded using the ratio of responses of two broadly-tuned disparity-selective channels. Our results are also consistent with a more standard multichannel model in which disparity is estimated from a population of disparity tuned filters that change their gain, rather than their preferred disparity. The two models make the same prediction but have different motivations: the standard model computes depth from horizontal disparities, and will only be tuned to vertical orientations; Li and Atick's theory optimizes information coding efficiency and encodes depth as a by-product. Thus, only Li and Atick's theory can predict that perceived depth would be altered by adaptation to purely horizontally-oriented adaptors (that contain no horizontal disparities). In support of Li and Atick's theory, we found similar effects with horizontal adaptors.

Investigation of interocular blur suppression with natural images reveals significant individual differences

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When the input from one eye is blurred, the sharp eye dominates the percept. The clinical use of monovision relies on this, correcting the eyes separately for different distances. We investigated blur suppression by studying sensitivity to dichoptic blur. Twelve subjects performed our task, viewing arrays of four photographs on a monitor through shutter goggles. In the first experiment, three photographs were presented binocularly, the fourth had dichoptic blur. We measured percent-correct for identifying the odd-one-out as a function of the cut-off frequency of the low-pass filter controlling the blur (f). We tested both with the same photograph presented in the four quadrants, and with four different photographs. In both cases, dichoptic blur was more easily detected when it was more severe. Performance for severe blurs (f = 0.25-0.5 c/deg) was high (>80%) for all participants, but decreased for milder blurs. For the mildest blur (f = 4 c/deg) subjects performed at chance. In the second experiment, subjects discriminated between three monocular photographs and one with dichoptic blur. We found significant individual differences. There were subjects who: i) behaved similarly to the binocular task, ii) found the task impossible, iii) showed peak performance at a "medium" blur (f = 1 c/deg) and worse for more severe blurs, and iv) performed better on milder blurs than severe blurs. Individual differences in blur suppression have been reported previously (Collins & Goode, DOI: 10.1111/j.1755-3768.1994.tb02777.x). Our approach reveals a surprising separation between judgements made against binocular and monocular comparators.

Tilt illusion during binocular rivalry from invisible patterns

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The parts of one visual object that are distributed between two eyes can be perceived as one complete visual object when they are sharing similar visual components. The main purpose of this study is to test whether the dominant visual object from interocular grouping can induce the tilt illusion without awareness. The components of the stimulus inducing the tilt illusion were distributed between two eyes. The stimulus designed to be perceived as single grating which had a same orientation when the interocular grouping occurred. In the experiment 1, the participants chose the orientation to which the target grating in the center was tilted. The result showed that the integrated grating induced the repulsive effect of the tilt illusion, but not attractive effect. In the experiment 2, the participants responded same as experiment 1, but with invisible spatial patterns. A chromatic grating counterphase flickering was perceived as a uniform color stimulus, but it produced the tilt aftereffect. The repulsive effect of the tilt illusion from the conscious gratings disappeared with the invisible stimulus. These findings suggest that the repulsive effect of the tilt illusions during interocular grouping need consciousness and the processing level of intercoular grouping is beyond consciousness.

Detecting binocular cortical visual activity against a background of neural dust

Andrew Parker & Holly Bridge

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High-field strength MRI offers the opportunity of measuring cortical activity on a spatial scale that is unprecedented for non-invasive methods in humans. A number of physiological factors determine the relationship between the measured blood-oxygen level dependent (BOLD) response and neural activity. Here we explore the spatial structure of BOLD activations with 7-Tesla imaging of the occipital cortex, in response to steadily varying patterns of stereoscopic disparity that follow a sawtooth waveform. We find that reliable detection of cortical activations must contend with a background of spatially correlated activity. It is most likely that this background activity consists of a set of weak physiological signals, rather than a truly random source of noise. For this reason, we call the low-level background activity 'neural dust', which is to say something that must be cleared away before we can detect the signals we need to analyse. We use methods from geospatial, environmental statistics to characterize this neural dust. We calculate the variogram, a distance-dependent measure of variance between sample points, and show that segregating the common and independent sources of variance between pixels in the MRI field provides a measure of the fundamental resolution of MRI methods, analogous to the spatial autocorrelation function. We show that true disparity–related signals reside in clusters of cortical activation, which have a distinct spatial structure, being larger in size than the spatial correlation structure of neural dust. Our methods deliver a new degree of objectivity to the analysis of cortical activity by high resolution MRI.

A different view on the Necker cube – differences in multistable perception dynamics between Asperger and non-Asperger observers

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During prolonged observation of the Necker cube perception becomes unstable and alternates repeatedly between a from-above-perspective ("fap") and a from-below-perspective ("fbp") interpretation. Both interpretations are physically equally probable, however, observers typically show an a priori bias in favor of the from-above-perspective interpretation. In the present study a group of 16 Asperger participants and control group of 13 Non-Asperger participants observed a Necker lattice – a combination of nine Necker cubes – continuously for 5 minutes and indicated perceptual reversals by key press. We compared reversal rates (number of reversals per minute) and stability durations for the fap and fbp interpretations between Asperger and control participants. Asperger participants showed lower reversal rates than Non-Asperger participants. Six Asperger participants did not perceive any reversal, whereas the minimal number of reversals for the Non-Asperger control group was five. Further, Non-Asperger participants showed the typical perceptual bias with significantly longer median stability durations for the fap compared to the fbp interpretation. No such perceptual bias was found in the Asperger group. During perceptual interpretations bottom-up sensory evidence is weighted with top-down concepts from perceptual memory. In the case of ambiguous sensory input, top-down influence gains more weight. The Non-Asperger's reversal dynamics and their perceptual bias of the Necker lattice may be explained by the existence of two solutions with high but unequal probabilities. Perception of Asperger patients is known to be dominated by sensory details with less top-down influence. This may explain their reduced dynamics and the absence of the perceptual bias.

Two factors of the Vista paradox

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The Vista paradox is the phenomenon that the perceived size of a target object decreases when observers approach it and increases when observers retreat from it. Such observations are in opposite direction to the changes of projected size and in discord with size constancy. A review of the few reported cases of this intriguing effect indicates two common features. First, the target object is located further away from the observer than some visually adjacent (framing) but spatially nearer objects. Second, the distance between the framing objects and the target object is difficult to judge and is generally underestimated. An analysis of how these two factors can account for the Vista paradox is presented. The analysis is based on the appearance of the effect in a city setting. The target object was a church, observed from various locations along a 1500+ meters avenue, framed by two buildings located on a square 400+ meters in front of the church.

The effect is demonstrated in an animation constructed from static views of the target and framing objects taken along the avenue. A geometrical analysis reveals that although with approach the projected sizes of both the target object and framing objects increase, the increase is slower for the target object, so that its projected size decreases relative to their projected sizes. Furthermore, given that the distance between the target and framing objects is underestimated, it follows from the size-distance invariance hypothesis that the perceived size of the target object will decrease with approach.

Topology-disturbing objects: A new class of impossible objects

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We present a new class of 3D optical illusion, in which topology of objects seems to change in a mirror. Topology is the mathematical characteristics about how objects are relatively placed, such as being separated, being intersecting or being enclosing. Theoretically the topology does not change when objects are reflected in a mirror. However, we can create objects whose direct appearance and its mirror image seem to have different topologies, although the shape of each object does not change. A typical example is that two cylinders appear to be separated when seen directly while they appear to be mutually intersecting when reflected in a mirror. This class of objects can be constructed systematically in the following steps. First, we select two topologically different situations consisting of the same objects, and two special viewpoints from which the selected situations are to be perceived. Second, we construct a one-to-one correspondence between points in the first situation and those in the second situation. Third, for each pair of corresponding points we compute the point that appears to be in the same positions as the original two situations when seen from the two special viewpoints. This can be done by applying the method for constructing ambiguous cylinders proposed by the author in 2014. Finally, we define the object as the collection of all the computed points. The resulting illusion might be considered as double anamorphosis in the sense the object has two meaningful appearances with respect to the two viewpoints.

Improvement of visual search task in children

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Different visual functions mature at different age of life. The attentional processes are one of the functions that mature lately in young adolescence. Attention is a fundamental process for correct and accurate processing of visual scene. It is evidenced that children have more difficulty in performance of conjunction search tasks than adults do. Training has been shown to improve perceptual performance of variety visual discrimination or detection tasks. Visual perceptual learning is one of the robust examples of plasticity in the adult brain. We used conjunction search task to see the effect of training on performance of search task in children. Two groups of subjects participated in our experiments: children (8-13 years old) and control young adults (20-28 years old). Observers were trained for two sessions of 10 blocks each (1200 trials each). Subjects were trained to search green horizontal line among distractors. Before and after training we also tested performance of serial search task. We found that reaction times of children were higher compare to adults but after training children improved their performance of the task as good as control young adults did. Improvement of serial search task was also improved in both groups.

Investigating the influence of infant touchscreen use on screen-based attention control.

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Despite modern societal concerns about how mobile technologies are impacting our lives, especially the very young, evidence based research is still lacking. One of the biggest fears is related to the way screen-use may be altering attention: alerting, our capacity to sustain attention; inhibiting certain distractors in our environment, and our capacity for shifting attention. These skills, which are part of the attention control set, are crucial in all aspects of our life and are predictors of later attentional and behavioural control. In this study (the intense lab-sample from the TABLET - Toddler Attentional Behaviours and LEarning with Touchscreens project; Bedford et al., 2016) we investigated whether daily touchscreen use by toddlers at 12 and 18 months-of-age was associated with differences in two screen-based measures of attentional control – the gap-overlap task (Johnson, Posner & Rothbart, 1991) and the infant version of the antisaccade task (Johnson, 1995). Fifty-Six 12-month-old infants were selected based on their reported daily touchscreen use (High, above 10 minutes per day and Low, 0-9 minutes). Participants were presented in the lab with a set of gaze-contingent tasks and free-viewing scenes. Saccadic Reaction Times and percentage of pro- and anti-saccades were extracted offline using a set of trial validation steps. No usage group differences were found in facilitation/disengagement or inhibition/anticipation effects. Individuals differed in their attentional control within and between ages but this variance was not associated with touchscreen use. Future analysis will relate these screen-based measures to real-world and parent-report measures of attention.

Exploration strategies and physiological reactions regarding car shape

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We use objects to perform various tasks, but the focus of choice of which object to use and buy has shifted from its utility and function, to the experiences it elicits, such as its pleasing properties, hedonic value, and the "values, needs,

desires and goals" associated to it (see Hassenzahl, Diefenbach & Goritz, 2010). Here, we focus on cars, since, more than a means of transportation, they are meant to fulfill certain needs, such as pleasure of use, and social status. Taking this into consideration, would one expect different exploration strategies for different car shapes? Our aim was to see whether, despite the overall needs and motivations regarding cars, different physiological reactions and processing strategies occurred. 52 participants saw freely 40 colorless car pictures, categorized according to their height (low or high) and outline (round or angular), during 30 seconds each. Eye movement, pupil size, electrodermal activity, and heart rate were recorded. Physiological data showed higher heart rate variability, and pupil size for high cars, and round cars. Comparisons between the obtained eye movement data and the saliency map of each car (graph-based visual saliency model; Harel, Koch & Perona, 2007) showed only a high similarity for low and angular cars. Hence, we attribute a bottom-up processing for low and angular cars, whereas the other three car shapes are associated to a top-down processing. Overall, despite function and motivation similarities, different cars seem to evoke different physiological reactions, as well as exploration strategies.

Spatial navigation and geometrical skills in children

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Spatial navigation is a sensorimotor process based on the capacity of representing the surroundings and the ability to update self-position in space while moving. Such information is used to aid orientation especially in conditions where spatial cues are limited, e.g. when vision is absent as in blindness. This study intends to disclose perceptual mechanisms underlying spatial navigation development that could be exploited to teach geometrical concepts by moving in space without vision. To this aim, we investigated the development of perception of right and left turns of 90° in blindfolded sighted children (6-11 y.o.). We also evaluated retention of landmarks orthogonally positioned after turns of different angles . Subjects were driven along a path divided in two segments of different lengths and were asked to name the closest landmark to them and, on a reduced amount of trials, to localize all landmarks. The angle between the segments was varied on a trial-by-trial basis. The results show that younger children are less precise than older ones in estimating the turned angle and they exhibit strong localization errors when requested to indicate the landmark position after 90° turn. These results indicate that spatial updating seems to be related to the capacity of estimating turns and such capability develops with age. By throwing light on how spatial updating and representation change with development, this study poses the basis for the possibility of teaching geometrical concepts by exploiting body movement in space which would be useful both for blind and sighted children.

Effect of time pressure and task order predictability on dual task interference in a simulated driving paradigm

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Previous studies have shown that when two tasks are performed concurrently, reaction times increases as the time between the two tasks decreases. This phenomenon is called the dual task interference. Most previous studies have investigated dual task interference using simple stimuli. Little attention has been paid to the dual task interference in more naturalistic settings. We designed a dual task paradigm in the context of a simulated driving task. Participants performed a lane change task in a simulated driving environment on a desktop computer, concurrently with an image discrimination task. We investigated the effects of Stimulus Onset Asynchrony (SOA) on the reaction times in response to the two tasks. The effect was as large as 200ms on the driving task in short SOAs. To further capture more naturalistic settings, we also manipulated the time pressure in response to the image and predictability of the order of the presentation of the two tasks. As previously reported, reaction times in response to the second tasks increased at shorter SOAs. Time pressure only affected the reaction time of the image and had no effect on driving. Participants had a tendency to respond to the driving task first. Predictability of the order of the presentation of the two tasks affected which task was responded first and as a result attenuated the effect of SOA on reaction times. These results extend the findings of previous dual task experiments to more naturalistic settings and should be considered in models of dual task interference.

Effects of relative target position on ipsilateral and contralateral manual operations in head-mounted virtual reality

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In a virtual reality scene, object location is important when aimed at interaction with a user. The spatial position of a virtual target can affect motor performance for ipsilateral and contralateral manual operations. To test for this effect, an Oculus DK2 Virtual Reality Head Mounted Set was used with a Leap Motion hand tracking system. 22 sticks, 25 cm long and 3 cm wide in the virtual scene, were placed on a grid to create five columns and six rows. Extreme target areas were defined as corner regions of the scene, and inner targets as regions close to the subject's eye level. 16 right-handed subjects followed the sticks manually in the virtual scene, from front to back, and from back to front, with their left and right hands. Results show that while subjects are more precise with their dominant hand, there is no significant difference in execution times between hands. Furthermore, subjects were more precise at eye-level interactions, and less precise at further away targets. The optimal location for interaction with extreme regions is above the eye level, for both ipsilateral and contralateral operations. These results show that object position in virtual depth affects motor performance, suggesting optimal interaction at eye level positions for close targets, and above eye level positions for further away targets.

Cue potency modulates task switching costs: The role of perceptual processes in cognitive control

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The repeated execution of a classification task is rapid and error free, but the cued trial-by-trial switch between tasks, e.g., classifying a stimulus as red/blue, or X/O, incurs significant costs in both reaction time (RT) and accuracy. Switch costs may arise due to the time-consuming exchange of task-sets, or they may reflect proactive interference from previously active task-sets, or they may reflect a relative perceptual cue-encoding benefit on repeat versus switch trials. Subjects (N=32) made cue-contingent speeded classifications of stimuli according to color or shape at two levels of Cue-Target Interval (CTI: 150 and 800 ms). Cues were either Strong or Weak. Weak Cues were a square or diamond shape which signaled the task and surrounded the target region in an otherwise featureless environment. In the Strong Cue condition the entire immersive environment signaled the task, where environments consisted of either a large theatre setting or a laboratory setting. The experimental design was within-subjects, with Switch State (Blocked, Repeat2+, Repeat1, Switch), Cue Condition (Strong, Weak), and CTI (150 ms, 800 ms) as factors. Dependent measures were RT and accuracy. All main effects and interactions were significant. RT increased and accuracy decreased as Switch State varied from Blocked to Switch. RT was faster and accuracy was higher in the Strong Cue condition. Strong Cues were most beneficial in the short CTI condition. These results support the cue-encoding hypothesis and suggest that virtual environments can be used to reduce switching costs and enhance performance.

A new CAPTCHA for improving the performance of computer-human differentiation using color constancy

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CAPTCHA is an entirely automated public Turing test which discriminates between computers and humans. This technique is commonly used to prevent bots from exploiting Web services. Initially, an image with distorted characters on a non-plain background was displayed, and a user was required to input the characters correctly to obtain the permission to use a web service. Subsequently, the technique has been shifting toward a method requiring a higher degree of judgment ability, such as selecting, from a group of images, one which is similar to a sample showing a type of animal. However, due to the recent development of artificial intelligence technology, CAPTCHA, which requires high image recognition capability, can be overcome by bots. Therefore, we propose a new generation CAPTCHA by introducing color constancy. Color constancy is a human color vision characteristic that renders the color of an object surface invariant despite variations in the illumination light of the environment. Currently, endowing computers with color constancy is difficult; hence, such feature can be expected to improve the capability of CAPCHA to distinguish between humans and computers. To put our new CAPTCHA into practical use, experiments were conducted to clearly identify the individual differences of color constancy and the distinction between human and computer color perception.

The clear-cut water drop: A visual illusion to perceive top-down saccadic fill-in

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Our visual system provides us with a seamless experience: Missing sensory information is filled-in by top-down processes; for example, the retina's blind spot is intelligently filled-in with most probable visual information (Reiter & Carbon, 2012). These mechanisms operate outside our awareness by default, making it hard to experience their nature and effectiveness first-hand. We discovered an illusion where these fill-ins can be experienced in an everyday situation: When looking at a falling water drop from above, so that line of sight is congruent with the drop's trajectory, many observers see a crisp, glossy water drop with well-defined contours being fully in focus during the entire way to the floor. We can experience this easily when taking a shower and observing the drops running across the nose, falling and finally splashing onto the ground. We simulated this refreshing experience in the lab by letting participants observing falling water drops from above. The drops started falling at a height of approximately 2 m. Recordings of participants' eye movements with a video camera revealed fast saccadic movements with two to five saccades per second while following the drops. As participants perceived water drops during the entire trajectory as sharp and crisp and because our depth of field does not cover this full trajectory, this perception must be considered an illusion where outline and size of the drops are filled-in. Some participants even reported perceiving the illusion for different drops falling down at different heights, thus perceiving several distinct and focused drops simultaneously.

The DiaNAH test battery for visual perceptual disorders: Validity and efficacy in rehabilitation practice

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We developed the DiaNAH test battery for the screening of mid-level and higher-order visual perceptual disorders in clinical practice. The DiaNAH battery comprises 11 different tests and can be administered in 30-60 minutes. Important feature of the DiaNAH battery is that it is administered on a 24" tablet, connected to a laptop. This allows dual screen technology, enabling the assessor to follow the patient's activities on the tablet. The tablet can be used with a wireless, battery-free electronic pen, which imitates paper and pencil administration. The software (DiagnosIS, developed by Metrisquare; www.diagnoseis.com) processes performance online and generates a clinical report (including comparison

to normative data) and a scientific report. The DiaNAH test battery is implemented in 19 rehabilitation centers of Royal Dutch Visio and Bartiméus in the Netherlands. So far, we performed a validation study, a normative study and a simulation (malingering) study, including healthy controls (n=600) and patients with visual problems after neurological disease (n=600). Anonymized data of the scientific reports are linked to independent variables such as age, sex, visual field deficits and type of neurological disease. Evidence suggests that the DiaNAH test battery is of added value for the assessment of visual perceptual disorders in clinical practice. It gives quick insight into the likelihood that a patient has perceptual disorders. It provides information about the possible nature and severity or the perceptual problem (e.g. mid-level, spatial, object-based) and may give direction to additional perceptual and neuropsychological assessment.

Feature-based selection is unaffected by dividing spatial attention

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It is well established that attention can enhance processing of visual stimuli based on spatial and non-spatial characteristics as well as their conjunctions. Previous research showed that spatial and feature-based attention operate independently and the effects of both types of attention are mostly additive. Here we study, using EEG and frequency-tagged stimuli, whether feature-based enhancement in processing is modulated by the distribution of spatial attention. Participants observed two pairs of spatially overlapped red and blue random dot kinematograms, one pair on the left and one on the right of the fixation cross. On each trial observers were cued to attend the dots of a certain type and respond to a luminance decrement in the attended stimulus. In focused attention conditions, the cue specified both the location (left or right) and the colour (blue or red) of the target stimulus. In the divided attention condition, only the colour was cued, with stimuli on the left and on the right attended concurrently. Both behavioural responses and steady-state visual evoked potentials showed enhanced processing for items of to-be-attended colour and location, and the distribution of spatial attention had no effect on the colour-based attentional enhancement. Additionally, both colour and location showed the "global" effect, that is, the enhanced processing of an unattended colour on the attended side, and of an attended colour on the unattended side. These results are consistent with the feature-similarity gain model and suggest that within conjunction-defined stimuli feature-based attention is independent from spatial selection.

Different time courses between the effect of fearful and disgusted facial expressions on attentional blink

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Many studies have reported that the effects on visual attention were different between facial expression stimuli in the various properties. In temporal properties, a previous study has reported that primed fearful faces increase a following attentional blink, while primed disgusted faces reduce a following attentional blink. However, the different effects of the inserted facial expression stimuli into visual presentation stream between fearful and disgusted faces have not examined. The present study compared the second target (T2: neutral face) identification performance when fearful, disgusted, and neutral faces were presented as the first target (T1). The results indicated that T2 accuracy was higher when T1 was fearful face than disgusted and neutral in lag-6 and lag-10. On the other hand, in lag-1, T2 accuracy was higher when T1 was the disgusted face than other faces. Additionally, when T1 was disgusted face, T2 accuracy was higher in lag-1 than in lag-2. However, when fearful and neutral faces were presented as T1, T2 accuracy did not differ between lag-1 and lag-2. Thus, fearful faces reduced attentional blink in longer lag conditions. This facilitation effect of T2 detection would require the encoding fearful faces as T1. Disgusted faces facilitate target detection right after T1. The present study found that the effects of facial expression on visual attention temporally differ between fearful and disgusted faces. This research was supported by JSPS KAKENHI Grant Numbers 15H06569 and 17K18069.

Effective task-switching behaviour despite fatigue by sleep restriction

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The negative effect of sleep-restriction on attention and working memory is well established (Alhola & Plo-Kantola, 2007). The current study compared task-switching behaviour across participants whose sleep was restricted to 4 hours for 3 consecutive nights and participants who maintained their usual sleep pattern. Participants were presented with two sets of seven letters from which they generated as many words as possible (Payne et al., 2007). Only one set of letters was visible at a given time, and participants could freely switch between them. Karolinska Sleepiness Scale (Åkerstedt & Gillberg, 1990) ratings were higher for the sleep-restricted than the control group. Results showed that sleep restriction lengthened the time between generating the last word in the difficult condition and the first subsequent word in the easy condition (giving-up time). A possible reason for these results is that sleep deprivation reduces either the ability to reconfigure the new task set or the ability to disengage from the previous task set (Couyoumdjian et al., 2010). There were no differences between sleep-restricted and controls in number of switches, number of words generated and number of errors, which may be due to sleep-loss affecting some areas of cognition more than others (Killgore, 2015). An alternative explanation is that voluntary selection of when to switch enables longer time to be invested in the reconfiguration or the disengagement process (i.e., the longer giving-up time), which then reduces costs after the switch (Arrington & Logan, 2004).

Conjunction visual search of isoluminant stimuli: Impact of fatigue

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In the very early stages of vision our perceptual processes attempt to organize sensory data into specific wholes, rather than separate parts, due to visual grouping. There is ample evidence that the visual attention and perception is substantially impaired in the presence of mental fatigue (Faber, 2012). The question is how visual grouping, which can be considered a bottom-up controlled neuronal gain mechanism, is influenced. The aim of our study is to describe how visual grouping of information is changed by presence of mental fatigue. Individuals provided subjective data by filling in the questionnaire about their health and general feeling. The objective evidence was obtained in the visual search task were achromatic and chromatic isoluminant Landolt stimuli were used in order to avoid so called pop-out effect due to differences in light intensity. Each individual was instructed to define the symbols with aperture in the same direction in four tasks. The color component differed in the visual search tasks according to the goals of study. The results reveal that visual grouping is completed faster when visual stimuli have the same color and aperture direction. Average reaction time on the first target is shorter in the evening. To be added, it is significantly influenced by presence of fatigue only when grouping by similarity occurrs not only for orientation of isoluminant visual stimuli but for color as well. But the mentioned effect does not have strong influence on the accuracy of task accomplishment.

Are effects of divided attention in change detection due to memory and decision?

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Studies of divided visual attention have largely depended on detection and search tasks because they minimize the role of memory and decision. Recently, the change detection paradigm has been used to study divided attention and the results interpreted as due to capacity limits to perception. Instead, might the divided attention effects in change detection be "inflated" by memory and decision processes? To consider this, we compare divided attention effects for change detection and simple detection tasks.

Subjects were presented with two intervals of dynamic 1/f noise patches on the left and right side of fixation and were pre-cued to attend to either one side (selective attention) or both sides (divided attention). For the change detection task, Gabors were embedded in the noise on both sides, in both intervals, with a 50% chance of a 90 degree change in orientation from the first interval to the second. The probability of change was independent across sides. For the simple detection task, Gabors appeared in each side with 50% probability and subjects were asked to detect the presence of the Gabor.

For the change detection task, subjects performed worse in the divided attention condition compared to the selective attention condition. However, for the simple detection task, where there is less of a role for memory and decision, there was no cost of divided attention compared to selective attention. Results are consistent with divided attention costs in change detection being due to memory and decision rather than perception.

Demanded task can delay time course of gaze-induced inhibition of return

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Gaze direction of others can shift our attention in an involuntary manner, similar to that of a periphery cue. Nevertheless, the inhibition of return (IOR) induced by gaze cues (2400 ms) emerges much later than that induced by periphery cues (300 ms). Previous studies showed that IOR time course of a periphery cue can be altered by task demands. The goal of this study was to test the effect of task demand on gaze-induced IOR. The task demands were investigated: detection, localization, and discrimination. Each task included 30 participants. The gaze cues were delivered by photographs of real persons, and the cue to target onset asynchrony varied from 1600 ms to 3200 ms. Results showed that gaze-induced IOR can be observed at 1600 ms SOA for a detection task, while it delayed to 2800 ms for a discrimination task. The finding supports the idea that the time course of gaze-induced IOR also depends on task demands, suggesting a similar orienting mechanism induced by gaze directions and periphery cues.

Unequal allocation of attention while tracking multiple objects

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The ability to allocate attention simultaneously to several objects moving independently is crucial for both everyday tasks and real-world occupations. Multiple object tracking (MOT) tasks have been used to investigate the processes underlying this ability and have revealed a limit for tracking 3-4 objects perfectly, indicating that there is a finite attentional resource available for tracking (e.g. Alvarez & Franconeri, 2007; Yantis, 1992). The nature of this resource is still uncertain, with some authors proposing a fixed architectural system consisting of a limited number of discrete 'slots' (Pylyshyn, 1989) and others suggesting a flexible, continuous resource (Alvarez & Franconeri, 2007). Under both theories unequal attention splitting is theoretically possible.

We examined participants' ability to split attention unequally in a strategic top-down manner using an MOT task. Target priority was manipulated using different top-down attentional prioritisation strategies (i.e. goal-directed instruction and reward) in a within-subject design to examine its effect on tracking accuracy indexed by localisation and direction of heading estimates. These experiments revealed that participants allocated more and less attention, indexed by tracking accuracy, to a high and low priority target respectively. This demonstrates participants' ability to split attention unequally and so the potential of such research to inform the ongoing

debate regarding the nature of the attentional resource. Under fixed accounts only certain types of attention splitting are possible whereas under flexible accounts any type of attention splitting is possible. Our results will be discussed in the context of this debate.

Neural mechanisms of dual-target visual search research based on brain stimulation methods

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«Subsequent search misses» are a decrease in accuracy at detecting a second target after a first target in visual search task. In this study, we tested the possibility to modulate this effect with the inhibition of the right temporoparietal area. The target stimuli were T shapes presented among L-shaped distractors. The participant's task was to find all targets or to report their absence. On each trial, it could be one high-salient target, one low-salient target, two targets - one high salient and one low salient, two high salient targets, two low salient targets, or no targets at all (catch-trials). Transcranial direct current stimulation (tDCS) included 3 conditions of stimulation: stimulation of the right temporoparietal area, stimulation of the left temporoparietal area, sham on the right temporoparietal area. The stimulation intensity was 1500 μA, it started after the training session, lasted for 10 minutes and finished before the main session. The results suggest that stimulation did not affect the dual-target visual search.

Differences in EEG delta and alpha power after sleep restriction predict increased sleepiness and slowed reaction times in a sustained visual attention task

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Sleep is an essential function in humans and most animals; sleep deficits can have important consequences on everyday functions, particularly those that require attention. Here we explore the neural processes underpinning the effect of sleep on vigilant attention.

Participants (n=24) undertook two experimental sessions, one after sleep restriction (5 hours' sleep) and one after normal sleep, counterbalanced. Sleep was monitored out of the lab via actigraphy and sleep diaries. Participants had EEG recorded on a Compumedics Neuroscan NuAmps 40-channel system during resting state, and during Attentional Blink (AB) and Psychomotor Vigilance (PVT) tasks. Since increased AB has been associated with increased alpha frequency oscillations, while deficits on the PVT have been associated with increased delta and theta activity, we hypothesized that sleep restriction might have differential effects on these frequency bands.

Spectral analysis of the EEG resting state data showed both decreases in central alpha and increases in central delta activity after sleep restriction. Reaction times on the PVT were slower after sleep restriction, while the magnitude of the AB was unaffected. We hypothesized that alpha reductions were associated with reduced alpha entrainment, balancing out any effect of sleep restriction on AB performance. Interestingly, individual differences in both PVT reaction time and subjective sleepiness (measured by the KSS) were predicted by increases in right central delta and decreases in right central alpha. Reaction time differences and sleepiness score differences were also closely related to each other. This suggests resting-state EEG may provide a useful objective measure of alertness.

A Gestalt-based guided visual model for multiple object search

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Visual search aims to aggregate the resources in the brain to one or few objects related to the current task so as to improve the efficiency of visual information processing. Modeling the visual search, especially for multiple objects, usually facilitates the subsequent higher visual analysis, such as scene understanding and object recognition. In this work, we build a Gestalt-based guided model to search multiple objects in complex scenes. Firstly, the layout and Gestalt features of the scene are extracted as spatial prior to act as the "where" information, which provides a task-irrelevant estimation of the locations where the potential objects present. Meanwhile, multiple local features are extracted in parallel along the selective pathway as the "what" information, which is used to identify the visual objects. Finally, Bayesian inference is used to integrate the information from the both pathways and to search multiple visual objects. Experimental results demonstrate that Gestalt features play an important role in proposing possible objects. Our system can also obtain quite competitive performance for multiple object detection and scene analysis comparing to the existing methods. The underlying biological mechanisms endow our system with the capability of being easily extended for various scene analysis tasks.

Target color and contrast influences temporal attention in rapid serial visual presentation tasks

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Attentional blink (AB) is a phenomenon that identifying the second target (T2) stimulus is restricted when it follows the first target (T1) with a short interval (200-500 ms). Various factors modulate AB; in this study, we investigated how target (I) colors and (II) contrast influence temporal attention. Attentional blink/temporal integration task was adapted to study in order to test how different color/contrast pairs influence T2|T1 accuracy and temporal integration. There were two color/contrast conditions: single color/contrast (T1 and T2 colors/contrast matched), mixed color/contrast (T1 and T2 were different colors/contrast). (I) It is found that T2|T1 accuracy were higher in single color condition. Further color specific analysis showed high T1 and T2 accuracy when target color was red and greater T2|T1 identification when T2 color was red. Moreover, greater integration was observed

in mixed color condition. It is a surprising finding since targets did not contain multiple colors in any trials. (II) There was no difference between single and mixed contrast condition on T2|T1 accuracy and temporal integration. Greater T1 and T2 accuracy was observed when targets were in high contrast condition. Better T2|T1 identification was observed in the high contrast T2 condition. Contrarily, integration was affected by T2 contrast, and more integration was observed when T2 contrast was low. In conclusion, (I) temporal attention was influenced by target color-pair conditions; however (II) contrast condition does not influence temporal attention in the same way color-pairs does.

Neurodynamical evidence of gaze prediction decrease with saccade number

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Computer Vision Center

Previous psychophysical research show that saliency is elucidated during the first and second saccade (Li & May, 2007; Li, 2014). Latest research using computational models for saliency prediction (Adeli, Vitu, Zelinsky, 2017) promote increasing patterns of prediction error in saccade landing and saccade amplitude with respect to the saccade number, suggesting the scepticism of including specific fixations temporally on the evaluation of saliency metrics using real image datasets (Bruce & Tsotsos, 2005; Judd, Ehinger, Durand, Torralba, 2009; Kootstra, de Boer, Schomaker, 2011; Borji, 2015). Acknowledging the outstanding results on saliency prediction from such models (Bylinskii et al., 2016) using temporally-invariant metrics, our evidence suggests that a gaze-based framework might help to minimize prediction error on both scanpath and saliency metrics. In order to evaluate such phenomenon, we have modeled a neurodynamical recurrent network using an excitatory-inhibitory firing-rate model (Li, 1998) of V1's lateral interactions, being responsible of bottom-up visual saliency. Our model provides foveation by including the cortical magnification towards V1's retinotopy (Schwartz, 1980). We show the results suggested by the stated hypothesis from scanpath prediction and we also provide a comparison of saliency prediction metrics from other computational models for further analysis. Moreover, we aim to highlight the biological plausibility of our model previously presented to work using the same parameters for brightness induction (Penacchio, Otazu, Dempere-Marco, 2013) and simultaneously reproducing perceptual processes such as chromatic induction (Cerdà & Otazu, 2016), binocular disparity (Rodrigues & Otazu, 2017) and visual discomfort (Penacchio, Wilkins, Otazu, Harris, 2016).

Perceptual orientation tuning before saccades

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Moving gaze from one point of a scene to another is coupled with a mandatory shift of attention causing an increase in visual performance in the vicinity of the saccade target (Kowler & Schneider, 1995; Deubel & Schneider, 1996). Changes in visual processing occur already before the onset of the movement. To determine if this pre-saccadic attention shift modulates perceptual orientation tuning curves, similar to attention-related changes in neuronal orientation tuning in the visual cortex, we compared the dynamics of perceptual tuning curves before saccade onset at the saccade target and in the opposite hemifield. Participants monitored a 30-Hz sequence of randomly oriented gratings for a target orientation. Combining a reverse correlation technique previously used to study orientation tuning in neurons with general additive mixed modeling, we found a spatially specific impact of saccade preparation on perceptual orientation tuning. Perceptual reports revealed a tuning for the target orientation at both the location of the saccade target and in the opposite hemifield. Importantly, at the saccade target, we observed an enhancement of the orientation profile starting 100 ms before saccade onset and finer tuning right before saccade onset. In the opposite hemifield, such modulations did not occur—instead we observed that orientation tuning washed out over time. These findings suggest that pre-saccadic attention boosts the encoding of visual signals at the saccade target by enhanced and sharper perceptual orientation tuning emerging during movement preparation.

Priming of pop-out is affected by expectations.

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Imagine you are picking strawberries in your garden. After several attempts it becomes easier to ignore leaves and green berries, and find the ripe red berries. Feature repetitions facilitate pop-out search while switching them slows down the response. In their seminal study Maljkovic and Nakayama (1994) argued that this priming of pop-out (PoP) effect is automatic and independent of observers' expectations. Strikingly, constant alternation of the target colors led to worse performance than when the change from red to green was determined randomly between trials, despite obvious predictability. This finding contradicted a large body of research showing that statistical regularities bias feature-based attention (e.g., Zhao, Naseem, & Turk-Browne, 2013). We tested the effect of expectations on PoP in a classic color singleton search task. Participants searched for a uniquely-colored diamond among same-colored distractors. Target color sequences were either stable (e.g., 2 red-target-green-distractors trials, then 2 green-target-red-distractors trials, and so on) or random. Observers' expectations affected search: responses were faster in predictable color sequences compared to randomly changing colors with equal length of streaks of adjacent trials. Exploratory analyses of eye tracking data indicate that predictability of target color alternation affects both first-saccade latency and overall direction. All in all, these results provide support for the view that PoP is governed not only by passive effect of previous target features but also by top-down expectations.

Intact attentional guidance but impaired explicit categorization of fearful expressions in antisocial violent cffenders

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Impaired recognition of fearful expressions has been documented in antisocial populations but it remains unresolved whether this deficit reflects impaired attention to fearful expression or is restricted to categorization. We used two visual search tasks to investigate the relationship between impaired visual attention and emotion recognition in a group of violent offenders (VO) and healthy controls (CTL). Task 1 measured attentional guidance by physical and affective saliency: participants indicated the gender of a face identity singleton in an array of neutral distractor faces with a different identity. Singletons were paired with additional physical (color) or affective (happy, angry, fearful expression) task-irrelevant features. Task 2 used similar search displays but required participants to categorize the emotional expression (happy, angry, or fearful) of a target face in an array of neutral distractors. In Task 1, both groups' visual search was aided by both physical and affective features, providing no evidence for impaired incidental processing of affective or physical saliency in violent offenders. In Task 2, violent offenders showed impaired explicit categorization performance, particularly for fearful expressions. Visual search performance was not correlated with self-reported psychopathy in neither of the search tasks. Our findings show that rather than being hard-wired in early visual and attentional systems, impaired processing of affective stimuli in antisocial individuals seems to result from later processing stages related to explicit recognition and categorization.

Gaze cueing is tuned to extract the mind behind the gaze: Investigations of 'gaze deflection'

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Yale University

The most salient 'social' visual stimuli we encounter are faces, and perhaps the most informative features of faces are eyes — but why? Presumably, gaze is important not because of what it tells a viewer about another person's eyes, but rather what it tells a viewer about the mind behind the gaze — e.g. about what someone is attending to. When you turn to look at something, however, it is not always because you are attending to it; sometimes, it is because you intend to look away from something (or someone) else. This occurs in what we will call gaze deflection — when you are surreptitiously looking at someone and then suddenly look away when they catch you doing so. In these cases, the 'deflected' gaze is not intended to be directed at anything in particular. Do such 'deflected' gazes still orient other people's attention? Subjects viewed videos of a person turning to look in a specific direction either to attend in that direction (Intentional gazes) or because of gaze deflection (Deflected gazes). Gaze cueing (measured by the ability to identify a briefly flashed letter in the direction of a gaze) was far stronger for Intentional gazes than for otherwise equivalent Deflected gazes — and this difference disappeared in control videos that were carefully matched for lower-level properties while only depicting Intentional gazes. This shows how the process of gaze cueing is especially sophisticated — insofar as it is well-tuned to extracting the 'mind' behind the gaze.

Assessing the influence of emotion in dynamic animated agent gaze-based cueing: The neglected role of handedness.

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The role of handedness and hemisphere dominance have been relatively neglected in assessments of efficacy of social cues such as gaze and emotion in the allocation of attention in animated agent based screen interaction. Neuroimaging evidence argues that across gender, the strength of lateralisation and hemispheric asymmetry would be expected to differ (Wager et al., 2003). The present study aimed to identify the impact emotional expressions have on response times to animated social cues. 62 participants (32m/30f) performed a Posner gaze cueing task. The stimulus was an animated virtual human character showing eye and whole head movements to either the left or right. The emotion of the face was either happy, sad or neutral. Gaze cues were congruent with the target location 60% of the time, and incongruent 30% of the time (10% were catch trials). Handedness was coded using the Edinburgh Handedness Inventory and the Chimeric face test coded for hemisphere dominance. A significant effect of cue congruence on response times was found, with congruent trials faster than incongruent. There were also significant main effects of handedness and hemispheric dominance, with right handers and right hemisphere dominant individuals responding faster. Side*handedness and Emotion*Hemisphere*Side Interactions were also found. Results support the hypothesis that there are differences between left and right-handers in responses to emotional cues. The data demonstrate the necessity of inclusion of left handed participants in the development of laterality based accounts of visual attention.

Vertical hemifield asymmetries in character decomposition and transposition processes of Chinese compound words

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The present study investigated the character decomposition and transposition of Chinese two-character compound words (canonical and transposed words) and pseudowords in the upper and lower visual hemifields by adopting a dual-target rapid serial visual presentation paradigm. The results showed that the character decomposition and transposition processes of canonical words was more accurate in the lower visual hemifield, however, the accuracy of transposed words was almost identical in the upper and lower visual hemifields. Fruthermore, there was no significant difference between canonical and transposed words at 0°, 2°, 4°, 6° eccentricities in the upper visual hemifields, accuracy of canonical words was

markedly higher than that of transposed words at 2°, 4°, 6° eccentricities in the lower visual hemifields. Finally, the order of words was more likely to be reversed at the central position and within the shortest SOA. The data, taken together, indicated that the character transposition of Chinese compound words was more sensitive in the lower visual hemifield, and the character order errors mainly occurred at 0° eccentricity with a duration of 100 ms in vertical visual fields. The findings further demonstrated that the lower visual hemifield preference could be attributable to the higher ganglion cell densities in the superior retina and the tendency to scan from top to down.

Illusory motion captures attention

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Akiyoshi Kitaoka has produced a number of very compelling "illusory motion" displays, many based on "optimized" Fraser-Wilcox illusions. Modelling, imaging and neurophysiological studies implicate the role of early visual mechanisms in these illusions. We provide supporting behavioural evidence from both visual search and cueing experiments. In Experiment 1, participants searched for an illusory motion target amongst a variable number of distractors (set sizes: 4, 5, 6) displayed in a circular array. Atomic elements were based on Kitaoka's "Rollers" illusion, organised into concentric rings as in "Rotating Snakes". Distractor stimuli had the same configuration but individual elements were rotated to eliminate any sense of motion. Average search slopes were completely flat, with the target "popping out" for 11 out of 12 participants. In two control conditions, we preserved the layout but manipulated contrast gradients to disrupt motion. Search was highly inefficient (>100 ms/item) confirming that the illusion, rather than structural differences between target and distractors, attracted attention. In Experiment 2, we used Kitaoka's Drifting Emboss Illusion with a modified Posner cueing task. On each trial, the illusion plus control (centre rotated 90°) were briefly presented either side of fixation. Following a variable SOA, a large X appeared either to the left or right of fixation and participants made a speeded detection using the appropriate hand. Consistent with the search data, responses were reliably faster following a valid illusion cue. Together, these results suggest that illusory motion can automatically attract attention, further implicating the role of early visual processes.

How does image geometry affect attention? Developing a novel gamified version of spatial orienting paradigm

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There is evidence that artists depict visual space using non-standard image geometries (Pepperell & Haertel, 2014). We hypothesised they do this to manipulate the attention of viewers. Game-based experiments are a reliable source of information to study visual attention (Abeele et al., 2015). We used this paradigm to investigate whether standard image geometries like rectilinear (RL) and fisheye (FE) projections influence attention differently to artistic manipulations (AM) commonly used by painters.

We developed two gamified versions of the spatial orienting paradigm (Posner, 1980): 1) geometrically-different: target changing with geometries (N= 10); 2) same: target constant in size and eccentricity (N= 10). Both versions represented a gallery-like environment and showed RL, FE and AM geometries. As expected (Chica et al., 2014), in the same condition participants didn't show any advantage for predictive cues, while in the geometrically-different condition participants were significantly faster in detecting cued compared to un-cued targets. Overall, participants were significantly faster in the same compared to the geometrically-different condition, suggesting that keeping the target constant while changing the background geometry made the task easier. AM reported the slowest reaction times, but difference with the other geometries was significant only in the same condition. Participants evaluated visual content on spatial presence and ecological validity (Lessiter et al., 2001). No significant difference was found.

Data collected with this novel methodology showed that altering the geometry of an image affects the distribution of attention across the visual field. This could have implications for the way we design and use imaging technologies.

Top-down modulation in the categorization of natural scenes

Andrea De Cesarei, Shari Cavicchi, Antonia Micucci & Maurizio Codispoti

University of Bologna

The perception and categorization of natural scenes is performed quickly, accurately and with little need of attentional resources. Moreover, the earliest neural signatures of categorization are observable few hundredths milliseconds from scene onset. Here we investigated how the top-down context, in which categorization is performed, modulates the processing of natural scenes. To this end we briefly (20 ms) presented natural scenes, and asked participants to categorize them according to one of several possible questions (animal or vehicle; indoor or outdoor; one or two). Critically, we manipulated the top-down context in which questions were asked, by varying the sequence of questions; specifically, in some blocks the same question was repeated through several successive trials (sustained condition), while in other blocks the question changed from trial to trial (mixed condition). An early negative ERP modulation was observed for targets compared to nontargets; this early relative negativity was left lateralized on occipitotemporal sensors. This early negative modulation was anticipated in the sustained compared to the mixed condition, but did not differ in amplitude or topography between the two conditions. Later in time, a P3 was observed in the sustained condition, and this P3 was more pronounced for targets than to nontargets. No P3 modulation was observed in the mixed condition. The results suggest that specific stages of processing are sensitive to different features of the top-down context in which categorization is performed.

No matter if you're black or white, for a color to be positive it has to be bright : On the universal and automatic association between brightness and positivity

Eva Specker, Helmut Leder, Raphael Rosenberg, Lisa Hegelmaier, Jan Mikuni & Hideaki Kawabata

University of Vienna

The present study investigates the hypothesis that brightness of colors is associated with positivity. Postulating that this is an automatic and universal effect. Study 1-3 used the Implicit Association Test(Greenwald, Nosek, & Banaji, 2003). Study 1 used color patches varying on brightness, Study 2 used achromatic stimuli to eliminate the potential confounding effects of hue and saturation. Study 3 replicated Study 2 in an East Asian sample and both included a measure of explicit association. All studies confirmed our hypothesis that brightness is associated with positivity, all studies $p < .001$ and Cohen's D varying from 0.90 to 3.99. Study 1-3 provided support for the notion that this is an automatic effect. Study 2-3 showed that people also have an explicit association of brightness with positivity. However, our results indicate as expected that the implicit association was stronger than the explicit association. Study 3 shows clear support for universality of our effects. In sum, our results support the idea that brightness is associated with positivity and that these associations are automatic and universal.

Is color-based attention an effective filter for symmetry detection?

Sophie G. Elschner & Ronald Hübner

Color-based attention is a possible mechanism to separate relevant from irrelevant stimulus information when the corresponding colors are spatially intermingled. Studies have shown that participants are able to attend to a dot pattern of a certain color for centroid estimation even if dots of a different color are scattered across the target (e.g. Drew, Chubb, & Sperling, 2010) or when coherent motion of those patterns must be detected (e.g. Müller et al., 2006). Our aim was to extend these findings to symmetry detection. We asked participants to decide whether a pattern of dots of a certain color was symmetric along the vertical axis or not. The target pattern was intermingled with an irrelevant dot pattern of a different color that could also be symmetric or not. As a result, we found a strong congruency effect that increased with response time, and that was larger for symmetric target patterns than for non-symmetric ones. Mean error rates reflected a large congruency effect for symmetric targets as well. Even for slow responses, accuracy remained relatively low. Lastly, non-symmetric distractors largely interfered with the processing of symmetric targets, but not vice versa. These results suggest that color-based attention is not generally effective.

The color perception of #TheDress

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Based on known color vision theories, there is no satisfactory explanation for the perceptual dichotomy of the #TheDress in which most people see either a white-and-gold (WG) dress or a blue-and-black (BK) dress. We employed standard color vision tests (i.e., color naming and matching to #TheDress, anomaloscope matching, unique white settings, and surface color preferences) to study #TheDress. Fifty-two young observers were tested. Observers reported the colors of #TheDress: 15 as BK, 21 as WG, and 16 as a combination of blue and gold. Subjects who perceived #TheDress as WG had significantly higher unique white settings, which means more blue was added to determine unique white. Perceiving #TheDress as WG was also associated with higher preferences for light green and light cyan. Moreland equation matching, which involves blue perception, showed a significant difference between WG and BK observers. For both bright and dark regions of #TheDress, color matching chromaticities followed the daylight chromaticity locus. Color matching to the bright region of #TheDress showed two distinct clusters along the daylight chromaticity locus and there was a clear cutoff for WG vs. BK. #TheDress color perception categories, color preferences, and unique white settings were associated. All tests showing a significant difference between the groups involved blue percepts. Previous studies and ours suggest that variations in attributing "blueness" to the #TheDress image may be the significant variable determining the perception of #TheDress. We propose a developmental hypothesis in that differential exposure to daylight during infancy may influence this variation.

Processing of chromatic and achromatic information in convolutional neural networks trained for object classification.

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There is evidence from psychophysics and physiology for the independence of luminance and chromatic processing in the early stages of vision. This seems to arise from different populations of retinal ganglion cells that process information along distinct pathways.

We tested whether separate processing of luminance and color would also emerge in the two separate initial streams of AlexNet, a Convolutional Neural Network for object recognition. We trained 15 instances of AlexNet and determined for the network nodes in the two separate halves of the first layer whether they would be more selective to chromatic or to luminance information.

We observed that for all instances there would be an approximately equal number of color and luminance tuned network nodes in the first layer, with an average of 50% color selective nodes. The proportion of color selective nodes within each half was severely biased, with a mean of 20% in the "luminance" part of the network, and a mean of 80% in the "color"

part of the network. The range of "minority" nodes went from 2% to 45%. Even though object recognition performance was fairly stable across network instances, the highest levels of performance were achieved by the more segregated networks.

Our result suggests that the functional independence of chromatic and luminance information processing naturally occurs in a feed forward convolutional network as soon as two streams are physically defined through its architecture. The advantage might lie in separate further processing achieving for example a separate normalization for luminance and color information.

Assessment of corrective and simulation filters for colour vision deficiencies

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Corrective filters claim to improve perception in colour vision deficiency (CVD) whilst simulation filters claim to mimic CVD in colour vision normals (CVN). This study assessed the EnChroma's (Cx-65) corrective effects on CVD and CVN, and the Variantor's simulation effects on CVN.

Fourteen CVN (4 using Variantor; 10 using EnChroma) and four CVD (1 protanope, 1 deuteranope, 1 protanomalous, 1 deuteranomalous) performed colour discrimination and naming tasks. A 5° chromatic square was presented on an achromatic-static luminance-noise background (Linhares et al., 2016 JOSA-A 33(3): A178-A83) using a calibrated CRT and ViSaGe-MKII. Observers indicated the square location (right or left) or named its colour (by reporting 1 of 11 standard colour names). Discrimination thresholds were measured twice for 16 hues (including on protan, deutan and tritan confusion lines). The naming task was performed six times for each hue at saturation levels of 100, 66 and 33%.

Repeated-measures ANOVAs conducted across filter and confusion axis conditions for discrimination showed (1) Variantor-CVN: a significant effect of filter (higher thresholds with Variantor), axis and filter*axis ($P<0.001$); (2) EnChroma-CVN: a significant effect of axis ($P<0.001$; higher thresholds for tritan axis) but no effect of filter, or filter*axis; (3) EnChroma-CVD: no significant effect of filter, axis, or filter*axis. Naming errors (1) significantly increased for the CVN with Variantor, but (2) were unaffected in CVN and (3) CVD, with EnChroma filters.

No significant improvement in colour discrimination or naming was demonstrated with EnChroma. Variantor showed expected protan-like losses.

On overcoming colour deficiency using a coloured filter

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Occasionally adverts for glasses designed for colour blindness treatment appear on the internet. As there cannot be a treatment for dichromacy, it must be only for anomalous trichromats whose colour vision might be improved by using such glasses. Is all this just charlatanry, or is there a grain of truth here? Can glasses make up for observer's anomalously close photopigment absorption peaks? This question is easy to answer when it is put more formally. Let N be a normal trichromatic observer with: (i) photopigment absorption peaks at wavelengths □□□□□□□and□□□; and (ii) pre-receptor filter f(□). Consider an anomalous trichromatic observer, A, with the photopigment absorption peaks at wavelengths□□□□□□□□and□□□, and the same pre-receptor filter f(□). It can be proven that there exists a filter, g(□), such that the anomalous observer with this filter will be metameric to the normal observer N. In other words, the quantum catch in the photopigments, peaking at □□□□□□□and□□□, and screened by filter f(□), will be equal to that in the photopigments peaking □□□□□□□and□□□, screened by filter g(□).The difference g(□) - f(□) is evaluated as a function of the differences □i - □i (i = 1,2,3). It follows that using glasses, one can, in principle, modify colour matches of an anomalous trichromat so that they will be identicalto those made by the normal trichromats. So, yes, glasses can improve colour deficient vision provided that their spectral transmittance is designed on an individual basis taking into account the photopigment absorption peaks of the colour anomalous person.

A topological perception theory inspired method for feature extraction from images

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Topological perception theory proposed by Lin Chen states that visual processing is from global to local. To date, few computational models are available for topological feature extraction from images. In this work, inspired by this theory, we propose an effective method for topological feature extraction from images, and the extracted features can be used for image classification. First we apply topological invariant transformation to artificial image to obtain different topological structures, including what we term as "dot, unit, nested, parallel or composite structure". Then a "hole function" is designed to represent the relation between two different structures, so as to generate a topological vector for artificial image classification. This model is further extended for processing natural color images, where Gaussian blur is first applied before the minimum barrier distance transformation. Then mathematically inspired by tolerance space theory, segmentation for topological feature extraction is obtained by comparing some local features between the inner and outer parts of segmentation. Then a topological vector is generated for this segmented binary image. Our method obtains the image classification accuracy up to 99.55% on a published database containing artificial topological shapes, and also performs well on the natural images with simple object shapes.

A method for performing colour constancy studies using a tablet computer

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A method for exploring colour constancy in real world environments has been developed, which uses a handheld tablet computer and successive presentation of isoluminant planes through CIELUV space, varying in spatial offset and orientation. The observer was required to select an achromatic point within each stimulus, and from their selection an estimation of their state of chromatic adaptation was acquired.

Aside from being suitable for real world environments, the technique may also be valuable as a method for assessing colour constancy quickly in large numbers of members of the public and, also due to the simplicity of the task and the familiarity of the apparatus, it allows for a broader demographic range of observers than are generally available for such experiments.

At AIC 2016 preliminary data was presented (Garside et. al, AIC 2016) based on experiments in the Grant Museum of Zoology where this technique was originally trialled, with the aim of understanding inherent observer variability, and deciding upon a recommended number of repeats for such an experiment. The derived number of repeats was 30, but it was decided that an environment with more constant and controlled lighting was required to more fully understand inter-observer variability.

Here, two new data sets will be considered; the first collected at various locations within the British Museum, with the aim of more comprehensively exploring inter-observer variability; and the second collected in the controlled environment of the PAMELA research laboratory at UCL, where the acuity of this system, and inter-observer variability was explored.

Picasso's contours and Seurat's shading: An abstract invariant anchors surface inferences

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Normally one formulates the shape inference problem from images - or line drawings - as an inverse map from the image to the surface (and light source, etc.). Because such problems are ill-posed, researchers normally seek 'priors' for regularization and demonstrate their sufficency psychophysically. Many such priors have been found and, from this perspective, shading (Seurat) and contours (Picasso) seem quite different.

We draw another message from the psychophysics: that individuals perceive qualitatively – but not quantitatively – the same shape. Importantly, differences across individuals are minimal near certain configurations, such as ridges and boundaries, and it is these configurations that are often represented in line drawings. We take this qualitative similarity as central, and show how it relates to a geometrical/topological invariant (the Morse-Smale (MS) complex). The *critical contours* along ridges derive from consecutive narrow bands of bright, dark, and bright intensity, and the exact identitiy exists between certain (critical) contours over the image and their counterparts on the surface slant function. Although the mathematics are abstract, the MS complex is computable from image (gradient) flows, which makes critical contours biologically plausible. The image segmentation implied by the contour complex is meaningful at the surface level. At the core of our derivation is a shading-to-contour limiting process that holds for a wide variety of rendering functions well beyond Lambertian. In the end, then, there is a deep invariant relating Seurat's drawings to Picasso sketches, and which grounds the surface inference process.

A two-stage model of decision making

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The drift diffusion model (Ratcliff, 1978) is widely used to model binary decision-making. In this model, evidence for the two alternatives is integrated over time until it hits a decision boundary leading to a reaction. The drift diffusion model fits many psychophysical data well and is mathematically tractable for analysis. We investigated whether this model could explain feature fusion. To this end, we presented two verniers briefly flashed in a sequence. The resulting percept is a vernier of intermediate offset, because the offset fuse. In a speeded 2AFC task, we asked subjects to report the direction of fused verniers offsets. Crucially, the reported more strongly determined by the second vernier offset than the first. The drift diffusion model cannot explain this result because accumulated evidence reaches the threshold for the first vernier before the second vernier can influence the decision. We show that a biologically plausible two-stage model is capable of reproducing the empirical data. In the first stage, evidence is integrated and buffered. In the second stage, this integrated information is fed to a decision process, modeled by a biologically plausible neural network for decision-making (Wong & Wang, 2006). The success of this model suggests that information is integrated for substantial time before a decision is made.

A quantitative model for attentional shift, shrinkage and visual compression in area MT

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Visual receptive fields (RFs) are modulated by spatial attention. Those modulatory effects occur in several higher visual brain areas e.g. the middle temporal cortex MT (Womelsdorf et al., Nat Neurosci, 2006, Anton-Erxleben et al., Cereb Cortex, 2009). Models of attention examining these effects are generally either simplified mathematical models (e.g. the Gaussian model of Womelsdorf et al., J Neurosci, 2008) or cover just qualitative effects. We devised a biologically plausible model, originating in rate-based neuron representations. Its parameters were fitted to electrophysiological measurements of macaque MT neurons of Womelsdorf et al. (2006) and Anton-Erxleben et al. (2009). In the experiments, four random dot patterns represent the input. One is the stimulus scanning the RF, moving in the neuron's preferred direction. The other three are fixed distractors, moving in the

anti-preferred direction, one in the opposite hemifield, two within the RF. They thereby yield a suppression of the neuron responses via lateral divisive-inhibition when attending at one of the two. The basic RF is described by an elongated Gaussian. When applying multiplicative attention, the model shows either shift, shrinkage or expansion, depending on the chosen width and height of the attentional signal. The fitted divisive-inhibition model can also be used to examine other previously shown effects of attention. We were able to replicate an experiment of visual "compression" during saccades (Ross et al., Nature, 1997, Kaiser & Lappe, Neuron, 2004). One global attentional signal to a target location could, therefore, account for perceived shifts of stimuli presented during the saccade.

A neurodynamical account of how emotions affect brightness perception

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Recent studies revealed that recalling emotional state or perceiving facial expression alter perception of brightness (Banerjee et al., 2012; Meier et al., 2007; Song et al., 2012). Here, we developed a neural network architecture based on the adaptive resonance theory (ART) to explain observed findings. In the ART cortical circuit, categorization of sensory input is achieved by matching bottom-up sensory signals with top-down expectations. When the bottom-up and top-down signals are closely aligned, resonant state develops that indicate successful recognition of the input pattern. On the other hand, mismatch between bottom-up and top-down signals produces a global reset wave that clears the traces of erroneous categorization and top-down expectation. According to Grossberg (1999), conscious perception arises from the network resonance. Therefore, recalling the emotional state associated with certain brightness will not produce resonant state if bottom-up signals are not consistent with the top-down prediction based on this recall. However, traces of erroneous prediction can still influence a decision or response preparation stage. We performed computer simulations with the proposed model to show how bias induced by recalled emotional state develops over time and how it shifts the decision to choose the certain brightness level without altering actual brightness perception. In conclusion, we employed established computational mechanisms of the adaptive resonance theory to show that emotions can alter brightness perception only indirectly by influencing decision or response, but not perception itself, which is consistent with the recent proposal of Firestone and Scholl (2016).

A differential equation-based spatiotemporal model of single neuron in the monkey's V4 area

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A computational spatiotemporal model of a single rate neuron in the monkey's V4 area has been proposed. The model, which is based on differential equation, can estimate the rate of the neuron at certain time, considering the position and lifetime of the stimuli, the Receptive Field (RF) of the corresponding neuron and the position of the cued attention. It has been evaluated by experimental data, gathered from 174 cells of the monkey's V4 area of the visual cortex. The animal performed a task in presence of cued attention. It should fix its gaze at the fixation point while the probes flash in its visual scene. The retinotopic position and the shape of the RF of each neuron were extracted using the Reverse Correlation method. It has been observed that the spatial shape of the RF could be estimated by 2-D elliptical Gaussian whereas its temporal response is like a Gamma function. Therefore the probes appeared in the RF resulted in a Gamma-shape train of rates as the response of the model. The constant coefficients of the model have been estimated through a data fitting process and the Coefficient of Determination (R-squared) has been used to evaluate the accuracy of the model. The simulation results have shown that for each single cell, in roughly 60% of cases, the response of the model matches with the experimental data (R-squared >= 0.3), even R-squared >= 0.8 for probes very close to the center of RF.

A luminance-free and event-based model for asynchronous motion prediction

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Different species efficiently decode position of moving objects, relying on the population response of speed selective and direction selective neurons. This highly dynamic process is explained by hierarchical organization of motion detectors in the visual system and at the cortical level has been modeled by motion energy sensitive units, after seminal models of Adelson and Bergen. Nevertheless, in most of proposed models the input layer is based on unrealistic light detection algorithms, which samples the visual scene by frames with a fixed frequency. While, according to various evidences from biology, the acquisition of sensory information from the visual scene seems to be done in a spatio-temporally flexible and asynchronous manner. In this work, to tackle this flaw of current models we have used an event-based and asynchronous input layer, from a spiking camera ATIS (Asynchronous Time Based Image Sensor). As such, we have proposed a two-layered descriptive model for event-based formulation of motion processing from retina to the cortex. Finally in a Bayesian framework we have estimated the trajectory of a set of moving bars with millisecond resolution. Importantly, all computations are performed luminance-free and time-based, suggesting that spatio-temporal pattern of stimulation is sufficient to initiate motion computation, with a significantly less cost than methods relying on luminance gradients, coherence, etc.

Saccadic gain modulation by manipulating a visual discrimination task

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Saccadic adaptation reflects the ability of the oculomotor system to quickly adapt to changes in sensorimotor contingencies. It has been shown that an arbitrary reinforcer such as an auditory tone or seeing the target on the fovea can control changes in saccade gains. That reinforcement learning can induce saccade adaptation in the absence of a visual position error suggests that conventional saccade adaptation might involve general learning mechanisms rather than specific motor calibration mechanisms.

The present study asks whether adaptation-like modulations in saccade amplitude may be induced by the ability to perform a visual discrimination task using a new gaze-contingent paradigm.

A 4AFC task was designed in which subjects were instructed to report which symbol was briefly (60ms) displayed across the whole screen immediately after a saccade. The possibility to perform the discriminative task was contingent on meeting a specific saccade amplitude criterion: when saccades did not meet the criterion, one of four irrelevant symbols was displayed such that the participant could not perform the discriminative task.

In four participants the criterion first encouraged an increase then a decrease in horizontal gain. The percentages of gain change were computed with respect to the mean of 200 baseline trials. We found a mean horizontal gain increase of 27% on average, followed by a decrease of 16%. We conclude that saccades are operant behavior that may be reinforced by the ability to perform visual discrimination tasks. These results extend the functional significance of saccadic adaptation well beyond motor calibration.

Can biological solutions help computers to detect symmetry?

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Symmetry is an important visual cue for a wide range of biological organisms regardless of size and cognitive ability. The perception of symmetry assists higher-level visual tasks such as object processing by facilitating target recognition and identification irrespective of its position and location. Although we perceive symmetry and detect axis of symmetries effortlessly, this happens to be a very challenging task for computers to the extent that it has been recently proposed as a robust "captcha" (Funk & Liu; 2016). The exact mechanism of symmetry detection is not understood. Several fMRI studies have shown that symmetrical shapes activate specific higher-level areas of the visual cortex (Sasaki et al.; 2005) while a large body of psychophysical experiments suggest that the perception of symmetry is critically influenced by low-level mechanisms (Treder; 2010). In this work we propose a biologically-inspired symmetry detection algorithm consisting of (i) orientation-selective V1 neurons implemented by a first derivative Gaussian function; and (ii) large odd and even symmetric Gabor kernels (resembling higher visual cortex neurons) that pool signals from the "edge image". Convolution of symmetrical patterns with two Gabor kernels of alternative phase produces a minimum in one and a maximum in the other (Osorio; 1996). A rectification and combination of these signals produces lines which hint of global symmetry in natural images. We tested the model on a benchmark dataset of symmetry detection which contains multiple symmetrical objects and our preliminary results suggest that such mix-level convolutional operations might account for much of the symmetry representation results.

Searching for indicators of changes in visual perception caused by sleep deprivation

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Sleep deprivation is under increasing interest of researchers because of its influence on human safety and physical and mental health. Among the cognitive functions, especially sustained attention, working memory and executive function are claimed to be affected. In our study we aimed to examine how that influence is expressed in visual functions. 20 healthy adults were selected from a group of volunteers asked to fill-in a questionnaire about the quality and length of their last night's sleep. They were separated into two groups of equal size: the first group referred to as "well-rested" (quality of sleep good or better, length of sleep > 7h), and the second one as "not-well-rested" (defined by perceived poor sleep quality and length of sleep ≤ 5h). All participants were generally healthy, drug and alcohol free, with normal or corrected to normal sight. They were asked to complete an experiment consisting of two visual tasks: choice reaction time task and visual memory task. The eye movement were measured. We present initial results investigating fatigue indicators in eye movement metrics.

A multi-scale neural architecture for incremental grouping

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Houtkamp and Roelfsema (2011) suggested that perceptual grouping consist of two processes: 1) base grouping that rely on a fast extraction of image features occurring in parallel across the visual scene and 2) incremental grouping that rely on slow, serial labeling of image elements that belong to perceptual group. At the neural level, the incremental grouping involves spreading of enhanced firing rate across neurons encoding the segments of the same contour (Roelfsema, 2006). Here, we developed a multi-scale neural architecture to explain how early visual cortex implements incremental grouping and object-based attention. We employed three different spatial scales arranged in an image pyramid with feedforward and feedback connections between scales. At each scale, a set of oriented filters is used to simulate the properties of cortical cells with oriented receptive fields. Within each scale, there are recurrent excitatory connections among nodes with collinear receptive fields. Furthermore, each scale implements iso-orientation and cross-orientation inhibition among nearby spatial locations. Computer simulations showed that the enhanced neural activity spreads along the contour segments with variable speed depending on the distance between attended and unattended contour and on their curvature (Jolicoeur et al., 1986; 1991). Also, we showed how activity spreading occur across X- and T-junctions without spill-over to unattended contour. Finally,

we showed that the model helps explain Gestalt principle of good continuation. In conclusion, we demonstrated that the proposed neural architecture can serve as a cognitive blackboard to implement visual routines as proposed by Roelfsema and de Lange (2016).

Detecting concealed memory via eye movements

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Can gaze tracking be used to reveal whether someone is familiar with another person, even when she tries to conceal this familiarity? During visual processing, gaze allocation is influenced not only by features of the visual input, but also by previous exposure to objects, resulting in idiosyncratic scanning patterns. However, the precise dynamic of gaze allocation towards personally familiar objects have not been studied in the context of revealing concealed familiarity. Here we show that when subjects try to encode several faces, gaze is inevitably attracted towards a personally familiar face, followed by a strong repulsion, even when participants were explicitly instructed to conceal their familiarity. Despite attracting overall less fixation time, familiar faces were nevertheless reported more rapidly and accurately. By exploiting these behavioral patterns, a machine learning classification algorithm detected the familiar faces at an accuracy rate exceeding 91%. These results shed new light on the temporal aspects of attention preferences and the efficient way in which existing memory representations are encoded into short term memory. It also provides a highly accurate method of detecting concealed information using eye tracking.

Collicular coding of efference copy in humans

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Each saccadic eye movement displaces the retinal image and may pose a problem to visual stability. A potential solution is for the brain to keep track of movement commands – via efference copy – and combine those with retinal information. In monkeys, a pathway carries efference copy from superior colliculus (SC) to frontal eye fields via mediodorsal thalamus (Sommer & Wurtz, 2004). In human patients with focal thalamic lesions, tasks requiring efference copy are impaired (Ostendorf et al., 2010). In the present study we investigated whether behavioral correlates of efference copy in healthy human adults point to the SC. Observers performed the double-step task, a series of two saccades to remembered target locations. The amplitude of the first saccade was 5, 10, 15, 20 or 25 dva. The second saccade was 8 dva. We hypothesized that any increase in the variability of the second saccade would be due to variability in the efference copy of the first saccade. To test whether this variability is represented in the SC, we recoded landing positions in collicular coordinates according to the Ottes et al. (1986) model. As expected, the classic increase in variability with the amplitude of the first saccade disappeared in collicular coordinates due to foveal magnification (Vitu et al., 2017). The increase of second saccade variability (in visual coordinates) with amplitude was much larger, and did not fully flatten out in collicular coordinates, suggesting that the SC is not the only structure involved in efference copy in the double-step task.

Eye movement strategies during recognition in own- and other-race faces

Alena Kogan & Galina Ya. Menshikova

Many studies have shown that people are better at recognizing faces of their own race own-race faces, relative to faces of other races. This effect is known as the other-race effect (ORE). The aim of the current study was to investigate eye movement strategies during recognition in own- and other-race faces. Twenty three participants were tested. They were presented images of the faces displaying features of four different racial groups (Caucasian, African, South Eastern Asian and East Indian). The experiment consisted of two series. During the first one the participants were asked to remember twenty faces, five for each race. In the second series they should recognize previously seen faces which were presented among other twenty distracter faces. During the performance recognition accuracy and eye movement parameters (fixation counts and durations, saccade counts and amplitudes) were recorded. The results showed that the ORE was replicated, with superior recognition accuracy of own-race faces, relative to other-race faces. The analysis of eye movement parameters revealed no significant differences between faces of different race groups. Our results also showed that for any race groups there were significant differences in fixation durations and saccade parameters between the learning and the recognition phases. Our results may suggest that studied eye movement parameters are not sensitive to the ORE effect. The research was supported by Russian Science Foundation, by the Grant 15-18-00109.

Eye dominance strength modulates the global effect on saccade accuracy

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The dominant eye is the one chosen to perform a monocular task. Vergilino-Perez et al. (2012) showed with binocular recordings that participants could exhibit weak or strong eye dominance. The dominant eye is known to be preferentially related to the ipsilateral primary visual cortex (V1). Recently, we have shown that for participants with strong eye dominance, the influence on saccade accuracy of a distractor proximal to the target ("global effect") is reduced in the hemifield controlateral to the dominant eye compared to the ipsilateral hemifield (Tagu et al., 2016). We concluded that for strong eye dominance, the relationship between dominant eye and ipsilateral V1 induces a better selection of the saccadic target in the hemifield controlateral to the dominant eye. Interestingly, this result was enhanced for strong left eye dominance and reduced for strong right eye dominance. We proposed this difference could be due to the co-occurrence of a leftward attentional bias giving more weight to the distractor because of the right hemispheric specialization for visuo-spatial attention. A way to test this interpretation is

to dissociate the saccade target selection process linked to eye dominance from the leftward attentional bias. Here we examine the global effect as a function of saccade preparation duration across paradigms known to induce short (gap-200 and step) and long (overlap-600) saccade latencies. Preliminary results on 52 participants (i) confirm the controlateral advantage on saccade accuracy when eye dominance is strong (ii) show that both the saccade target selection and attentional bias increase with saccade latency.

Contextual control of saccadic reaction times using a latency-contingent paradigm

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Because saccades are used to acquire information localized in our visual environment they are conventionally regarded as being exclusively concerned with the spatial position of objects. However, recent studies have shown that they are also affected by the temporal regularities in dynamic environments. Here we ask whether contextual control of latencies in a search task can be established using reinforcement learning. Five subjects made saccades within 80-750ms toward a target displayed among distractors. For each subject we constructed two classes of latencies, "short" and "long", using the first and last quartiles of individual baseline distributions (e.g. [80;294] and [432;750]ms respectively). We then used a latency-contingent display paradigm in which finding the target was made contingent upon specific saccadic latencies. For group 1, the target was displayed only for "short" latencies with leftward saccades, and for "long" latencies with rightward saccades. The opposite was true for group 2. When short- and long-latency saccades were reinforced (i.e. the target was displayed) depending on the saccade direction (9600 reinforcement trials), median latencies differed by 85ms on average (all outside the 98% null hypothesis CIs). Post-training, in the absence of reinforcement, we still observed considerable differences in latency distributions, i.e. on average 95ms for leftward versus rightward saccades. Our results demonstrate the contextual control of saccadic latencies, further supporting the extent of reinforcement learning for saccades. This study reveals that saccade triggering is finely controlled by learned temporal and spatial properties of the environment.

How the dynamics of human smooth pursuit is influenced by speed uncertainty

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It is still not fully understood how global motion speed is estimated by the visual system under complex, variable naturalistic conditions. We have investigated the effects of local speed variability (i.e. speed bandwidth) on voluntary pursuit eye movements in human participants. We used a well-controlled class of broadband random-texture stimuli called Motion Clouds (MCs) with continuous naturalistic spatiotemporal frequency spectra (1,2). MCs allow manipulating visual motion signal distributions along both spatial and temporal frequencies as well as along the speed axis. Subjects were instructed to track a large (5° diameter) patch of moving clouds (mean speed=10 or 20°/s), presented with different speed bandwidths (ranging rom 0.05 to 8 °/s). Speed bandwidth had no effect upon pursuit latency but non-linearly affected initial eye velocity: response amplitude remained constant for small bandwidth but rapidly decreased for increasing bandwidth above a cut-off value of (1 °/s). Tracking responses became largely transient at these values. These nonlinear relationships remained largely unchanged when varying the mean or bandwidth of spatial frequency MC distributions. These results allow estimating the width of speed tuned channels across a broad range of spatiotemporal frequencies. This work is supported by the PACE ITN MSCA network and the SPEED ANR project. 1 Sanz-Leon et al. (2012) 2 Simoncini et al. (2012)

Expressive faces confuse identity recognition

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We explored the effect of facial expressiveness on recognition. We created two packs of cards from images selected from our own database of highly variable, naturalistic facial images. Each pack contained an equal number of face images of two unfamiliar identities. While one pack depicted neutral faces, the other contained faces varying in expressiveness. Importantly, for each card in the neutral pack there was a corresponding card in the expressive pack that came from the same movie segment; therefore variables such as lighting were constant within image pairs, while expressiveness differed. In two experiments, participants sorted the card packs into piles, one for each perceived identity. Consistent with other studies using this paradigm, the perceived number of identities was higher than the veridical two. However we found a clear difference between the expressive and neutral sorting tasks when we measured the internal accuracy of the identity piles. When the task was performed with expressive faces, identity piles were significantly more likely to contain cards of both identities, indicating that the two had been confused. This finding uniquely demonstrates that variability of expressions, over and above other sources of variation, give rise to these errors of identity confusion. This shows that expressions are not factored out when we make decisions about identity of unfamiliar faces. These results support face-processing models that permit both invariant and changeable facial information to be drawn upon for identity decisions.

Eye-movement patterns and reaction-time as indices of cognitive impairment malingering

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Malingering means intentional production of false or exaggerated psychological symptoms, motivated by external incentives. The Word Memory Test, (WMT) is commonly utilized as main malingering detection tool. We examined eye-movement patterns and Response –Time: measures of less conscious control, as additional indices for detection of cognitive malingering. Eye-movements and response

times were measured while participants performed the WMT, as add-on measures and additional indices that may increase the predictive power of cognitive malingering detection. Healthy University students participated as "simulators" (experimental-group), or controls (n=65). All participants read similar scripts: involvement in car accident resulting in mild traumatic brain injury followed by a complete recovery. Controls performed the immediate recognition subtest of the WMT to the best of their ability while simulators were notified that their attorney advised them to act as memory impaired in order to receive a higher-settlement. Both groups received performance reinforcements. Eye-movement data was obtained by coupling an eye tracker to the WMT. During WMT participants chose previously displayed (remembered) words out of adjacently displayed word-pairs. These comprised two "relevant" areas-of-interest (AOI's), while the upper instruction display areas comprised "irrelevant" AOI's. Our eye-movements and response-time results revealed significant group differences: Simulators showed higher fixation frequencies within the "irrelevant" AOI's and lower fixation frequencies within "relevant" AOI's compared to controls. Simulators showed lower saccadic frequencies between AOIs than controls. Simulators showed also higher response-times. A combined measure of eye-movements and response-time showed high predictive power, and provides potential improvement of cognitive malingering detection

Neural correlates of face identity learning: Establishing representations of own- and other-race people

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It is possible to examine face identity learning by exposing participants to within-person variability through the use of multiple, naturally varying images. Previous behavioural and event-related potential (ERP) work suggests that such exposure leads to the formation of stable representations, which allow identification from previously unseen instances. However, it has not yet been investigated whether stable representations can be similarly developed for other-race identities. While it can be challenging to recognise unfamiliar own-race faces from novel images, this may be even harder for other-race faces. Here we present findings from an ERP experiment investigating the neuro-cognitive processes underlying learning of own- and other-race facial identities. A clear behavioural advantage for own-race identity learning was observed, indicating that identity-specific information is more easily extracted from own-race faces. ERP results revealed modulations in the late N250, which has been shown to be sensitive to face learning. Importantly, more negative amplitudes for novel images of the learnt identities relative to unfamiliar faces were evident for own-race faces only, suggesting image-independent identity learning for own-race faces, but only image learning for other-race facial identities. These findings will be discussed along with the implications for the neural and cognitive processes involved in face recognition.

Effect of sudden image onset and early gist extraction on the central fixation bias

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The study of scene perception investigates eye movements to study allocation of attention on natural stimuli under well-controlled conditions. The first fixations of human observers tend to be placed near the center of an image, a tendency called Central Fixation Bias (CFB). This effect is consistently found in scene viewing experiments, potentially obscuring less pronounced effects. Recent evidence shows that experimentally delaying scene exploration by as little as 125ms after image onset can significantly reduce the CFB. In this experiment we dissociate two factors possibly contributing to this reduction: i) using the center as the optimal location for early gist extraction and, ii) attentional capture induced by a sudden change in luminance at image onset. In the experiment participants saw a valid, invalid, or phase-scrambled preview of the target image before exploration, allowing varying levels of gist extraction prior to exploration. The target image was presented with one of two onset types: a sudden image onset or an onset using a 250 ms fade effect. Participants exhibited a reduced early CFB for valid preview conditions. Sudden and gradual onsets of the image did not differentially affect the early CFB. We conclude that the CFB is caused by early gist extraction from the strategically auspicious center. Previous knowledge of an image, even if gained from a non-central position, decreases the tendency to fixate the center after image onset.

Human-computer interaction in forensic face matching

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Automatic facial recognition is becoming ubiquitous in security contexts such as passport control. Currently, Automated Border Crossing (ABC) systems in the United Kingdom (UK) and the European Union (EU) require supervision from a human operator who validates correct identity judgements and overrules incorrect decisions. As the accuracy of this human-computer interaction is unknown, this research investigated the extent to which human accuracy in face matching is impacted by decisions such as those made by automated face recognition software. Observers matched pairs of faces that were already labelled onscreen as depicting the same identity or two different identities. The majority of these labels were correct, but a small number were also misleading. In addition, a small number of labels also provided 'unresolved' information. Observers were informed that their task was to validate correct labels, and overrule labels that provided incorrect identity judgements. Accuracy deteriorated on falsely labelled match and mismatch trials. However, observers also falsely rejected some match and mismatch trials, despite the fact that the correct solution was provided onscreen. These results suggest that errors by ABC systems can promote errors in human observers, and also that human performance in face matching is so unreliable that errors can persist when the correct solution to the problem is supplied.

How many observers do you need to create a reliable saliency map in VR attention study?

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Attention and saliency investigations are becoming more popular with technology progress. It is widely accepted, that the minimum number of observers required to create a reliable saliency map begins from 8 depending on content type. However, this number has been estimated for traditional content, so it should be verified for the virtual reality (VR) helmet case. Two straightforward hypotheses suggest that this number should be increased proportionally to the stimulus angular size or potential visual field (due to head rotation) enlargement. Required number for VR should be about 60 observers according to the first hypothesis (typical angular size of stimuli in experiments is 45-50°) and about 30 according to the second (VR helmet field of view is about 90°). We have recorded eye movements from 91 observers during watching 360° video content (total duration - 33 minutes) using VR helmet eye tracker based on Samsung Gear VR. We have found that required number of observers for VR is varying from 25 to 45 depending on content type to obtain saliency map covering fixations of all subjects with probability of 80% (when 8 observers give from 45% to 65%). From the data collected it may be concluded that both hypotheses seem to be plausible: the first one may be applied for complicated scenes (many moving objects against rich background), while the second one may be applied to the plain scenes (one moving object against smooth background). The research was supported by the Russian Science Foundation grant (project No.14-50-00150).

Electrophysiological brain dynamics during preconscious processing of facial attractiveness

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Of the various facial attributes, people are most sensitive to facial attractiveness due to its importance as a biological and social signal. Recent research suggests that even in the complete absence of conscious awareness of a face, facial attractiveness can be processed rapidly and spontaneously. However, the brain dynamics underlying preconscious processing of facial attractiveness are still unclear. In the current study, we recorded event-related brain potentials (ERPs) during subliminal presentation of face stimuli using a continuous flash suppression (CFS) paradigm, in which monocularly viewed stimuli were erased from visual awareness by exposing the other eye to continuously flashing masks. For 800 ms under CFS, the participants observed either an attractive or unattractive face and guessed the facial attractiveness of the presented face during each trial. Under CFS, the participants did not consciously discriminate the facial attractiveness of the presented faces. However, from approximately 200 ms onwards, attractive faces elicited an increased posterior negativity relative to unattractive faces. The effect of facial attractiveness on ERPs was more pronounced when faces were presented in an upright position rather than in an inverted position. Enhanced posterior negativity has been reported for attractive faces compared to unattractive faces and was associated with facilitated processing of emotionally salient stimuli. The results of our study provide novel evidence for cortical processing of facial attractiveness without conscious awareness.

The influence of previous rewards on attentional selection is dependent on visual awareness

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Reward has widespread effects on visual attention: For instance, attention is biased towards or away from stimuli in dependence on previously delivered rewards, even when these rewards are irrelevant for the current task. This suggests that reward-driven attentional biases are based on automatic and involuntary processes. Here, we tested whether previous rewards can shape attentional selection even outside of visual awareness. In each trial, participants completed two consecutive tasks. Firstly, they performed a visual search task with clearly visible stimuli. Upon selection of the target stimulus, participants received either a high or low monetary reward. In the second phase of each trial, participants had to detect a Gabor grating, which was masked by interocular suppression. Trial-by-trial confidence ratings and a two-alternative forced-choice task indicated participants' awareness of the Gabor stimulus. Furthermore, eye movements were recorded to quantify attentional biases towards the suppressed stimulus by comparing dwell times on the stimulus vs. a control area. We observed an attentional bias towards the stimulus vs. the control area, which was independent of awareness. However, only in trials in which participants reported awareness of the Gabor stimulus this attentional bias was increased after a high vs. a low reward had been obtained. In unaware trials, in contrast, the attentional bias was not modulated by the previous reward magnitude. These results suggest that despite the attentional stimulus selection in the absence of awareness, the influence of past rewards on attention requires visual awareness.

The influence of orientation on discrimination of composite facial expressions

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Previous work has demonstrated that facial expression recognition relies on a holistic representation. It was proved also that holistic processing may be disrupted when faces are inverted. We investigated expression discrimination at upright and upside-down orientations to obtain a measure of the influence of orientation on holistic face processing. Stimuli were images of six basic emotional expressions of a male poser, and 24 composite expressions which combine Happiness, Anger and Fear in upper or lower face with other 5 expressions. The experiment consisted of two parts in which images of faces were upright (in the first part) or upside-down (in the second). Twenty one participants were tested. Faces were presented in pairs, each for 2000 ms. The participants were asked to rate similarity between face expressions on a 9-point scale. Full matrices were processed

with PROXSCAL multidimensional scaling program. We retained a 6D solution for both upright face (Stress = 9.8%) and upside-down face data (Stress = 10.5%). For both data the arrangement of points (i.e. basic and composite expressions) in the "expression space" was very similar: D1 separated X-Happiness (smiling mouth) from other stimuli, with X-Anger (compressed mouth) at the other extreme; D3 opposed X-Disgust (closed mouth) and X-Fear, X-Surprise (open mouth); D2 separated Fear-X, Surprise-X (wide-opened eyes) from other expressions; D4 opposed Surprise-X from others; D5 separated Fear-X from others. The proposed method proved of low efficiency for assessing holistic processes.

Proof validation in abstract algebra: An eye-tracking study

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Proof validation is the process that one makes a judgment on a given proof whether it is valid or not. From the literature review, we found that undergraduate students' performance of proof validation were not good enough. And graduate students learn mathematics mostly longer than undergraduate students. For mathematics learning, the performance of proof validation may be due to participants' years of mathematics learning. Therefore, the aim of this study is to compare graduate and undergraduate students' differences in proof validation processes. Five graduate and five undergraduate students, all major in Mathematics, volunteered to participate our eye-tracking study to validate 2 valid and 2 invalid proofs of Algebra. A Tobii T120 eye tracker with a sampling rate of 120 Hz was used to collect proof validation processes data and then the participants were interviewed for their answers to each proof. The eye-tracking task and the interview lasted for about 30 to 45 minutes per participant. Graduate students' fixation counts of both proposition area and proof area were more than undergraduates. Graduate students especially fixated and visited the proof areas longer than undergraduates. Overall, participants' fixation counts on invalid proofs were higher than valid ones. The above results could be explained by the form of error and the length of proof. Our findings may provide mathematics educators for designing better proof validation problems which could enhance proof validation teaching and learning as well.

Cross-cultural features of manifestation of the categorical perception in viewing faces of different races

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The effect when the objects perceived as pertaining to different categories are differentiated by the subjects more effectively than elements of one category is known as "categorical perception". In a study supported by the Russian Presidential Grant for Young Scientists MK-3133.2017.6, samples of 36 Russians and 42 Tuvinians performed the AB=X task on pairs of facial images, A and B, morphed between authentic photos of a Caucasian and a Mongoloid combining them with a 20% step, followed by a third image X, which the subject was to identify with one of the two seen previously. Both samples demonstrated the effect of categorical perception, however differently. The distribution of correct responses revealed significant differences between Russian and Tuvan samples, Pearson $\chi 2$, $p < 0.01$, the accuracy of identification being higher in the Russian sample. The Tuvan sample showed the highest accuracy in comparing two images, one of which was 80% of the "Mongoloid" and in the other one 60%, with 20% and 40% "Europeoid" contribution, respectively. The Russian subjects demonstrated the highest accuracy when comparing two pairs of images, one containing 40% and 60%, the other 60% and 80% of the "Mongoloid" component, the difference in the accuracy between these two pairs being statistically insignificant. The Tuvan subjects showed a strong decrease in the accuracy with the increase of the "Europeoid" component in the compared images. The Russian subjects demonstrated no similar decrease in the identification accuracy when viewing images with a large contribution of the "Mongoloid" type face.

Maintaining the spatial memorandum - Interplay between internal and external strategies in a digital CORSI task.

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A wide variety of cognitive tasks require processing of information distributed across the internal mind and the external environment. Here, such internal and external strategies serve as two indispensable parts of the same representational system. The CORSI block tapping task (CBT) is a classical and well established spatial working memory (WM) task involving internal computations (memorizing CORSI sequences, organizing & updating memory maintaining as well as recall processes) as well as eye movements to support external actions that serve to encode and maintain the CORSI block sequences. By introducing a new digital version of the CBT, where (i) the difficulty of the memorandum (using sequence lengths reaching from 3 to 10) and (ii) the degree of execution of eye movements during the maintaining phase of the CBT were manipulated, we present data concerning varying adaptations in order to rely on internal and/or external representations in humans. In a within-subject design, 15 participants had to solve three different CBT conditions. In each condition we controlled either the internal, the external or both strategies. The results show individualized and robust adaptations concerning the external strategy due to a different application of eye movement supported rehearsal of the CORSI sequences. Individuals were classified by their use of oculomotor rehearsal (from low to high use) and further analyzed concerning their rehearsal rate and CBT performances as well as other WM characteristics.

Individual differences in children's face recognition abilities

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Accurate face identity recognition is crucial to social functioning yet this ability varies among typical adults. This variation is argued to reflect variation in face-specific perceptual and cognitive mechanisms, with only small contributions from more general cognitive abilities. Consistent with this view, variation in the strength of two face-sensitive perceptual mechanisms: holistic coding (in which information is integrated across a face) and adaptive norm-based coding (in which faces are coded relative to a norm in a multidimensional face-space and that norm is updated by experience) is associated with individual differences in face recognition abilities in adults. However, little is known about individual differences in face recognition abilities in children. Face recognition skills improve during childhood yet children rely on the same face-sensitive perceptual mechanisms as adults, suggesting that variation in these mechanisms may also contribute to variation in children's face recognition abilities. We examined the contributions of holistic and adaptive norm-based coding, along with general cognitive abilities, to individual differences in face recognition ability in over 150 children aged 6–9 years. Adaptive norm-based coding was associated with both face perception and memory ability whereas holistic coding was only associated with face perception ability, when age and sex were controlled for. Cognitive ability was not associated with face ability, when age was controlled for. These results suggest that face recognition ability in childhood primarily reflects variation in face-sensitive mechanisms and is consistent with a view that face recognition ability is a specific ability that may reflect a substantial genetic contribution.

Using an image-computable early vision model to predict eye movements

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It is widely believed that early visual processing influences eye movements via bottom-up visual saliency calculations. However, direct tests of this hypothesis in natural scenes have been rare as image-computable models of early visual processing were lacking. We recently developed an image-computable early vision model, and thus we now have the means to investigate the connection from early vision to eye movements. Here we explore eye movement data measured while subjects searched for simple early vision inspired targets like Gabors and Gaussian blobs overlaid over natural scenes. We compare the output of the early vision model processing patches around fixated locations with randomly chosen patches. Additionally we use a neural network to predict the fixation density from the early vision model output. Finally we use the model's predictions of target detectability to predict search performance. We find clear differences between the early vision outputs at fixated locations which roughly follow the activations generated by the target alone. Additionally the fixation density can be predicted reasonably well from the early vision outputs using different weightings for different targets. Finally, target detectability at the specific location predicts search performance in terms of both the probability of finding the target and the time needed to find them. Our findings show a clear dependence between eye movements and early visual processing. Additionally they highlight the possibility to use our spatial vision model as a preprocessing step for models of mid- and high-level vision.

Faces, fingers and guns: Implicit preference for any self-directed attention

Rebecca Lawson

We have a strong preference for faces looking towards us as opposed to faces that look to the right or left side (Lawson, 2015). This robust preference for direct compared to averted gaze generalizes across face pose and emotional expression. We also have a weaker preference for neutral shapes and arrows that are labelled as "looking at you" versus "looking to the side" so the preference is not face-specific. I will present a series of studies that used the implicit association test to investigate whether these results arise from our desire for self-directed attention. The results revealed that the preference for direct gaze was not reversed by training that associated averted gaze (but not direct gaze) with helpful information. However, the preference for faces with direct gaze was eliminated if gaze direction was not explicitly mentioned, for example by using a task requiring the categorisation of the emotions shown by direct-gaze and averted-gaze faces. Finally, and most surprisingly, people also showed a preference for stimuli that directed negatively-valenced attention towards them, namely fingers pointing and guns shooting at rather than away from them. Thus our egotistical preference for self-directed attention is not limited to social stimuli such as faces, and nor is it limited only to positively-valenced stimuli. Instead, we apparently are biased to like anything that draws attention to ourselves.

Reference Lawson, R. (2015). I just love the attention: implicit preference for direct eye contact. Visual Cognition, 23, 450-488.

Accurate saccadic reaction time discrimination in humans

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We have previously established that saccadic reaction times (SRTs) may depend on reinforcement contingencies. It follows that one must be able to discriminate one's own latencies to adequately assign credit to one's actions. To probe this, we trained five participants in an adaptive procedure ("staircase paradigm" or "up and down procedure") to determine their perceptual just noticeable difference (JND) of SRTs. On each trial they had to saccade to a stepping target. In a 2-AFC task they had to choose the number representing the actual SRT while the second number was a made-up value which proportionally differed from this SRT. The relative difference between the two alternatives was computed by either adding or subtracting one of the percentage values of a decreasing fixed staircase range. The percentage value was larger at the beginning of the task (starting at 50%) and decreased following the participant's discrimination performance that determined the position in the staircase range. To encourage learning, feedback was provided after each response. JNDs were computed by averaging the percentage

values for the reversals (peaks and valleys) of the staircase in the last six sessions and after the fourth reversal. Results reveal a very accurate perception of SRTs : in three participants, JND reached respectively 5%, 9% and 7% whereas in the other two participants, JND was approximately 12%. This indicates that participants can discriminate very small SRT differences, providing support for the possibility that the credit assignment problem may be solved even for short reaction times.

Do sunglasses hide your feelings?

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Twenty two Participants viewed Nimstim and Ekman emotional faces. Half the faces had their eyes covered with sunglasses. Participants fixated a cross while the face was presented 15 degrees to the right or left of fixation. They made a seven alternative forced choice response of one of the standard emotions. Once this emotion recognition had been made participants were allowed to free view the face centrally and name another emotion if they so wished. The observer's eyes were tracked to check the fixation was maintained and monitor where the eyes moved when free viewing was permitted. Emotion recognition 15 degrees in the periphery was overall 60% correct for the normal faces but only 52% for the faces wearing sunglasses. When centrally viewed the emotion recognition went up to 80% for the normal faces but was only 67% for those wearing sunglasses. The happy face was the most recognized emotion under all conditions. The faces which were most badly affected by having sunglasses were sad, angry and fearful faces. Eye tracking data will be reported.

Eeny meeny artsy fartsy: Eye tracking to explore preference for paintings generated by deep neural networks

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A frequently asked question in experimental aesthetics and psychology is whether we can isolate aesthetic primitives in paintings from their content, and measure their 'beauty' independently. To answer this question, we applied deep neural networks (Gatys, Ecker and Bethge, 2015) to systematically separate and recombine the content and style of artistic images, adhering to formal stylistic rules, while keeping the compositional and semantic content untouched. We implemented a 2AFC task and a variant of drift-diffusion model (DDM) (Kajbich et al., 2010) in addition to eye tracking to establish whether both style and content contribute independently to the general liking of paintings. We integrated accumulated behavioural evidence (i.e. image preference) with evidence based on cumulative fixations to extract bias coefficients towards different styles and contents, respectively. These coefficients were found to have higher predictive power than the initial values associated with 'paintings' in determining the ultimately chosen image. In addition, we showed that an extended DDM (Kajbich et al., 2010), which uses the weighted difference between initial values of fixated and unfixated images, does not extend to novel stimulus choices.

Do spatial frequencies combine into a holistic representation of a face in the short-term memory?

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It is known that an input image is decomposed to the spatial-frequency components by parallel pathways. However, according to previous face recognition issues, the long-term memory stores their holistic representations. The short-term memory serves as a mediator between the level of perception and the long-term memory. Though, characteristics of representations in the short-term memory are unknown. The aim of our research was to find out whether the face representations in the short-term memory keep spatial-frequency specificity or lose it while transforming to holistic representations. We have conducted two experiments using unfamiliar faces of 7 angle degrees as stimuli. There were four observers in each experiment. In Experiment 1 each trial started with a presentation of a test face with exposure time varied from 26.6 to 133 ms (limited by a mask) with step of 26.6. After that, four comparison faces were simultaneously shown. These faces were filtered in order to keep 2-octaves band-pass with central spatial frequency 1, 2, 4, or 8 cpd. Observers were asked to select the face that matched to the test one. The dependencies of recognition accuracy on test stimulus duration were determined for each spatial frequency of the comparison faces. In Experiment 2 we cut off one frequency band (4 cpd) from the tests stimuli. In other aspects this experiment replicated the previous one. We found that this manipulation didn't effect on the performance. The result suggests that the face representations in the short-term memory are holistic and do not have frequency specificity.

Psychophysical evidence suggests late rather than early integration of visual information from facial expression and body posture

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Facial expressions are one of the most important sources of information about another person's emotional states. Recently, other cues such as body posture have been shown to influence how facial expressions are judged. In particular, an expression viewed in the context of an incongruent body posture is often (mis-)judged as expressing the emotion indicated by the body. This biasing effect has been argued to be underpinned by an early integration of visual information from facial expression and body posture. Here, we replicate this bias and, using a psychophysical adaptation procedure, provide direct evidence that in contrast to previous claims even high-level representations of facial expressions encoded late in the visual system are unaffected by body context. Specifically, while we show that perceptual judgment of a disgusted facial expression viewed in the context of an angry body is biased towards anger, adaptation to a disgusted face is identical irrespective of whether it is seen in a disgusted or angry body context. These findings are consistent with a model of social perception, in which

signals from different social sources are processed by specialized visual mechanisms that act largely independently up to a high-level stage. Combination of information underlying the integrated representation of social signals seems to occur once processing in these late mechanisms is completed.

Gender differences in visual perception of own body weight

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The previous body image literature has focused on how females perceive their body weight. We investigated potential gender differences in the use of visual cues (shape, texture) to estimate own body weight. A full-body scanner was used to capture each participant's own body geometry and colour information and a set of nine personalized 3D virtual bodies (avatars) with realistic weight variations (0, ±5%, ±10%, ±15%, ±20% of actual weight) was created based on a statistical body model. Additionally, a second set of avatars was created for each participant with an average underlying body shape matched in height, weight, inseam, and arm length. In four sets of psychophysical experiments, the influence of visual cues on accuracy of body weight perception and sensitivity to weight changes was assessed by manipulating body shape (own, average) and texture (own, checkerboard). The avatars were presented on a large-screen display, and participants responded to whether the body corresponded to their own weight. Overall, we found no gender difference in the accuracy of body weight estimation. Men however visually perceived the avatars with underlying average shape as thinner as avatars with their own shape. Further, males were less sensitive to weight changes than females and accepted a larger weight range as corresponding to their weight. Females' desired body weight was lower than their actual weight, while actual and desired body weight for males was identical, suggesting that the weight dimension might be more important to women than to men in terms of their ideal body.

The processing of dynamic faces in the human brain: Support for a revised neural framework of face processing.

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Faces convey rich information including identity, gender and expression. Current neural models of face processing suggest a dissociation between the processing of invariant facial aspects such as identity and gender, which engages the fusiform face area (FFA) and the processing of changeable aspects, such as expression and eye gaze, which engages the posterior superior temporal sulcus face area (pSTS-FA). Recent studies report a second dissociation within this network such that the pSTS-FA, but not the FFA, shows much stronger response to dynamic than static faces. The aim of the current study was to test a unified model that accounts for these two major functional characteristics of the neural face network. In an fMRI experiment, we presented static and dynamic faces while subjects judged an invariant (gender) or a changeable facial aspect (expression). We found that the pSTS-FA, but not the FFA, was more engaged in processing dynamic than static faces and changeable than invariant facial aspects. Functional connectivity analysis revealed that the motion area, MT, is functionally correlated with all face areas, suggesting that motion information is used throughout the face network. Our results support a revised neural face model, in which the dorsal face areas are sensitive to facial motion and changeable facial aspects; and the ventral face areas extract face form for both changeable and invariant aspects. This framework indicates no dissociation between the processing of changeable and invariant facial aspects, but higher sensitivity to the processing of changeable facial aspects by motion-sensitive areas.

Affective mindreading and metacognitive accuracy in recognizing emotions in others among patients with schizophrenia

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Recent research on social cognition in a schizophrenia population shows abnormal mindreading patterns in recognizing others' emotions. There are also empirical studies indicating deficits in metacognitive capacity, including explicit awareness about one's own knowledge among patients with schizophrenia. The purpose of the present study was to empirically assessed the relations between social cognition and metacognition in recognizing visual emotion perception in other people. In a group of patients diagnosed with schizophrenia we measured their capacity to recognize the mental states of others from facial expressions using a Polish version of Reading the Mind in the Eyes Test (RMET) and then assessed metacognitive knowledge regarding others' emotions recognition. Participant's metacognitive knowledge was estimated either with post-decision wagering (PDW) based on economic categorizations or the typical confidence ratings (CR) scale in the randomized fashion. We compared the patients' results with the group of healthy controls (undergraduate students) and found that the patients exhibited diminished capacity in recognizing others' mental states. In addition, there was no difference in the metacognitive evaluations between patients with schizophrenia and healthy participants as indicated by the CR and PDW measures. Our findings indicate that schizophrenia may be associated with specific patterns of the relationship between social cognition and metacognition, where abnormal mindreading patterns are linked with largely preserved metacognitive accuracy. Funding: This research has been supported by the National Science Center (Poland), and funded under the award number 2014/15/B/HS6/03834.

Task dependent effects of head orientation on perceived gaze direction

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Accurate perception of where someone else is looking is an important social cue that must be utilised across vast changes in stimulus properties and quality. One such changing property is head rotation, which causes a repulsive effect on perceived gaze direction, as the visible part of the sclera changes in a similar way to the rotation of the eyes in the opposite direction. At the same time, the direction of the head can act as a coarse scale spatial cue to the direction of gaze, causing an attractive effect of head orientation on perceived gaze direction. These opposing effects have been accounted for in a dual-route model. Typically, the overall effect of head rotation is measured with a single-interval task, and is shown to be more repulsive. However, using a two-interval task, we found performance was close to veridical. This difference between measurements across the two tasks is weakened when the observer is shown only the eye-region, rather than the full head. This suggests that the way information from the head is incorporated into the perception of gaze direction might be dependent on the task at hand.

Perceptual face-categorization constraints imposed by duration of stimulus presentation and inter-stimulus interval

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Fast periodic visual stimulation (FPVS) combined with electroencephalogram (EEG) has unique sensitivity and objectivity in measuring rapid visual perception processes (Rossion, 2014; Rossion et al., 2015). FPVS-EEG constrains image processing time by presenting stimuli for brief durations and using short inter-stimulus intervals, although the relative impact of these two parameters is largely unknown. Here, natural object images are presented at a rate of 10 images per second (10 Hz), with faces appearing every one out of ten images (1 Hz), leading to two distinct frequency-tagged EEG responses. We test 12 observers with three square-wave image presentation comparisons: 1) a traditional 50% duty cycle: images are presented for 50 ms, separated by a 50-ms ISI; 2) 100% duty cycle: images presented 100 ms with 0 ms ISI; 3) 100% duty cycle at a 20 Hz presentation rate: images presented 50 ms with 0 ms ISI. Results for the first two conditions at 10 Hz show similar face-selective responses at the face-presentation frequency and its harmonics, with maximal responses over the right occipito-temporal scalp region. However, the face-selective response significantly decreases in the 20 Hz 100% condition, indicating that decreasing the time between images by reducing the ISI impairs face categorization. Moreover, the 100% conditions' response onset is delayed by about 20 ms over the right occipito-temporal region relative to the 50% condition. Thus, immediate forward-masking is shown to delay high-level response onset. These results may be taken together as evidence that FPVS-EEG is able to tightly constrain perceptual image categorization.

The three-quarter face view in yaw and pitch: Generalising within and across axes.

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Viewpoint dependent effects on the recognition of faces viewed from above or below (pitch rotations) appear to be qualitatively different to those for faces viewed rotated left or right (yaw rotations). The current study investigated whether these differences are a function of generalising from front face views or whether this pattern of results remains when generalising from "three-quarter" views rotated in either the pitch or yaw axis. Four groups of participants completed a sequential matching task in which they were asked to match either a: (i) 45° yaw right, (ii) 45° pitch up, (iii) 45° pitch down, or (iv) front/0° face view to one of 21 different test views rotated in either axis (0°, 15° – 75° left and right yaw, 15° – 75° pitch up and down). Matching performance patterns varied significantly across groups: generalisation depended upon the angle and the axis of rotation of both the initial and test views. Generalisation from three-quarter pitch views was relatively poor for all test views except those within 15° of the initial view. However, generalisation was considerably better from three-quarter yaw and front views to all other test views except 75° pitch up. These results highlight the importance of the three-quarter yaw view and suggest that face depth and three-dimensional shape information plays an important role in face recognition.

Material dependent appearance effects brought out by natural light environments

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In a previous study we investigated which type of light modes brought out which material qualities. Photos were taken from same shaped objects covered by four canonical material modes (matte, velvety, specular and glittery) and illuminated under three canonical light modes (ambient, focus and brilliance). These twelve stimuli were rated for nine qualities, namely "matte", "velvety", "specular", "glittery", "glossy", "rough", "smooth", "hard", and "soft". Material dependent lighting effects were found.

The aim of the current study was to validate our predictions of light effects on material appearance for generic light environments. In this study, we rendered the four material modes using state-of-the-art surface reflectance models. Based on light field analyses (Xia et al., 2016), three light maps were selected to represent our canonical light modes best among all of the high-resolution light maps from USC, namely the "Glacier", "Ennis", and "Grace-new" for the ambient, focus and brilliance light, respectively.

We repeated the rating experiment with the rendered stimuli. Results from twelve participants correlated strongly with previous results and material dependent lighting effects could be reproduced. For instance, "specular", "glossy", "hard" and "smooth" ratings for the specular mode and "glittery" and "hard" for the glittery mode increased from "Glacier" (ambient) to "Ennis" (focus) and further to "Grace-new" (brilliance) lighting, while "hard" for the matte mode and "rough" and

"velvety" for the velvety mode were rated highest in the "Ennis" (focus) lighting. This suggests that material qualities can be systematically influenced by enhancing or attenuating the corresponding modal components of the lighting.

Hemispheric lateralization of the N170 inversion effect for faces and words

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University of Szeged

Neuroimaging studies revealed that the right fusiform area is crucial for processing faces, while the corresponding region in the left hemisphere is involved in word form perception. These results can be interpreted within the visual expertise framework, associating fusiform activation with holistic processing. A well-documented electrophysiological evidence for the holistic processing of faces is the N170 inversion effect, with larger amplitudes and longer latencies for inverted stimuli. Similar effect was reported for words, although it seems to be less robust as for faces. In our study, we investigated whether the N170 inversion effect differs for faces and words when stimuli are presented in the left or right hemifields. Twenty-five healthy participants performed an orientation decision task with upright and inverted stimuli presented peripherally for either 75 or 250 ms. EEG was recorded at 64 scalp sites. Results showed that the scalp distribution of the face inversion effect is largely bilateral, regardless of presentation time or the hemifield of stimulation. On the other hand, N170 amplitude enhancements for inverted words are sensitive to presentation time and mainly appear over the right hemisphere. Additionally, source reconstruction by low resolution electromagnetic tomography revealed bilateral fusiform activation for upright and inverted faces, while for words, upright stimuli resulted in left hemispheric activation and bilateral maps were observed for inverted words only. In conclusion, the neural background of the inversion effect proved to be different for faces and words, with the right fusiform gyrus being sensitive to inverted but not to upright words.

Lightness contrast and assimilation: Classical effects revisited

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While contrast effects perceived lightness of a surface (target) in the direction away from the reflectance of the neighboring surfaces (i.e. inducers), assimilation has an opposite effect. Previous studies showed that the most influencing aspects of stimulation, favoring occurrence of the two phenomena, were: the spatial frequency of the inducers, reflectance difference and perceived depth between the target and the inducers. However, these findings originate from various studies in which these effects were independently tested using very different stimuli and paradigms. The goal of our study was to test main effects and interactions of significant factors in a single type of experiment, while controlling for the exposure time (3s) and visual angles of targets and inducers. The spatial frequency of the inducers had 3 levels and the reflectance difference was tested on six levels: 2 targets (12 and 28%) x 3 inducers (7, 20 and 33%) reflectance levels. Results showed the significant main effects of target ($F(1,6)=267.188$, $p<.001$) and inducers ($F(2,12)=23.130$, $p<.001$) reflectance, as well as their interaction ($F(2,12)=4.948$, $p=.027$). However, largest reflectance difference did not always produced the contrast and the smallest difference did not always produced the assimilation effect. The main effect of spatial frequency was not significant ($F(2,12)=2.434$, $p=.130$) contradicting previous findings that demonstrated assimilation effect whenever thin and narrow inducers were present. Our results suggest that previous findings on contrast and assimilation obtained in dissimilar experimental conditions are not necessarily directly comparable.

Reflecting and optimizing the terminology of prosopagnosia research

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While acquired prosopagnosia is clearly termed and defined, there have been various terms for non-acquired prosopagnosia since the first published case in 1976. Developmental prosopagnosia (DP) and congenital prosopagnosia (CP) are the main terms for non-acquired prosopagnosia. However, both terms reflect very different issues and imply different causes for prosopagnosia. The definitions of DP comprise cases with early brain damage or people with Asperger syndrome up to cases without any brain damage and cases with potentially genetic causes. Some researchers accordingly prefer to use CP to denote the inability to efficiently code faces without any macro-spatial brain damage. As DP and CP are often used interchangeably, even within one research group, the separation of potentially different phenomena is hard to achieve. One marked difference between recent definitions of DP and CP refers to the assumptions of the onset. Whereas CP is assumed to be apparent from birth, DP refer to prosopagnosia that is present from early age or emerges during the developmental period of face perception. The mere use of different terms and respective concepts and general assumptions has divided the face community vis-à-vis different research agendas and theoretical explanations. A clearer terminology of the entire phenomenon of prosopagnosia including different constructs and terms is very much needed, so we followed a multi-step strategy: 1) compiling all available constructs and definitions, 2) identifying different schools and research agendas in accord to respective constructs and 3) proposing a clear terminology based on the general separation of acquired vs. non-acquired prosopagnosia.

Effects of different luminance levels on population receptive field estimates in primary visual cortex

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Under bright light conditions visual information is processed at the retinal level by cone photoreceptors while under scotopic light conditions visual signals are solely conveyed by rod photoreceptors. Rod initiated vision leads to a decreased

visual acuity, no colour vision and a small central scotoma, marking the rod free foveal zone. In order to maximise sensitivity to low light, there is greater convergence and hence spatial summation in the rod than cone pathway. We sought to examine whether the increased spatial integration that is a feature of the rod pathway is reflected in changes in population receptive field characteristics in primary visual cortex. To this end we employed established population receptive field mapping techniques under four different luminance levels – photopic, mesopic, light and deep scotopic. We then evaluated how the population receptive field size varied in a representation of the peripheral visual field in V1. This representation can be driven by either rods or cones. We found a strong effect of light level on population receptive field size, with the lower, scotopic light levels yielding larger estimates of size than those obtained at mesopic and photopic light levels. Our finding is in line with our hypothesis that neurons that integrate information over larger areas of the visual field are used under dim light conditions than those used under brighter light conditions, and that these effects are observable at the level of primary visual cortex.

The influence of face identity noise on face recognition in healthy subjects and patients with mild traumatic brain injury - an equivalent noise approach

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The impairment of visual functions is a frequent complaint following mild traumatic brain injury (mTBI). It has been shown that mTBIs can affect brain areas involved in face recognition. The aims of this study were two-fold. First, we aimed to investigate how face identification sensitivity is affected by introducing face identity noise to test models of face representation and secondly, to study the influence of mTBI on face identification. To do so, face identity sensitivity was measured as a function of external noise, i.e. face identity noise. Face identity thresholds were measured between a mean face two different identities. The synthetic face stimuli were generated using a software (FaceGen Modeller 3.5) which allowed us to precisely control the amount of identity noise for a given face identity. Various face identity noise levels, e.g. a twin, sibling, cousin or distant relative (four noise levels) were created for each morph level between the mean face and the two individual identities. To estimate the amount of internal noise and efficiency, we applied the equivalent noise paradigm and fit a Linear Amplifier Model (LAM) to the data. Results show that face identify thresholds increase with increasing face identity noise. This result can be explained by a representation of faces in a norm-based, multidimensional face space. Further, face identity thresholds were increased for all noise levels in mTBI patients (N=10). The LAM analysis shows that compared to the control group (N=20), mTBI patients have an increased internal noise and decreased efficiency.

The human visual cortex responds to melanopsin-directed stimulation

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Human daylight vision is based on signals from the three classes of cones. The photopigment melanopsin is also active under photopic conditions and contributes to reflexive visual functions such as pupil constriction. What contribution, if any, melanopsin makes to conscious visual perception is less studied. We used the technique of silent substitution to create spectral stimulus modulations that targeted melanopsin separately from the cones, as well as luminance (L+M+S) modulations with little melanopic contrast. In a series of pre-registered experiments we asked if melanopsin-directed stimulation using pulsed (3 s) spectral modulations around a photopic background (100-200 cd/m2) produces responses within human visual cortex, and characterized the associated perceptual experience. Concurrent infrared video of the consensual pupil response confirmed that the luminance and melanopsin-directed pulses stimulated distinct retinal mechanisms. A response in area V1 to the melanopsin-directed pulses was seen in each of the four subjects. This response scaled with melanopic contrast and was not easily explained by imprecision in the silencing of the cones. Twenty additional subjects then observed the luminance and melanopsin-directed pulses and rated nine qualities of their perceptual experience. Melanopsin-directed stimulation was reported as an unpleasant, blurry, minimal brightening of the stimulus field that quickly faded. In agreement with prior work, the addition of melanopic contrast to the luminance modulation resulted in reports of a brighter stimulus. We conclude that isolated stimulation of melanopsin is likely associated with a response within the cortical visual pathway and with an associated conscious percept.

Does interest equal ability? Probing the association between social motivation and face expertise

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The widely assumed association between social motivation and face processing expertise has proven challenging to quantify in the typical population. This study sought to test directly links between the extent to which faces represent a rewarding stimulus category (in and of themselves) and face processing expertise (Cambridge Face Memory Test performance). We compared the reward value of neutral faces (varying in attractiveness) and houses, assessed via a economics style key-pressing paradigm, in high-expertise (n=52) and low-expertise (n=52) participants. As expected, there was no difference in reward-related responses to the house stimuli. Critically, the low-expertise group were willing to expend effort (i.e., work) to increase viewing times for the face stimuli more than the high-expertise group. In a second study, a new sample of participants (n=60) completed a similar reward task, this time viewing images of attractive and unattractive emotional faces (happy, neutral and angry). As

in Study 1, those participants with relatively lower scores on the CFMT consistently worked to view the faces for longer (particularly happy expressions) than the higher scorers. In a second task run with each participant, we compared the time it took for these same stimuli to break through into conscious awareness in a Continuous Flash Suppression paradigm. Preliminary results indicate faster face break through for participants that performed poorly on the recognition memory test. Together, this intriguing set of findings suggest that the association between social motivation and mature face expertise is a complex one, worthy of further, nuanced investigation.

Top-down and bottom-up neuromodulation over two different visual illusions

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For decades visual illusions have been used as a tool to investigate the properties of the visual system. In parallel, the neural bases of visual illusions have been investigated. Two principal methods have been used: the modification of perception in brain damage patients and the recording of brain activity induced by illusion perception. In general terms, the neuropsychological and imaging techniques suggest that the perception of illusions takes place at low level in the human brain. Here we use a non-invasive brain stimulation technique (tDCS, transcranial Direct Current Stimulation) to verify the bottom-up arising and the top-down modulation of a visuo-spatial illusion (Brentano illusion, BI) and of a brightness illusion (Glare effect, GE). Two groups of healthy subjects were tested with BI and GE while receiving cathodal or sham tDCS to the right or left posterior parietal cortex (PPC) or to the right or left occipital cortex (OC). Results show different effects for the two illusions. For BI, there is an increase of the illusory effect after cathodal tDCS of the right PPC and a decrease after the stimulation of the left PPC. No changes were found for OC stimulations. On the contrary GE was not modulated neither by PPC nor by OC stimulations. These evidences uphold the involvement of attention and its hemispheric asymmetry in modulating the perceptual processing underlying the BI, mediated by PPC and not by OC. GE as a pure luminance gradient illusion does not seem to be modulated by tDCS.

Visualization of beautiful and ugly face representations of individuals

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Osaka University

Facial attractiveness may influence many human social interactions (e.g. promotion, voting, and mate choice). Therefore there are many studies that investigated the facial characteristics influencing attractiveness judgments of faces (e.g. self-similarity, symmetry, and size of eyes). However, it was still unclear whether we have ideal image representation of beautiful/ugly faces, or not. To probe the question, with reverse correlation image classification task, we visualized the beautiful- and ugly-face-image representations (classification images) of each participant without any a priori assumption. For all participants (N = 16), we obtained significant classification images of beautiful and ugly faces. There were large personal deviations among the classification images both in beautiful and ugly faces. In Exp. 2, the same participants evaluated the attractiveness of the classification images of others. We found that one's own classification images well estimated attractiveness scores of the classification image of others. When a face image was similar to one's own beautiful classification image, the attractiveness score was significantly higher than the average. In contrast, when the face image was dissimilar to the own classification image, the score was lower than the average. Significantly opposite trends were observed for the ugly classification images. Our results show that using reverse correlation technique, it was possible to visualize the beautiful/ugly face image representation of individuals. The results suggested that we have beautiful/ugly face image representations and use them to evaluate the attractiveness of human faces.

Light zones in depth

Tatiana Kartashova[1], Huib de Ridder[1], Susan te Pas[2] & Sylvia Pont[1]

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Previously, we (Kartashova et al., ECVP 2016) demonstrated that a difference in light conditions over the depth of a scene (i.e. different front and back light zones) leads to more spread in inter- and intra-observer light inferences than such a difference in the picture plane (different left-right light zones). In order to study perception of light in scenes with multiple light zones more systematically, we created three configurations of two adjacent light zones with light direction differences, in a rotationally symmetric scene. The symmetry of the scene allowed observing each configuration from two viewpoints, so that the border between the light zones was along or across the viewing direction, while the viewed layout of the scene stayed the same. Additionally, we created four base cases in which light was coming from one side, without light zones. The observers were asked to set the light on a spherical probe to make it fit the scene. A probe was either in one of the light zones, or on the border between the zones. The spread of the settings and the angular differences between the settings and the veridical light directions were on average larger for the light zones than for the base cases. Additionally, for two Front-Back light zones conditions we again found strongly increased spreads of inter- and intra-observers settings and that settings in the back light zone often corresponded to the illumination in the front zone. Acknowledgements: This work was funded by the EU FP7 Marie Curie ITN (PITN-GA-2012-316746).

Lack of the other race effect in Malaysian-Chinese population

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The other-race effect shows that people are more accurate recognizing faces from their own ethnic group compared to faces from different ethnic groups. The holistic-based expertise hypothesis posits that, due to experience, people become experts recognizing faces from their own ethnic group; consequently, own-race faces would be processed more holistically rather than analytically. Besides, according to this hypothesis, extensive exposure to other-race faces would also increase the amount of holistic processing, diminishing or even abolishing the other-race effect. This study explores this hypothesis by using participants from a highly multi-racial society and restricting holistic and analytical processing with a gaze-contingent paradigm. Malaysian-Chinese observers were presented with Chinese, Malay, Indian and Caucasian faces. In the window condition, observers were forced to rely on analytical processing by restricting the facial information to the fixated feature. In the mask condition, observers were forced to rely on holistic processing by masking only the fixated feature. In the control condition, there were no restrictions. Results showed no evidence of other-race effect. In addition, regardless of the race of the face, participants' performance was worse in the window condition compared to the mask and control conditions. These results indicate that the other-race effect may be reduced or abolished in a multi-racial population, and, under these conditions, the emergence of holistic face processing can be independent of the race of the face.

Saliency of "Magic Mirror" projected images

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So-called "magic mirrors" have been made in China for over two millennia, as well as in Japan in more recent centuries. Often made of solid bronze, they have a raised image of a scene or object on one side and a smooth, polished slightly convex surface on the other. Careful inspection by eye reveals no features on the smooth, mirrored surface. When the shiny side of the mirror is illuminated by a bright, essentially point source of light like the Sun, the reflected image displayed on a viewing screen shows the features from the opposite (textured) side of the device, as if it were transparent. Hence the name "magic mirror". The first serious discussion of the metallurgical properties of these devices was made in 1932 by Physics Nobel Prize winner Sir William Bragg. More recently, British physicist Sir Michael Berry has done an extensive treatment of the geometrical and ray optics of magic mirrors. However, there appears to be no analysis in the literature of the astonishing perceptual saliency of the projected images. In this presentation, the phenomenon will be demonstrated using several magic mirrors made in China and in Japan. To do this, we employ just recently available ultra bright LED point sources. I will discuss the possible role of Mach Band related effects on the astonishing clarity of the very low contrast projected images – presumably involving local lateral inhibition as well as long-range perceptual effects.

Visual working memory of own- and other-race faces

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Recognition of own-race faces tend to be better than that of other-race faces. Although this other-race effect has been frequently demonstrated with different tasks, whether it is observed when testing in visual working memory has not yet been established. Here we investigated whether visual working memory of own- and other-race faces differs in terms of memory capacity (i.e., how many faces can be hold in memory) and memory precision (i.e., how well a face can be maintained in memory). Using a continuous recall paradigm, participants first saw 3 or 6 target faces shown in different locations, and then either with or without a delay, they were asked to find one target face among a continuum of facial morphs. Their responses showed that they had a higher guessing rate (i.e., smaller memory capacity) for other-race faces than for own-race faces. This was true whether memory was probed with a 4 seconds delay or a 10 seconds delay. However, we found no difference in terms of memory precision between own- and other-race faces. Hence, the other-race effect is also found in visual working memory, but only in terms of memory capacity. These results indicate that the advantage in recognition of own-race faces is caused by higher capacity, but not better memory quality, in encoding these faces into memory.

Are memorable images easier to categorize rapidly and do they survive shrinking better?

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KU Leuven - University of Leuven

Some images are intrinsically more memorable than others (e.g., Isola et al., 2014) but the features making them memorable are not yet well understood. Based on the hypothesis that memorability depends on perceptual organization, we present two studies in which we ask whether (i) more memorable images are also easier to categorize rapidly, and (ii) whether they survive shrinking to thumbnail size better. We used meaningful real-life scene photographs from a previous memorability study (Bylinskii et al., 2015). In the rapid-categorization study, on each trial such an image (32 ms) was presented, directly followed by a mask (80 ms) and a category label. Participants indicated whether the label matched the image. An image's 'categorizability'-score was calculated as the proportion of correct responses on yes-trials. In the shrinking study, a regular-sized image, surrounded by nine thumbnails was presented on each trial. Participants had to locate the shrunken version of the middle image as fast as possible. An image's 'shrinkability'-score was the mean RT across correct responses. Most categories showed high consistency (mean split-half Spearman's ρ up to .90) for both output variables, suggesting these are intrinsic image properties too. However, the predicted correlation with memorability was only observed for shrinkability ($\rho = -.22$), not for categorizability ($\rho = -.05$). To rule out distinctiveness as a confounding variable for the absence and/or presence of the observed correlations, we are currently quantifying the images on that variable. This additional analysis might provide a deeper insight into the current, unexpected pattern of results.

How many faces do people know?

Rob Jenkins

University of York

Despite decades of psychological research into face perception, no one has attempted to estimate the number of faces that individuals know. It is perhaps surprising that such a basic question has gone unaddressed for so long. In linguistics, the number of words that people know (vocabulary size) has been intensively studied, and has clear implications for word reading and other verbal abilities. By analogy, the size of one's vocabulary of facial identities may explain documented variations in face recognition ability. In this talk, I will describe recent work in which we quantify vocabularies of facial identities for the first time. I will report likely upper and lower bounds for this estimate as well as large individual differences.

The possible role of area LO1 in numerical cognition

Marvin Maechler, Wilhelm Malloni & Mark W. Greenlee

Universität Regensburg

Neuroimaging and lesion studies have found a network of brain areas involved in numerical cognition. Parietal as well as frontal areas were found to be active during mental calculation, while a region in the fusiform gyrus has been found to respond selectively to Arabic numbers. We examined brain activation in n = 18 healthy participants, who performed arithmetic operations (addition/subtraction, multiplication/division) during fMRI (Siemens PRISMA 3T, 64-channel head coil). In concordance with earlier studies we found intraparietal and frontal areas to be active during mental calculation. A small region in the fusiform gyrus (e.g. Number Form Area) was active during the presentation of Arabic numerals. Contrary to other studies we observed differences between arithmetic operations bilaterally in the lateral occipital cortex (LO1), a region usually associated with object recognition. Compared to an implicit baseline, LO1 was more activated during addition and multiplication, while it was inhibited (i.e., less active than implicit baseline) during subtraction and division, suggesting a possible role of early visual areas in numerical cognition. Partial regression indicated the existence of a cluster in the right LO differentially sensitive to the solution magnitude. We discuss our findings in the context of the role of LO1 in visual cognition.

Cathodal-tDCS over the human right occipital cortex induces the "Other-Race" effect

Davide Rivolta, Andrea Ivan Costantino, Matilde Titoni, Francesco Bossi & Michael Nitsche

University of East London (UEL)

Neurophysiological aspects that mediate cognition can be causally investigated using non-invasive neuromodulation techniques, such as transcranial direct current stimulation (tDCS). Albeit anodal tDCS (a-tDCS) typically enhances cognitive skills, the role of cathodal tDCS (c-tDCS) in visual cognition is largely unexplored and inconclusive. Here, in a single-blind, sham-controlled study, we investigated the effects of 1.5 mA c-tDCS (20 minutes of offline stimulation) over the right occipital cortex of 86 participants on four tasks assessing perception and memory of both Caucasian faces and objects. Results demonstrated that, compared to sham, c-tDCS does not overall affect performance on the four tasks. However, when participants were divided by race in Caucasian and non-Caucasians, c-tDCS showed a 'face-specific' performance decrease (≈ 10%) in non-Caucasian participants only. Thus, our results demonstrate that c-tDCS can induce the "other-race effect" (ORE) in participants that did not show any ORE before stimulation, and in the sham condition. Our findings add relevant information about the breadth of cognitive processes and visual stimuli that can be modulated by c-tDCS, and have important implications for the potential neurophysiological bases of ORE.

Can metacognition really be dissociated from visual short-term memory?

Timo Stein & Mike Keijser

University of Amsterdam

Most theories of consciousness posit a close link between short-term memory and subjective awareness or metacognition. This notion has recently been challenged by research showing a dissociation between visual short-term memory performance and metacognition as measured with confidence scores. Invisible distractors affected performance and confidence in a delayed cue-target orientation discrimination task in qualitatively distinct ways (Bona, Catteneo, Vecchi, Soto, & Silvanto, 2013). While confidence was impaired by invisible distractors of all orientations, memory performance was only affected when distractor orientations were very different from the memory cue. Given their importance for theories of both consciousness and short-term memory, we set out to replicate and extend these findings. In contrast to these previous findings, Experiment 1 provided no evidence for an effect of invisible distractors on memory performance. Although we found confidence to be impaired by invisible distractors, this effect most likely reflected response biases rather than impaired metacognition. Indeed, when using bias-free measures of metacognitive sensitivity (type-2 signal detection theory), no such impairment was observed. With improved measures of visual short-term memory performance, Experiment 2 did reveal some interference from invisible distractors. However, we again failed to obtain an effect on bias-free measures of metacognitive sensitivity. Together, this indicates that memory interference from invisible distractors is more circumscribed than previously thought. Moreover, previous demonstrations of dissociations between metacognition and short-term memory may have been due to response biases. Rather, our findings provide support for theories assuming a close relationship between consciousness and short-term memory.

Unfamiliar face matching at a virtual reality airport

Hannah Tummon, John Allen & Markus Bindemann

University of Kent

Person identification at airports and borders requires the matching of a passport photo to its bearer. In psychology, this process is studied with pairs of faces, which require identity match (same person shown) versus mismatch (two different persons) decisions. Extensive research demonstrates that performance in this task is prone to error. However, a real life environment is more complex and difficult to control than such simple visual displays. Virtual reality (VR) might provide a means of examining face matching under conditions that allow stimuli and environment to be controlled but also realistic. A series of experiments explored this possibility, by examining face matching with VR avatars that were derived from photographs of real people. An initial matching experiment of avatars versus photographs showed that the avatars captured the identity of the source image (Experiment 1), and can be matched to a different image of the same person to an above chance level (Experiment 2). Avatar matching also correlated with performance on established face matching tests, both for face-face (Experiment 3) and face-body comparisons (Experiment 4). These findings held when avatar identity matching was assessed in an immersive VR airport environment (Experiment 5). The potential of virtual reality as a method for investigating face matching in complex environments is discussed.

The influence of cardiac signals on visual sampling and memory performance

Stella Kunzendorf, Felix Klotzsche, Mert Akbal, Arno Villringer, Sven Ohl & Michael Gaebler

Max Planck Institute for Human Cognitive and Brain Sciences

Cognition and perception vary with cardiac phase: visual sensitivity (Garfinkel et al., 2014), microsaccade generation (Ohl et al., 2016), and memory judgments (Fiacconi et al., 2016) differ between processing in systole vs. diastole of the cardiac cycle. In the present study, we investigated whether people prefer visual information to arrive at certain points of the cardiac cycle and whether, in this scenario, memory performance is influenced by cardiac phase. During encoding, 47 young, healthy participants (23 female, age: 26±4 years) clicked through 120 emotional pictures (Wessa et al., 2010), which they were asked to memorize. Critically, by button press observers prompted the onset of the next picture (stimulus duration: 100 ms). In the recognition phase, they indicated for each picture (60 old, 60 new) whether they had seen it before. Simultaneous electrocardiography was recorded to analyse behaviour relative to the cardiac cycle. Performing circular analysis, deviations from uniform distributions were assessed with Rayleigh tests. We found a trend of self-chosen stimulus presentation in the early phase of the cardiac cycle. Memory performance specifically for negative pictures was not uniformly distributed across the cardiac cycle: they were more likely to be recognized when presented around the heartbeat during encoding. We show that self-paced visual sampling and recognition of negative pictures vary across the cardiac cycle. While the physiological pathways remain unclear, baroreceptor signalling may be implicated (Garfinkel & Critchley, 2015). These results contribute to recent findings that bodily fluctuations influence mental processes including visual memory.

Newborn chicks show lightness constancy despite a change in either illumination or background.

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Ten white leghorn chicks, average age 11 days, were trained to peck a middle gray door within a testing chamber containing 3 doors (white, gray, and black) embedded in a uniform white wall. In the test phase, a shadow was cast across the wall so that the white door now had the same luminance as the gray door had during training. Out of 10 trials each they chose the gray door 88% of the time, the black door 22%, but not once the white door. But did they choose the door with the same reflectance (as during training) or the door with the same door/wall luminance ratio? Ten additional chicks were trained in the same way, but for the test phase the shade of the wall surrounding each door was changed (using Munsell values 9.5, 4.0, and 2.0), rather than the illumination level. Now the black door on the gray background had the same luminance ratio as the gray door during training while the gray door had a different luminance ratio. Out of 10 trials they chose the gray door 78% of the time and the door with the same door/wall luminance ratio only 3% of the time. Locations of all door and wall shades were randomized. Thus newborn chicks apparently show both illumination-independent constancy and background-independent constancy, just as humans do, undermining lightness theories based on past experience or high level cognition.

Three-dimensional space representation of morality concepts

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ABSTRACT Conceptual Metaphor Theory contended that abstract concepts are represented by concrete experience. In the present studies, we examined the association between morality concepts and three-dimensional space by lexical decision task. In Study1, judgments were faster when word valence and vertical position were congruent (moral-up, immoral-down). In Study2, Left–Right congruency effect was only true for moral words (moral-right, but not immoral-left). In Study3, judgments were facilitate when words appeared correspond to Front–Back Congruency. The studies suggest that, people automatically assume that up, right and front is moral, whereas down, left and back is immoral. Keywords: conceptual metaphor, moral concept, space

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Internal but not external noise frees working memory resources

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Visual working memory can be characterized as a limited resource that governs the precision with which information is stored. Typically, if one item is stored more precisely, another must be stored with lower resolution. We investigated how the sensory strength of memoranda affects resource allocation in a working memory task. We presented participants with pairs of orientation stimuli, one with fixed low noise and the other with noise that varied from trial to trial. In Experiment 1, we varied internal (sensory) noise by manipulating stimulus contrast, while in Experiment 2 we varied the external (stimulus) noise by manipulating the within-stimulus variability. In both cases increasing noise decreased the precision with which the noisy stimulus could be recalled, but the two manipulations differed in their impact on memory precision for the other stimulus. Increasing the internal noise of one stimulus improved the precision of storing the other. Increasing the external noise, however, had no such effect. We show that these observations can be explained by a neural model of working memory encoding, in which spiking activity takes on the role of the limited resource. External noise causes the encoded stimulus value to vary but does not affect the gain (mean spiking) of the neural population encoding it. In contrast, in the internal-noise condition the gain decreases with decreasing stimulus strength, "freeing up" neural resources to encode the other stimulus.

Perception of expressive body movements by individuals with autism spectrum disorder

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Individuals with autism present impairments in social interaction and communication. Little is known about how music and dance are processed by these individuals, especially regarding the expressive and perceptual properties of such signals. The present study investigated the perception of biological motion by individuals with Autism Spectrum Disorder (ASD) in point-light displays depicting dance. Adult participants with ASD and a matched typically developing control group watched point-light displays (1-5 seconds long) depicting expressive and inexpressive dance movements in visual-only, audiovisual-congruent (i.e., synchronous music to movement) and audiovisual incongruent (i.e., asynchronous music to movement) conditions. The task was to identify the dancer's intended expression intensity (i.e., expressive vs. inexpressive). A signal detection analysis indicated that expressive body movements were identified reliably even for displays of 1s, and equally well in both ASD and control groups, with discrimination accuracy improving with increasing stimulus duration. Accuracy did not differ across visual-only, audiovisual congruent, and audiovisual incongruent conditions. Although individuals with ASD scored significantly lower than controls on self-report empathy and alexithymia scales, no relation between these measures and perceptual discrimination accuracy was found. The results are discussed in relation to the potential of music and dance signals to stimulate the latent communicative skills of ASD individuals.

Imagery of distant places: Interaction of visuospatial working and long-term memories

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In the representation and mental imagery of distant places, egocentric perceptions of views from a place interact with allocentric long-term memories. For example, Röhrich et al. (PlosOne, 2014) had participants sketch a map of target locations from various interview locations in an outdoor environment. As result, orientations of the sketch map productions depended significantly on distance and direction of the interview location from the target location.

Here, we develop and test a new experimental paradigm for assessing the orientation of imagined distant places to better understand the interaction and transition between the position-dependent spatial working memory and position-independent long-term memory and the influence of the current position and orientation on the working memory of space.

We repeat the Röhrich et al. experiment in virtual reality and also test the influence of body orientation. Subjects are seated in a rotating chair, wearing an Oculus Rift head-mounted display showing familiar city locations in virtual reality. They are asked to imagine a place close-by but out of sight from the location displayed in virtual reality and then to draw what they have imagined on paper. We expect subjects to draw the imagined location more often from a direction of approach in reality when oriented towards the imagined location, and more often from a general, position-independent view when oriented away from it.

Effects of motion picture frame rate on image quality

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Modern digital cinema supports much higher frame rates (HFR) than the traditional 24 frames per second (fps). Theoretically, higher fidelity should allow viewers to see more detail. We filmed image sequences of a male and female actor (in different costume) at all combinations of two resolutions (2k and 4k), three frame rates (24, 48 and 60 fps), and two shutter angles (180º and 358º). We asked viewers (N = 26) to watch 20-s movie clips and to rate (1) the image sharpness and (2) the quality of the motion.

Motion quality and image sharpness ratings improved with increasing frame rate, especially from 24 to 48 fps. The ratings of sharpness for 180º shutter angle were higher than for 358º, consistent with the expectation of more motion blur in the latter. The benefit of higher resolution depended on frame rate: at 24 fps, ratings of sharpness for the 4k sequences were similar to, or even lower than, ratings for the 2k sequences. We propose that motion blur was more apparent in the low frame rate 4k imagery because it could be

compared with high resolution, static, portions of the same image.

Our results show that naïve observers perceive enhanced detail in moving fabrics and costumes in HFR film. This improved perception of detail could underlie both the positive and negative reactions to HFR film, depending on the nature of the content and whether it lends itself to such high fidelity.

Decoding attended and unattended items in working memory: No evidence for activity-silent memory representations

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Working memory enables retention of a limited number of stimuli differently prioritized depending on current goals. In prior work, attended memory items (AMIs) were found to be represented in a form of brain activity patterns which can be decoded using multivariate pattern analysis (MVPA). Unattended memory items (UMIs) that are less relevant during the task, however, could not be decoded even if they could be recalled. These findings lead some to postulate that working memory operates in an activity-silent state using short-term synaptic plasticity. We revisited this question using (a) a much larger sample size, (b) an experimental design cleanly separating AMIs and UMIs and (c) a more comprehensive set of brain regions. In each trial, participants memorized the orientation of two gratings. A first cue indicated that one of them should be used for a first orientation change discrimination task after a delay. Then, a second cue could select either the same or the other orientation for a second task. Such a double-cuing task forces participants to maintain the orientations of both gratings until the second cue, but directs attention to the cued item (AMI). We used multivariate pattern analyses (cvMANOVA MVPA) to measure the distinctness of brain activity patterns evoked by maintenance of AMIs and UMIs. Consistent with prior work, visual areas (V1-V4) carried information about AMIs, but not UMIs. However, more anterior regions (IPS and FEF) carried information about both AMIs and UMIs. These results demonstrate that UMIs are retained in an active (not an activity-silent) state.

Exploring the effects of contrast on optic flow-parsing

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Background. Extensive evidence suggests that a neural flow-parsing mechanism filters out retinal motion due to self-movement in order to aid assessment of salient scene-relative object movement. Parallel research on the spatial summation phenomenon suggests the existence of a low-level mechanism with a similar function – filtering of irrelevant background motion. Are these mechanisms related? Spatial suppression depends strongly on stimulus contrast so here we investigated the effects of contrast on local and global motion contributions to flow-parsing.

Method. Observers (N=6) fixated the centre of a field (40° x 30°) of radial flow consistent with forwards self-movement through a dot cloud, together with a probe moving upwards (displaced ±2° horizontally from fixation). To investigate local and global motion processing we presented flow either only inside (local) or only outside (global) a probe-centred aperture with variable radius (0°, 1°, 1.5°, 2°, 3°, 5°). Flow dot contrast was 100% or 4%. After each trial participants reported perceived probe trajectory by adjusting an onscreen paddle.

Results. In global conditions perceived trajectories were significantly biased (by around 20°-25°) consistent with flow-parsing to subtract radial flow globally. These effects showed little dependence on flow contrast or aperture size. In local conditions, perceived trajectory bias grew with aperture radius and there was greater evidence for an effect of contrast.

Conclusions. Global flow-parsing appears remarkably robust over a wide contrast range. We suggest that low-level mechanisms underpinning spatial suppression are distinct from those supporting global flow-parsing but may be implicated in local motion contributions to parsing.

Cognitive strategies for solving graphically presented chemical tasks

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The purpose of our work was to identify differences in the way information is processed in visually presented graphical chemistry tasks in experts and novices. It was assumed that experts solve problems faster and make fewer errors, using fundamentally different cognitive strategies. Cognitive strategies were identified through the analysis of eye movement patterns.

In total, 35 people took part in the experiment, 18 of them were novices (undergraduate chemistry students) and 17 experts (specialists in chemistry, with work experience of 15 years and more). The study consisted of two stages. First, the subjects were asked to read a text describing a chemical process, then, using information from the text and the answers, they had to solve the problems in the form of graphs: fill empty cells in the circuits; indicate errors; swap individual elements to maintain the correct structure of the chemical process. Time was unlimited both at the stage of reading the text, and at the problem solving stage.

Expert chemists were significantly faster in solving graphically presented tasks. In addition, it was found that eye movements of the experts were characterized by longer fixation duration and shorter saccadic amplitude, which indicates deeper cognitive processing. Novices solve problems slower using less effective strategies, which is manifested in shorter fixations and high-amplitude saccades. Significant distinctions were found in amount of correct answers in task solving graphs: experts have more correct answers. Differences in indicating errors graphs weren't detected. The study was sponsored by the RFBR; research grant №17-06-00652

Two-point resolution evaluated with apparent motion

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An investigation of the phenomenon of apparent motion occurring in laser beacons (Savelyev, 1989) motivated us to call attention to the problem of visual acuity. The challenge has been in a direct psychophysical measurement of the two-point resolution. A dedicated two-LED stimulator was developed. Two point light sources are observed through the beam splitting cube. The luminance of the each light point is approximately 4000 cd/m2, the angular size is 7 arcsec at a viewing distance of about three meters. The angular distance between light points is accurate to 1 arcsec, and controlled with a stepper motor. To eliminate the effect of eye movements, the 12 ms flash duration was selected. Two experiments were performed: 1. Estimation of the discrimination threshold. Two light points were presented simultaneously. Subjects were asked whether they observed 1 or 2 points. The resulting thresholds were in the range 80 -100 arcsec for several subjects. 2. Measurement of the apparent motion thresholds. Two light points were presented with time delays 0, 20, 40 ms. The subjects answered whether a movement was occurred, and assessed its direction. The following motion detection thresholds were obtained: for asynchrony 20 ms 60-80 arcsec, for 40 ms 30-40 arcsec. It is known that for stimuli with different spatial size the apparent motion detection thresholds are less than the theoretical resolution threshold. Our findings are in line with these results, but for point stimuli, and coincide with the estimates made under operating conditions of the laser navigation device.

Boundary extension in upright and inverted faces

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Sabanci University

Boundary extension is a common false memory error, in which people confidently remember seeing a wider-angle view of the scene than was viewed. The present research explored boundary extension in face images. During the encoding, participants observed photographs of faces, cropped either in a forehead or in a chin area. Subsequently, they performed face recognition through a forced choice selection. The recognition options represented different degrees of boundary extension and boundary restriction errors. Participants completed the task with either upright or inverted faces. Eye-tracking and performance data were collected. The results demonstrated boundary extension effect in both, upright and inverted, conditions. Furthermore, the present work provided evidence of asymmetry of boundary extension. In the upright condition, boundary extension errors were more pronounced for forehead-cropped than for chin-cropped faces. Vice versa, in the inverted condition, boundary extension errors were more pronounced for chin-cropped than for forehead-cropped faces. Thus, boundary extension was more pronounced for images cropped in the upper part than for those cropped in the lower part, independent of whether the face was inverted or normally oriented. The examination of oculomotor behavior during the encoding showed that in both, upright and inverted, conditions, a greater attention was paid to the upper part of the face. While both 'eyes' and 'mouth' regions were the most salient regions, for the upright faces, 'eyes' attracted more attention than 'mouth'; however, for the inverted faces, 'mouth' regions attracted more attention than 'eyes'. These results suggest that boundary extension could be affected by attention.

Fast random motion biases judgments of visible and occluded motion speed

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Speed discrimination of either visible or invisible objects is very precise, and yet speed judgments may be biased by events, concomitant or not. We investigated how dynamic visual noise (DVN) that looks like a detuned TV affects the sensitivity to either visible (Experiment 1) or invisible target speed (Experiment 2). In experiment 1, nine students judged in a 2IFC task, whether a moving circle was faster when moving in front of a static (SVN) or a dynamic visual noise (DVN). In experiment 2, eighteen students judged, whether a moving target that disappeared for a brief duration behind a rectangle of SVN or DVN (invisible motion), reappeared early or late. Psychometric functions were fitted to the proportion of "faster" (Experiment 1) and "late" (Experiment 2) responses. We found that DVN affected the point of subjective equality (PSE) in a way indicating speed overestimation, without affecting speed discrimination threshold (or just noticeable differences, jnd). According to recent models, we suggests that DVN, whereas it does not affect speed encoding, it affects speed decoding by non-sensory mechanisms, thus producing a response bias in favor of the target that moved in front of or behind the DVN, when the two target had similar speed.

Test-retest comparison of current source density estimates obtained using magnetoencephalography and electroencephalography during a visual short-term memory task

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It has been debated whether current source density estimates for magnetoencephalography (MEG) are reliable than that for electroencephalography (EEG) while various types of inverse-solutions are proposed to date. Systematic and quantitative validations of source estimation methods are missing, particularly on neural activities for higher cognitive function. We quantitatively evaluated test-retest reliability on three estimation methods on both MEG and EEG, namely variational Bayesian multimodal encephalography combined with the minimum-norm algorithm (vb-MN), the minimum-norm algorithm alone (MN), and the beamformer algorithm alone (BF).Reproducibility of neural sources as well as behavioral accuracy were quantified from pairs of data sets obtained by performing the same match-to-sample visual short-term memory task with one or four target items

on different days. As was expected, both MEG- and EEG-derived current source estimates revealed activations in the intraparietal and intraoccipital regions, accompanied by a load-dependent manner. A comparison of the reproducibility of the current maps revealed that MEG was superior to EEG when the MN or vb-MN methods were used, while the trend was marginal with the BF. In addition to the spatial reliability, we extended the test-retest reliability on a load-dependent effect. As it turned out, the reproducibility of load-dependent effect in the intraparietal sulcus estimated with MEG was significantly or marginally better than that with EEG when current sources were estimated by MN or vb-MN methods, respectively. In contrast, we did not find statistical differences between MEG and EEG on the reproducibility of load-dependency effect in the in the intraoccipital region.

Temporal dynamics of a perceptual decision

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The stream-bounce effect refers to an ambiguous motion sequence that can be interpreted as two intersecting targets either 'streaming' past or 'bouncing' off one another. The presence or absence of a brief tone at the moment of target coincidence acts to polarize response patterns such that observers report mostly bouncing in the presence of the tone and mostly streaming in its absence. Previous research suggests that cognitive factors acting in a top-down manner influence the resolution of these displays as either streaming or bouncing. To better understand how such influences may be occurring, we have investigated when they may be occurring.

We have developed a novel approach that allows us to track responses to stream-bounce stimuli dynamically over the entire course of the motion sequence rather than simply collecting a subjective report after the fact. Using a trackpad we had participants control a cursor to track a stream-bounce target actively from start to end and measured tracking speed throughout. Our paradigm replicated the usual result that sounds induce a bouncing bias. Further, we found significant behavioural differences between streaming and bouncing responses during the 500ms before coincidence of the targets and presentation of the sound. Specifically, for trials in which the sound was presented, tracking speeds were significantly slower during this early period for bounce compared to stream responses. We suggest that this may reflect a cognitive expectation of a particular outcome that then biases the interpretation of sensory input to favour that forthcoming percept.

TMS-induced disturbance of self-motion perception

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In everyday-life we need to judge our self-motion direction (heading) accurately in order to interact with our environment. Previous studies have emphasized the role of monkey and human medial superior temporal area (MST) in self-motion processing. A previous study combining monkey neurophysiology and human psychophysics has provided evidence that saccadic eye movements modulate perceived heading. In this neuronavigated transcranial magnetic stimulation (TMS) study we investigated whether TMS over human area MST can mimic the effect of saccades and induce disturbance of heading perception. We presented an optic flow stimulus (random dot pattern) on a large projection screen 54 cm in front of the participants. In a given trial, the stimulus first was stationary, then moved for 50 ms, simulating forward self-motion across a ground plane in one of three directions separated by 30°, and was stationary again. Participants fixated a central target throughout the trial. After each trial, participants had to indicate perceived heading direction. In 57% of the trials three TMS pulses were applied, separated by 100 ms each, centered on self-motion onset. TMS-stimulation site was either right-hemisphere MST, which we identified using an fMRI localizer, or a control area 1.5 cm posterior to human MST. TMS over MST increased response variance of perceived heading. Remarkably, and as predicted by our model, this result was strongest for simulated self-motion to the left (contraversive). Our results provide evidence for a role of response suppression (as induced by saccades or TMS) for the modulation of perceived heading.

Olfactory stimulation affects motion perception.

Yoshiaki Tsushima, Yurie Nishino & Hiroshi Ando

National Institute of Information and Communication Technology

Our perceptual system sometimes works not in one-modality but multi-modality, as we say, multi-sensory perception. There are a great number of multi-sensory perception researches, vision-auditory, vision-tactile, and so on. However, vision-olfactory perception remains largely unexplored. Does olfactory stimulation alter our visual perception? Here, we conducted the visual motion perception experiments with olfactory stimulation. Eight people who had normal/corrected vision and normal olfaction participated in a series of psychophysical experiment. In a trial of the main experiment, participants viewed expanding motion dots for 1.0 sec after releasing three kinds of aroma for 1.0 sec, lemon, vanilla, or odor-free air. Participants were asked to reported motion dots speed, slower or faster. There were seven different motion speeds presented on the computer display, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, and 6.0 degrees/sec. As a result, we found that participants felt motion dots with the smell of lemon slower than ones with odor-free air, and that they also felt ones with odor-free air slower than ones with the smell of vanilla. These results clearly suggest that our visual perception is influenced by olfactory stimulation. This finding might help us understand not only our vision-olfactory multi-sensory system itself but also naturally endowed multi-sensory system such as synesthesia.

Men's perception of women's personality from static and dynamic visual cues.

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University of Bamberg

Research has documented that attractive individuals are often considered to have desirable personality traits. Most studies reporting such relationships have investigated facial attractiveness in relation to self-reported and perceived personality. Here we expand on this research by investigating women's self-reported personality in relation to men's attractiveness and personality assessments from facial photographs in addition to that from dance movements. Facial photographs and short video clips of dance movements, visualized in the form of point-light displays, were collected from 31 women aged 18-31 years. A sample of 102 men aged 19-40 years judged both types of stimuli on attractiveness and on the Big Five personality traits. For both types of stimuli, men's assessments of female personality did not correlate with women's self-reported personality. Additionally, attractiveness assessments correlated positively with perceived extraversion, openness, conscientiousness and agreeableness, and negatively with neuroticism. Our data are in accord with previous studies documenting a positive relationship of attractiveness judgements with personality, but indicate that women's (self-reported) personality cannot be assessed accurately from facial photographs or dance movements. We discuss these results with references to literature on the role of human body movement in social perception.

Partially overlapping visual and auditory spatial representations revealed by sensory augmentation

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Visual-to-auditory sensory substitution (SS) was envisaged as a tool to allow visual impaired people to perceive distant and silent objects through audition. Additionally, SS is used as a research tool to gain information about how objects and space learnt through audition are represented by blindfolded sighted individuals. Usually, in these experiments representations arising from audition are compared to those arising from vision, to detect commonalities and differences. Rather than substituting a sensory modality with another, recent studies are investigating whether SS can be used to augment input by using vision plus SS. In Experiment 1, participants stood in the centre of a set of objects, and learnt the position of the objects located before them by using audition (sensory substitution), and the position of the objects located behind them by using vision (a mirror was used). In Experiment 2, experimental conditions were inverted; vision was used for the objects located before the participants, and audition was used for the objects located behind. In both experiments, after the learning phase, a perspective-taking task was administered to investigate visual, auditory, and multisensory (audio-visual) spatial representations. Independently from the sensory modality, objects located before the participants were represented more accurately than objects located behind. This suggests that vision and audition are equally able to represent the location of the objects. Same representation? Multisensory representation was more accurate in Experiment 1 (audition ahead and vision behind) than in Experiment 2 (inverted conditions), suggesting that visual and auditory spatial information is differently represented.

Individual differences in social perception and cognition related to autistic traits

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People with high autistic traits and Autism Spectrum Disorder (ASD) have difficulties in interacting socially with others. This could be due to difficulties in correctly perceiving and interpreting social signals and/or to differences in social cognition abilities. In the following three experimental paradigms we tested whether variations in autistic traits (autism quotient, AQ) in healthy student populations were related to individual differences in social perception and/or cognition: 1) classification and classification learning of dynamic facial expression stimuli; 2) task interference during the perception of biological motion stimuli depicting social interactions; and 3) deciding whether to engage in a simple game involving social or non-social feedback. We found that 1) AQ correlated significantly with classification accuracy of complex everyday expressions; 2) people with higher AQ traits showed a greater performance decrease as a result of task interference during perception of social interactions than people with lower AQ traits; and 3) people with higher AQ traits avoided engaging in a game involving social feedback even when this led to a monetary disadvantage, while people with lower AQ traits sought those situations (no such effects were found with comparable non-social feedback). Our data show that even in healthy student populations, variations in autistic traits are reflected in differences in several aspects of social perception and cognition.

Shorter response time with a warm hand for "warm" stimuli: The compatibility effects between "warm-cold" visual stimuli and hand temperatures

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The current study examined the stimulus-response compatibility effects between visual stimuli that are physically and psychologically "warm-cold" and physical temperatures of participants' hands. Before each experimental session, participants were asked to immerse one hand in warm water and the other hand in cold water. In Experiment 1, either a "warm" or "cold" landscape picture (e.g., fire or snow) was presented in each trial. Participants were instructed to respond by pressing designated keys as fast as they could, using a warm hand for "warm" landscape pictures and a cold hand for "cold" landscape pictures (consistent trials), or using a cold hand for "warm" landscape pictures and a warm hand for "cold" landscape pictures (inconsistent trials). The results showed that the average response time in consistent trials was shorter than in inconsistent trials. In Experiment 2, a photograph with either a happy or sad face (suggesting

psychological warmth and coldness, respectively) was presented in each trial, with other procedures being kept similar to those in Experiment 1. The results indicated that the average response time in consistent trials was significantly shorter than in inconsistent trials for happy faces, and a similar tendency was obtained for sad faces. Therefore, the results of the two experiments revealed the stimulus-response compatibility effects between visual stimuli that are physically and psychologically "warm-cold" and hand temperatures. Our findings suggest that the information regarding physical and psychological warmth-coldness is interrelated (e.g., Williams & Bargh, 2008) and this information is shared between perceptual/cognitive and motor production systems.

Stairs or ramps: Gender difference in route selection

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Numerous research finds that when encountering two divergent routes leading to the same destination, humans tend to apply different walking heuristics for the route selection, such as deferring the decision, initial segment strategy, adhering to the direction of destination, etc. The route selection is significantly biased in various conditions even when two routes have the same distance. In this paper, we explore another kind of route selection by examining whether people tend to take stairs or ramps when proceeding to roads with steep grades. 2,133 pedestrians data were collected from Zurich city (Switzerland) which has many stairs alongside the ramps to help travelers. The gender, selection (stair or ramps), and proceeding direction (climbing up or down) of the travelers were recorded. Travelers with wheel trolley suitcases or wearing high heel shoes were excluded from the records. The results shows that both males and females prefer stairs (M: 65%; F: 81%) than ramps (M: 35%; F: 19%) when climbing up the road. The Pearson chi-square test reveals significance of the crosstab. Obviously, females show a stronger tendency of taking stairs than males when climbing up the roads. However, an opposite pattern was observed when climbing down the roads. Males prefer to take ramps (55%) than stairs (45%), while females remain prefer to take stairs (70%) than ramps (30%) when climbing down the roads. Chi-square tests were significant for both males and females. The possible reasons of the gender differences in the walking route selections and its application are discussed.

Development of multisensory integration in newly sighted individuals

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Our perceptual world is inherently multisensory and we integrate multisensory signals effortlessly. However, how are multisensory signals integrated if you were deprived from vision during early development? For integration to occur, correspondence between multisensory signals needs to be established. Recent studies in healthy children showed that establishing correspondence (i.e., inferring which signals belong together) is challenging during development, and that it can take years before children integrate multisensory signals optimally. We investigate multisensory integration in Ethiopian children who were classified congenitally blind as they suffered from dense bilateral cataract during early postnatal development and were surgically treaded years later (5-19 yo), enabling them to "see". How do these children integrate visual signals with other information? Different alternatives were considered: 1) Is their developmental path for multisensory integration identical to those of healthy children, which would indicate that multisensory integration develops independent of the sensory input? 2) Is their developmental path time-shifted by a period that corresponds to the duration of deprivation? This would indicate that sensory experience is the critical factor for development. 3) Is there a critical period for multisensory integration to occur and if deprived during that period multisensory integration does not develop normally? Surprisingly, initial results from a series of perturbation experiments including different sensory modalities indicate that sight-recovered children integrate multisensory signals in a similar fashion as do typically developing children, thus favoring the first alternative. Overall, sight-recovered individuals weigh vision systematically less compared with typically developing-children, which likely reflects their reduced visual acuity.

Sensitivity of visual motion to two stimuli presented in peripheral vision with horizontal eccentricities of 20° to 50°

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We examined the minimum motion distance threshold (MMDT) for motion stimuli presented in peripheral vision. Two white circular stimuli with luminance modulated with a Gaussian function were presented at horizontal eccentricities of 20° to 50°, at 10°-steps. One of the stimuli visually vibrated at frequencies of 1, 2, and 5 Hz. Movement stimulus was presented at one of the bilaterally symmetrical positions from the fixation point, and static stimulus was simultaneously presented at the other. The subject observed the stimuli with binocular vision and indicated whether the left or the right stimulus was moving using two keys. Eye movements were measured using an electrooculogram (EOG) for checking gaze. A stimulus was presented based on the forced-choice tracking method and the MMDT was obtained. Our results showed that: 1) the MMDT increased as the eccentricity increased under the 1 Hz condition, 2) the MMDT at 1 Hz was significantly larger than that at 2 and 5 Hz. 3) Under the 1 Hz condition, the increase in the MMDT was higher than that at 2 Hz and 5 Hz, and as the eccentricity increased, the difference from the 2 Hz and 5 Hz conditions increased. From these results, we cannot explain the change in the MMDT with eccentricity only by the reducing retinal rods. We suggest that the visual information processing beyond retinal cells [e.g., vision for action (Milner, A. D. and Goodale, M. A.; 2008)], may have influenced the results of this experiment.

Virtual insanity – perceived distance anisotropy in virtual and physical reality

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Distance perception is anisotropic in that sense that distances on vertical direction, towards zenith, are perceived as longer than physically equal distances on horizontal direction. This anisotropy relies on multisensory integration from visual, proprioceptive and vestibular system and it is explained through relation between action and perception. If perceived distance anisotropy depends on multisensory integration it is interesting to investigate whether it would appear in virtual reality displays, too. First two experiments were done in dark gym, on 14 participants in upright position and 13 participants lying on their left side. In last two experiments we used virtual reality display, Oculus Rift DK2, on 17 participants in upright position and 14 participants lying on their left side. In all experiments participants visually matched stimuli distances on vertical and horizontal directions, and changed viewing direction by moving their head. In upright position, during the task vestibular and proprioceptive information changed, and if participants were lying on side, proprioceptive information changed only. Stimuli were set on three standard distances 1m, 3m and 5m from the observer. Results from all experiments show significant effect of stimuli distance (further stimuli are perceived as further), direction (vertical distances are perceived as larger than horizontal) and interaction of the two (on further distances anisotropy is larger). If only proprioception changed (lying on the side) anisotropy effects were smaller. We can conclude that combination of vestibular and proprioceptive information produced larger anisotropy effects, while there were no differences between physical and virtual reality setups.

A predictive retinal map for perceptual stability and efficient coding

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Even during fixation, the retinal image is continuously moving and changing due to self-movement. Despite this our perceptual experience is of a rigid and unchanging environment against which objects that change in size or position are detected effortlessly. What underpins this process? There have been a number of proposals, for example that perceptual stability relies on keeping track of a few key points in the scene; that extra-retinal information is used in a compensation process; that retinal motion due to self-movement is parsed out; that retinal motion due to self-movement is discounted; that the tuning of receptive fields changes dynamically to compensate for eye-movements. I will outline an alternative. Traditional models of motion processing assume a hierarchical progression from motion detection up to identification of global motion (optic flow). I suggest an inverted model. Here low-level local motion detectors serve as dynamic memory that can shift information across space; global motion templates select specific local motion detectors and so predict the upcoming retinal input at each location. Discrepancies between the predicted and detected input indicate changes in object position, orientation, size, shape or appearance. Processing resources can thus be devoted to these discrepancies.

"Aha"ptics: Experiencing and enjoying an aesthetic aha during haptic exploration

Claudia Muth, Sabine Albrecht, Slobodan Marković & Claus-Christian Carbon

Perceptual insights, e.g. recognizing a hidden figure, is known to increase the appreciation of a visually perceived object—this so-called "Aesthetic Aha" effect (Muth & Carbon, 2013) is independent of the valence of the material (Chetverikov & Filippova, 2014). Can the Aesthetic Aha effect be transferred to the haptic domain as well? Participants were asked to think aloud during the haptic exploration of 11 visually non-accessible panels representing scenes of a children's story. They explored each of them again four times evaluating it verbally on liking, pleasantness, complexity and interestingness. Afterwards they rated photographs of the panels on the same variables. Three independent raters evaluated the think-aloud protocols on intensity of insight. This strength of insight per stimulus correlated significantly with haptic pleasantness but not with liking. Evaluations on haptic and visual panels correlated significantly and in both domains the correlation between complexity and interest was slightly stronger than between complexity and liking whereas there was no significant link to pleasantness. A multiple regression analysis showed that liking could be predicted by interest and pleasantness for the visual domain whereas for the haptic domain liking depended more strongly on pleasantness. Our study transfers the Aesthetic Aha effect to the haptic domain and reveals slight differences in the affected hedonic quality: Instead of a link between insight and liking, we revealed a link between insight and pleasantness. Liking seems to integrate various hedonic tones whereas pleasantness might be more specific and more central for haptic experience than for the visual domain.

The effect of stimulus intensity on perceived audio-visual simultaneity, temporal order and reaction times.

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Recent behavioural findings suggest that auditory-visual integration mechanisms feed into separate neural streams (Leone & McCourt, 2015). The 'action' stream is proposed to mediate simple reaction time (RT) tasks, and the 'perception' stream, is suggested to underlie simultaneity (SJ) and temporal order judgement (TOJ) tasks – yet prior research suggests that the two 'perception' tasks do not necessarily rely on the same mechanism (van Eijk, Kohlrausch, Juola & van de Par, 2008).

We implemented all three tasks with identical bimodal flash/bleep stimuli with varying stimulus onset asynchronies (SOAs) (-200, -150, -100, -50, 0, 50, 100, 150, 200 msec). Two stimulus intensity conditions were run, in which we adjusted

the flash brightness. In the TOJ task participants indicated which stimulus preceded the other, whereas in the SJ task they decided whether the stimuli occurred simultaneously or separately. In the RT task observers responded as quickly as possible to the onset of the bimodal stimulus.

Our results demonstrate that adjusting light intensity led to a significant shift in the point of subjective equality, in both the SJ and TOJ tasks, but not in the SOA at which participants react quickest in the RT task. Furthermore, we found no correlation between the PSEs and sensitivity measures recorded in the SJ and TOJ tasks. Our results therefore provide support for the proposed separate mechanisms underlying the 'action' and 'perception' tasks. They also highlight the disparity between the two 'perception' tasks. Further results, including an EEG study comparing the SJ/TOJ tasks will be discussed.

Directed inhibition of emotional scenes in iconic memory: Interference of positive information

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Scene gist can be extracted from iconic memory, the vast, but highly fleeting memory storage (Clarke & Mack, 2014). It has also been shown that emotional scenes interfere with the reporting of neutral scenes from iconic memory (Porubanova, Clarke, & Erol, under review). The main question of our study examined whether akin to directed forgetting, one can suppress this interference by being asked to ignore the emotional scene before attention is engaged with a target. Alternatively, perhaps emotional information always engages attention resulting in attentional capture. In the study, we examined participants' ability to actively inhibit emotional scenes of different valence and arousal when reporting on neutral scenes. In three experiments, a 4-scene array was presented for 250 ms while one emotional scene was to be ignored, indicated through a presentation of a pre-cue at the location of the to-be-ignored scene. In the control conditions, the to-be-ignored scene comprised of neutral scenes. To our surprise, negative high arousal scenes seem to interfere the least, while particularly positive high arousal scenes showed the greatest interference. The results suggest that the interference from emotional scenes is a pervasive phenomenon suggesting attentional capture by emotional information. Moreover, despite the vast literature on the evolutionary advantage of preferential processing of negative information, we show the attentional bias toward positive information possible revealing the importance of their reproductive value.

Sound attraction toward non-visual zones in patients with scotoma

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Macular degeneration (MD) is associated with vision loss, cutting inputs on corresponding visual cortical representations. Recent studies suggest that visual cortex is recruited by audition after loss of vision e.g. (Weeks, Horwitz et al. 2000, Gougoux, Zatorre et al. 2005, Poirier, Collignon et al. 2005, Renier, Collignon et al. 2005, Striem-Amit and Amedi 2014). This plastic change can enhance skills of blind individuals to sound localization (Rauschecker and Korte 1993, Elbert, Sterr et al. 2002, Meng, Kao et al. 2015). Here we investigated if the presence of scotoma induced a change in the audio spatial domain of patients with Macular Degeneration (MD). We studied sound localization with a 2D array of speakers in 12 MD patients and 12 age-matched controls while fixating a central point of the array. MD patients tend to report more frequently selective spatial responses. The set of responses was different for different MD patients depending on scotoma positions while it was normally distributed in sighted participants. More importantly the audio localization responses matched with the scotoma position of each subject. These results support the idea that the lack of vision attracts the sound toward the blind zone. We can speculate that this plastic change could involve the recruitment of audio inputs on the visual cortex after the loss of vision. It supports the idea that the recruitment of the visual cortex by audition after loss of vision is a fast plasticity mechanism that starts immediately after vision loss to support multisensory integration.

Scale invariance does not hold for high dynamic range images, but is reestablished by early retinal nonlinearities

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The statistics of real world luminances have been extensively investigated for images captured with single exposure photography, which are therefore of standard dynamic range (DR). One commonly reported feature is that the average Fourier amplitude falls off as a function of one over the spatial frequency, a property that implies the scale invariance of natural images. However, it has been reported (Dror et al. 2001) that this 1/f statistic does not hold for some images with a high dynamic range (HDR). We investigate this topic using a HDR natural image database (Adams et al., 2016) and corroborate that the 1/f law commonly fails for natural images of medium and high DR. We fitted the power spectrum with a second order polynomial and find that the leading term is negatively correlated with DR. For HDR images, this value becomes significantly nonzero making the power spectrum fit concave.Taking these images as input to our visual system, we then study the effect on them of two successive processes: light scattering in the eye, modeled by the eye's point spread function (PSF), and the photoreceptors response, modeled by the Naka-Rushton equation. While convolution with the eye's PSF reduces DR, the resulting images still don't follow the 1/f rule. However, the nonlinearity of the photoreceptors' response ensures that the 1/f statistic is recovered at the retinal level for all images tested.

Development of non-visual multisensory integration in sighted and non-sighted individuals

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To interact with people and objects in our environment in a meaningful way we have to first form a precise and accurate representation of them. Integrating information from multiple senses in an optimal fashion is known to increase perceptual accuracy and precision. However, in typically developing humans the ability to improve precision through integration of sensory cues develops rather late (Gori et al., 2008; Petrini et al., 2014). But what if one sense is lost or absent – does this further delay or accelerate the development of integration in the remaining senses? Here we investigate whether blind and visually impaired individuals, who depend largely on touch and hearing, develop optimal audio-haptic sensory integration, as the absence of vision could lead to a compensatory and early occurrence of audio-haptic integration. By employing a ball size discrimination game and an adaptive staircase method, we asked participants to judge which of two balls was bigger, being given only haptic or auditory information, or both cues combined. We then compared discrimination thresholds of sighted to non-/partially sighted individuals to see whether there are any differences in multisensory precision gain. Preliminary results show that blind adults combine audio-haptic information in an optimal fashion, similar to sighted adults, while sighted children do not. Knowing how and when audio-haptic integration develops in blind individuals is essential to develop successful sensory substitution devices that exploit these two unaffected senses (Proulx et al, 2014), and determine when training and intervention might be possible and optimal.

Human sensitivity to distortions of image structure induced by a deep neural network texture model

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Due to retinal sampling and to pooling in the visual stream, we can be insensitive to distortions of image structure in the periphery. Whether distortions of an image can go unnoticed depends on the image structure. For isolated objects, such as faces or street signs, we expect that small distortions are easily visible for human observers. In contrast, for cluttered and texture-like regions, we expect that even large distortions may not be detected. In our study we induce local perturbations on these two different types of image content by replacing a circular patch of the image by a new patch generated by the texture model of Gatys et al. (2015), which is based on the features of a deep convolutional neural network. Observers discriminated which of two otherwise identical images contained a local distortion (temporal forced-choice paradigm). The distorted patch was always centred at an eccentricity of approx 6 deg and we varied its size. For isolated objects the performance of the observers increases quickly for larger distortions, whereas for cluttered regions the performance of the observers is still close to chance even for the largest distortions tested (9.8 degrees in diameter). We seek to learn image statistics that discriminate sensitivity to local textural perturbations. A feature based on the variability of the power spectra of subpatches, which we term homogeneity, was correlated with both subjective ratings of object / texture content and with psychophysical performance, such that higher homogeneity was associated with poorer performance.

Visual-tactile integration in low- and high-level visual processing: Applications for impaired persons

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When visual and tactile information are presented simultaneously, multimodal interactions can be observed by increased detectability and shorter reaction times than one would expect from the performance in reaction to a stimulus of only a single sensory domain. For instance, we show that vibrotactile signals to the fingers decrease luminance contrast detection thresholds. We find similar effects in high-level tasks, such as the identification of the emotions of faces. Furthermore, rhythmically synchronous visual and tactile stimuli enhance the ability to select and attentively hold a percept of an ambiguous stimulus. To test whether these fundamental research findings can be applied to help impaired persons we conducted several clinical and applied studies. In chronic hemi-neglect patients, we show that visual-tactile stimulation enhances the ability to detect sensory stimuli presented in their neglected side of space, which might be relevant for new rehabilitation paradigms. For persons with low vision we designed and tested a wearable device consisting of a head mounted camera and a haptic belt to evaluate whether vibro-tactile cues around the waist can be used to improve recognition of facial expressions. These studies suggest that the power of multimodal integration can be used to help impaired persons.

A role for parietal area LIP in object recognition behavior

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Visual object recognition in primates is an efficient and reliable cognitive ability. Psychophysical studies have shown that flexibility, efficiency and performance of visual object recognition is achieved by the representation of shape similarities as opposed to the representation of shapes themselves. Stable versions of such neural representations have been found in the ventral pathway of non-human primates. However, some aspects of visual object recognition require dynamic comparisons of shape similarity in the context of goal oriented tasks. This form of representation is more likely to appear in an area that can integrate bottom-up sensory with top-down task relevant information. We tested whether neurons in the lateral intraparietal area (LIP) of posterior parietal cortex could fulfill this role by collating information from

object specific similarity map representations to allow general decisions about whether a stimulus matches the object being looked for. We found that when animals compared two peripheral stimuli to a sample at their fovea, the response to the matching target remained stable, but the response to the distractor depended on how similar it was to the sample: the more similar, the greater the response to the distractor. Our data suggest that LIP integrates incoming visual information, including that from the ventral stream about object identity, to create a dynamic representation that is concise, low dimensional and task relevant, and which signifies the choice priorities in mental matching behavior.

Cross-modal mappings between vocal sound and motion imagery: Implicit association test

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The present study used an implicit association test (Greenwald et al., 1998) to determine whether auditory stimuli of language sounds could convey motion imagery. We hypothesize that voiced obstruents (/ba/, /da/, /ga/, /za/) may convey images of motor actions requiring greater effort, while voiceless obstruents (/pa/, /ta/, /ka/, /sa/) may convey images of less effort. Nineteen participants responded to a discrimination task on the motion images and vocal sounds. The task was to discriminate between two types of motor activities: one required relatively greater effort to execute (e.g., running fast, lifting a large barbell, serving a tennis ball, place-kicking a soccer ball), the other required less effort (e.g., walking, lifting a small dumbbell, tossing a tennis ball, approaching to a soccer-ball). The task also included a discrimination between the sound categories: voiced obstruents vs. voiceless obstruents. Each participant was presented with one mono-syllabic sound via a headphone, and separately, an image photo depicting an actor's motion on a PC display. For each sound or image stimulus, they responded by pressing a key. We expected faster reactions for compatible combinations (voiced obstruents with effortful motion images, or voiceless obstruents with effortless motion images) than incompatible combinations. Participants significantly speeded responses to the compatible combinations than to the incompatible combinations. There was no significant difference in error rate of responses between the conditions. These results support our hypothesis. Auditory stimuli of voiced and voiceless obstruents could convey imageries associated with stronger and weaker motor executions, respectively.

Seeing through transparent layers

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The human visual system is remarkably good at decomposing local and global deformations in the flow of visual information into different perceptual layers, a critical ability for daily tasks such as driving through rain or fog or catching that evasive trout. In these scenarios, changes in the visual information might be due to observer motion, object motion, deformations of a transparent medium, such as structured glass or water, or a combination of these. What information does the visual system use to accomplish layer decomposition? We used eidolons to investigate equivalence classes for perceptually similar transparent layers. We created a stimulus space for perceptual equivalents of a fiducial scene by systematically varying the local disarray parameters reach and grain. This disarray in eidolon space leads to distinct impressions of transparency, specifically, high reach and grain values vividly resemble water whereas smaller grain values appear like structured glass. We asked observers to adjust image deformations so that a spherical object in the scene looked like it was seen 1) under water, 2) behind haze, 3) behind structured glass. Observers (n=16) adjusted image deformation parameters by moving the mouse horizontally (grain) and vertically (reach). For all conditions, we observed high intra-observer consistency: responses were not random. Responses yielded a concentrated equivalence class for water. We quantified randomness by calculating the distance from the centre of the display in polar coordinates. Strongest agreement was for the 'under water' condition at high reach and grain values, suggesting a local disarray similar to waves.

Sounds facilitate visual completion

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CHUV

Everyday vision must surmount impoverished viewing conditions to enable figure-ground segregation. An example of such mid-level vision is border completion across physically-absent contrast gradients. It is well-established that multisensory processes can influence both low-level vision and higher-level object recognition. It is unknown if mid-level vision benefits from auditory inputs. This would be important, given evidence for impaired IC perception in sight-restored individuals after cataract removal. We reasoned that sounds would impact completion processes supporting IC sensitivity. Participants viewed arrays of black pacmen inducers on a dark grey background that were oriented to form ICs or no-contour (NC) counterparts in a 2x2x2 within-subject design. Two varieties of inducers were used to differentiate potential effects of sounds on completion processes as opposed to brightness enhancement of the inducers (for 'amodal' stimuli). An uninformative sound was presented on half of the trials. Participants indicated IC presence vs. absence while 128-channel EEG was recorded. We replicated prior ERP findings of IC sensitivity at 150ms and 300ms. Crucially, there was a significant interaction between IC/NC and sound presence at 150ms. Sounds thus facilitated visual completion. The 3-way interaction was significant only at 300ms, suggesting that the effect of sounds on IC sensitivity at 150ms was indistinguishable across modal and amodal completion. Our findings extend prior work documenting the presence of multisensory interactions during early stages of stimulus processing by indicating that multisensory interactions can facilitate mid-level vision and may thus be a strategy for visual rehabilitation.

The role of contextual congruency and spatial location plausibility on object recognition

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We tested how two types of information, contextual congruency and location plausibility, affect the recognition of objects in scenes. Contextual congruency was defined as the probability of an object to appear in a specific scene. Location plausibility was defined as the probability of an object to appear in a specific location in space regardless of contextual congruency: plausible – resting on a solid surface, implausible – floating. Participants (N=15) named a cued object in backward-masked briefly presented displays (130ms). A grayscale target object was either congruent or incongruent with a grayscale background and was located in a physically plausible or implausible location. A control group (N=21) performed the task without the background scene to provide baseline recognition rates. The experiments were conducted using a web-based online platform (Amazon Mechanical Turk). Mean recognition rates for each condition were calculated and normalized by the baseline rate of that condition. Both contextual congruency and positional plausibility affected recognition. Contextual incongruency had the strongest effect on recognition degrading it by a significant amount (plausible location – mean improvement -26.7%, se=2.1%; implausible -27.4%±2.9). Contextual congruency led to moderate changes in recognition, further modulated by positional plausibility: facilitation in the congruent-plausible condition (11.3%, se=5.9%), and interference in the congruent-implausible condition (-12.7%±3.9). Both main effects and the interaction were significant in a rm-ANOVA (all $p<0.0056$). We will discuss two possible mechanisms that can produce this pattern of facilitation and interference: inhibition of incongruent information and biasing recognition to induce global coherency.

The tuning of human visual cortex to naturalistic stimuli varying in their 1/fα amplitude spectra in both space and time

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While natural scenes vary widely, they are abundant in statistical consistencies, such as the 1/fα amplitude spectrum ($\alpha = 1.2$). This property describes a consistent distribution of amplitude across spatial and temporal frequencies. While this property is present in both space and time, little work has investigated the tuning of the visual system to this property in the time domain. To address this, psychophysics and fMRI were used to measure visual sensitivity and BOLD responses in early visual areas (V1-V4) across a wide range of spatial (α = 0.25, 1.25, 2.25) and temporal (α = 0.25, 0.75, 1.25, 1.75, 2.25) slopes. In the psychophysics experiment, a significant effect was found for both spatial slope and temporal slope, whereby sensitivity peaked for stimuli with natural 1/fα spectra in both space (1.25) and time (1.25). The interaction between spatial and temporal slope was also significant, whereby peak sensitivity for shallow spatial slopes (0.25) peaks for shallow temporal slopes (0.25 – 0.75), for intermediate spatial slopes (1.25) sensitivity peaks for intermediate temporal slopes (1.25), and for steep spatial slopes (2.25) sensitivity peaks for steep temporal slopes (1.75 – 2.25). In the fMRI experiment, we find the same significant effects and interactions with the exception that peak responses for intermediate spatial slopes (1.25) were observed for stimuli with a temporal slope of 0.75, which is within the natural range. Together these results show that behaviourally and at the cortical level the visual system is tuned to natural 1/fα distributions of frequency in both space and time.

Comparing human and deep convolutional neural network performance on scene segmentation

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The most recent variations of deep convolutional neural networks have managed to match and surpass human performance on classification of objects in images. An open question remains whether humans and those networks process visual information in a similar fashion. It is known that humans perform object recognition best under certain conditions: e.g. when the object is shown in the canonical view (often three-quarter view) and when the object is presented on a homogenous background. In the current study we compare human and computer model performance on those different levels. Carrying forward the object classification task, we manipulate the relationship between object and background by presenting 3D models of objects A) in isolation, B) with a congruent background and C) with an incongruent background. Finally, we manipulate the viewpoint by presenting these 3D models of objects in different angles. We evaluate the performance of human subjects and compare that with performance of deep convolutional neural networks with different depth and complexity. Preliminary results indicate an important, implicit, function of network depth to segregate the object from the scene. Overall, comparing performance of humans and computer models on these more detailed tasks will give a more fine-grained view of the similarity between both and could link more cognitive descriptions of behavior to neural networks.

The role of contrast normalisation and surround suppression mechanisms in modelling suprathreshold differences ratings in natural images

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To et al. (2010, JoV, 10(4):12, 1-22) used magnitude ratings to measure perceived difference between 900 pairs of natural image derived stimuli and also inverted, pixel reversed versions of the same 900. Fitting a multi-neuron V1 model to predict perceived difference (VDP) where contrast normalisation and surround suppression occur in parallel (To et al, 2010) gave Pearson's r=0.657 (n=1800) between actual ratings and model predictions. However, it is more neurophysiologically realistic to envisage surround suppression occurring after normalisation, using the normalised values. A new sequential VDP model gave r=0.677 (n=1800). Although the

improvement of r is small and the sequential model has one extra parameter, we computed the Akaike Criterion Difference (ΔAIC), a measure that compares the performance of two models whilst taking into consideration the number of parameters involved, and its value of 83.9 implies that the neurophysiologically more realistic sequential model is better than the original parallel model. Furthermore, To et al. (2010) argued that some image change types (e.g. texture changes) could never be fit well by VDP models such as ours with their very literal spatial coding. If ratings from those images pairs are discarded and only the ratings of the remaining 1324 image pairs are considered, the Pearson's r values for the original and sequential models rise to 0.738 and 0.752, respectively. Again, despite the modest improvement of Pearson's r between the two models, the ΔAIC (57.9) reveals a real improvement in the sequential model fit.

Neurophysiological correlates of conflict between gesture representations during object perception

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Whereas several recent studies have evidenced a competition between distinct gesture representations during planning and execution of object-directed actions, very little work has focused on the existence of such a competition during mere object observation. Nevertheless, a similar conflict seems to be at play during manipulable object perception, which slows down object visual processing. The aim of the present EEG study was to investigate the neurophysiological correlates of conflict between gesture representations during object perception. The impact of the conflict between evoked gestures on the activation of the motor neural network was specifically tested. Fifteen participants performed a reach-to-grasp and a semantic judgment task on conflictual (with competing structural and functional gestures) and non-conflictual (with similar structural and functional gestures) objects. Objects were presented at difference distances in a 3D virtual environment while EEG was recorded. Time-frequency decomposition was used to compute the power change induced by object presentation on the 8-12 Hz frequency band recorded in the central region (μ rhythm) known to reflect the activation of the motor neural network. Results revealed that μ rhythm desynchronization was reduced when the observed object evoked distinct gesture representations. More specifically, reduction of μ desynchronization for conflictual objects was selectively observed when objects were presented in peripersonal space, where both structural and functional gestures are potentially relevant. However, the effect was independent from the task performed by the participants. Findings demonstrate that conflict between evoked gesture representations reduces the involvement of motor neural network during visual perception of objects.

Towards perception inspired numerical measures of compression error in digital holograms of natural three-dimensional scenes

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Digital holography is a well-known technique for both sensing and displaying natural three-dimensional scenes. Holograms captured using a laser have space-variant multiplicative speckle noise. Lossy compression of holograms changes the characteristics of this speckle noise. The quality of a compressed hologram is typically evaluated with numerical methods (e.g. mean square error) however, due to speckle noise, simple numerical measures do not reflect the actual perceptual quality of the compressed hologram. In this study, we quantify the differences between the perceived error and numerical error in speckle-distorted natural scenes encoded in digital holograms, for different compression algorithms and compression levels. We also demonstrate that numerical measures of error are sensitive to speckle noise, and that differences in speckle (before and after lossy compression) can lead to a high numerical error. However, these differences in speckle, uncorrelated for each eye, are not always perceived by a viewer, who may conclude that both holograms are equally noisy and thus have equal quality. This results in a variation between the numerical estimate of quality and the viewer-perceived quality. In some cases, highly compressed holograms with high numerical error were perceived as having the same quality as the originals. In other cases, even marginally-compressed holograms were perceived by a significant proportion of observers (more than 50%) as having lower quality than the original. Finally, we explain the significance of these findings for future three-dimensional video applications. We propose modifications to the standard numerical error measures that bring them closer to the perceived error.

Category-selective processing in the two visual pathways as a function of visibility

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Category-selective visual processing is a core characteristic of the ventral vision-for-perception pathway, but it is also found in cortical areas along the dorsal vision-for-action pathway. According to the two visual systems hypothesis (TVSH), ventral stream processing is closely linked to visual awareness, while dorsal stream processing is not. Category-selective processing of fully visible stimuli has been reported in both pathways, but so far the relationship between graded levels of visual awareness (i.e., visibility) and functional activity has not been systematically examined for both streams. Recently, we used continuous flash suppression (CFS) in a functional magnetic resonance imaging (fMRI) study to parametrically modulate visibility of face and tool stimuli (Ludwig, Sterzer, Kathmann, & Hesselmann; Cortex, 2016). Using multivariate pattern analysis (MVPA), we observed that decoding accuracies in ventral areas more closely reflected graded differences in awareness compared to dorsal areas. In our follow-up fMRI experiment (N=20), we parametrically modulated the visibility (i.e., recognisability) of the same stimulus

sets by linear combinations of the original images and phase noise images. The phase noise approach minimizes the low-level differences between images associated with different signal-to-noise ratios and levels of visibility. Our fMRI-MVPA analysis will explore the visibility tuning curves of category-selective cortical areas in the human ventral and dorsal visual pathways.

Effect of scene memorability on change detection performance

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Human visual memory can store large amount of information. Recent research showed the memorability can be considered an intrinsic property of an image. Images with high memorability tend to be remembered, while the images with low memorability are likely to be forgotten. The memory performance is usually evaluated within minutes or hours. Here, we ask whether high memorability also helps people to identify changes made in the image in short time-scale (fraction of second). We asked participants (N=40) to identify changes in 128 change detection trials. We measured how the detection time is dependent on memorability of an image. The presented images came from 8 different scene categories with known memorability (FIGRIM dataset, memorability range 0.43 – 0.89, median 0.70). For each image, we designed an alternative version (object removed/colour changed) blind to its memorability rating. In each change detection trial, both versions were alternated for 30 seconds or until the participant identified a change. In case of missing/incorrect response, the detection time was set to a maximum (30 seconds). Participants correctly identified changes in 87.8% (SD 4.9%), median response time was 3.9 s (mean 6.4 s). We used linear mixed models to analyse results. We found small significant effect of memorability on log-transformed detection times. The changes in memorable images were more difficult to find. We got analogous results when we used logistic regression model to predict detection success/failure based on image memorability. We discuss the results in the context of memorability predictors and image content.

A novel 'superstitious approach' reveals the role of color and external lighting in the reconstruction of mental imagery

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Mental imagery is a hypothetical internal cognitive representation of knowledge about physical or conceptual entity. Despite the extent of research regarding mental imagery, very little is known about its nature: is it picture-like or is it a propositional representation, by which objects are represented by abstract symbols. In the current study, I used a novel top-down approach, rooted in Gosselin and Schyns (2003), to reconstruct mental images in color. The key idea here was to create stimulating noise with similar spatial frequency properties as the target category. This was achieved by stimulating the top-down visual pathway with stimuli made of randomized-phase color images. In the first experiment, observers were led to believe that they identified faces in random images. Reverse correlating their responses with stimuli revealed the mental imagery underlying this top-down process. The reconstructed images of faces included color a* and b* information, suggesting that some mental representations are mentally represented in 'color', additionally to lightness levels. In a second experiment, observers were instructed to identify a 3D sphere in random stimuli. Each naïve observer was assigned to one of two conditions: there was a light source i) to the right side or ii) the left side of the observer. The reconstructed images were found to be with higher level of lightness in one half of the image in correspondence to the direction of the external lighting. This finding suggests that mental representations are not fully-lightness-detailed but interact with external input according to optical laws.

Graphical impression reproduced by 2D raster scan spectrum measurement

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Our scene perception is produced by the image constructed from colours and their arrangement. While evaluation of imaging performance caused by changes in colour and their arrangements has been often reported, few studies have reported the shifts of graphical impression. To verify the effects of colour information on image evaluation, the graphical impressions of images were measured and compared with impressions of images constructed from random arrangement of the same colours. The images used in the experiment were textiles measured by 2D raster scan spectral radiometer (Topcon SR-5000), which could take 1376 × 1024 pixel spectrum measurements with one shot, and these pixel data were rearranged randomly in order to ensure that only colour information was available. The observers evaluated their impressions about both the original textile picture and randomly arranged one, but same colour picture by the semantic differential method. The results showed that the colour information showed dominant effects on the graphical impressions of the textile pictures, and also showed that 2D raster scan spectrum measurement, which provided the exact colour data, could be used to construct data archives of craft textile works.

Visual illusions affect aiming performance and skill acquisition

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Visual illusions have been used extensively to examine the main hypothesis of the two-visual-systems model that the visual system consists of two distinct but interacting systems: vision for perception and vision for action (Milner & Goodale, 1995, 2008). However, besides fundamental behavioural and neurophysiological research, recent applied work scrutinizing the influence of visual illusions on aiming performance such as in golf putting (Witt et al., 2012) and skill acquisition (Chauvel et al., 2015) also cast doubt on clear-cut separations between vision for perception and vision for action.

Here, I present two studies that demonstrate that visual illusions may in fact influence both motor performance and skill acquisition. In study 1, participants performed a verbal distance estimation task or a beanbag throwing task towards the end location of the shaft of a large-scale Müller-Lyer illusion. Manipulations of the egocentric and allocentric reference frames across three experiments revealed that whether or not illusions affect action may depend on the relative availability and use of egocentric and allocentric information (Cañal-Bruland et al., 2013). In study 2, participants trained an aiming task (a marble-shooting task) embedded in an Ebbinghaus configuration that made the target appear larger or smaller. Pre-post-test comparisons showed that the group practicing with the apparently smaller target enhanced performance from pre- to posttest (as did the control group), whereas the group practicing with the apparently larger target did not show any improvements (Cañal-Bruland et al., 2016).

Rapid categorization task in normal aging

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Aim: We tested whether age-related changes in the visual pathways affect the rapid categorization of isolated objects from center to far periphery of the visual field. Methods: Sixteen young (mean age 21 years) and 12 older observers (mean age 67 years, ophthalmic and cognitive assessment) had to respond as quickly and accurately as possible if the presented item was an animal (Block 1) or a piece of furniture (Block 2) and to refrain from responding when it was a vegetable or a tool. We manipulated contrast (100%, 30% and 8%) and eccentricity (0°, 25°, 50° and 75°) of the stimuli. Results: The accuracy of young and old participants did not differ when pictures were presented with a contrast of 100% and 30% at the center of the visual field. Performance was impaired for the old group when pictures were presented peripherally; accuracy decrease and response time particularly increased with the low contrast (8%). Older participants cannot detect the targets in far periphery (75°), the target detection was under 15% (independently of the contrast). Discussion: The performance was similar for young and old participants when images were displayed centrally at high and medium contrast. This situation is the one in which the parvocellular system was probably the most involved in the categorization task. However, in the conditions in which the magnocellular system was the most isolated (low contrast and far periphery) the performances (accuracy and response time) were strongly falling with age.

Arousal boosts decision- and attention-related top-down signals in early visual cortex

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Early visual cortex does not respond passively to the sensory environment, but its state is strongly shaped by top-down factors. Previous work has identified different top-down signals in visual cortical activity. Little is known about the relationship between these top-down signals because they have not been compared directly within a single experiment. Here, we performed such a comparison, with a focus on pupil-linked phasic arousal as a possible but unexplored source of top-down modulations in visual cortex.

Human subjects performed a yes-no contrast detection task during fMRI. They viewed a continuous stream of dynamic noise centred around the fixation mark on a grey background. Each trial started with an auditory cue, followed by a low-contrast target signal superimposed onto the noise, or a continuation of the noise. Subjects reported their yes-no judgment by button press.

The stimulus-responsive sub-regions of visual cortical areas V1-V3 exhibited a robust and spatially-specific fMRI response, which however did not encode the signal presence; this was a known top-down signal previously referred to as attention-related in detection tasks. Multi-voxel pattern analysis delineated two further signals: (i) an orientation-specific sensory response and (ii) a decision-related top-down signal. The former reliably encoded signal presence, but did not predict choice, and conversely for the latter. Trial-to-trial variations in pupil responses modulated the attention- and decision-related top-down signals, but not the sensory response.

Attention- and decision-related top-down signals coexist in early visual cortex and are boosted by pupil-linked phasic arousal. Thus, phasic arousal can sculpt selective cortical population signals.

Traffic scene segmentation method for smartphone advanced driver assistance system

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The objective of this work was to identify a feasible segmentation of a traffic scene aiming to enhance the classification of traffic signs and cars, and lane detection in order to develop a smartphone based Advanced Driver Assistance Systems [Duguleana2015]. The traffic scene recorded by the back camera of the smartphone was segmented in four main regions, the objects being consequently identified based on the probability to appear within the predefined regions. This approach was chosen to ensure a minimum computational effort for mobile devices, while the application was implemented based on OpenCV libraries. Time to collision, headway and lane departure warnings are computed in real time. The histogram of oriented gradients was used to describe the properties of the detected objects and artificial neural networks models were used to verify the results. The classifier was trained based on approximately 60.000 positive and negative images. False positives were extracted from videos of real driving conditions and were labeled as "noise" in order to eliminate the classification errors. The workflow combined with the machine learning algorithms and the continuous refinement of the application has enabled smartphones to run all the functions without concerns regarding battery use or overheating. Results showed that the detection rate of traffic signs was over 97%, 98% for lane detection, while lane classification rate was around 95% due to poor markings. This paper is supported by the Romanian Government, specifically MEN – UEFISCDI under the program PNII ''Partnerships in priority areas'', under the project no 240/2014 – NAVIEYES.

Grasping in the context of the visual Uznadze illusion driven by relative, not absolute size

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More than twenty years ago, Aglioti et al (1995) reported that grasping is immune to the Ebbinghaus illusion. This finding has been widely reported as key evidence for the functional dissociation between vision-for-perception and vision-for-action in the human brain, but its validity and generality have remained hugely controversial. Using the visual Uznadze illusion (physically identical target disk appear larger when preceded by a smaller contextual disk, and smaller when preceded by a larger disk), here we report large and comparable effects of the illusion on grasping vs. perceptual measures of size. In experiment 1 (N = 32), both grasping single targets and manually reporting their size were strongly affected by larger or smaller contexts. In experiment 2 (N = 14), participants grasped the perceptually larger of two target disks preceded by larger and smaller contexts. They always chose to grasp the disk preceded by the smaller context, again demonstrating a perceptual illusory effect, and also opened their fingers much more than a baseline condition with identical disks and neutral contexts, suggesting that the illusion also affected grasping. We conclude that grasping was based on relative, not absolute size information. These results provide conclusive evidence against the claim that vision-for-perception and vision-for-action respond differently to size-contrast illusions.

Selective attention in a stepwise discrimination task by pigeons

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We trained eight pigeons (Columba livia) on a stepwise go/no-go task of increasing complexity, in order to document the dynamics of discrimination learning involving complex visual stimuli. We constructed compound stimuli on the basis of their similarity to the S+, from 4 binary-valued dimensions: shape (circle/square), size (large/small), line orientation (horizontal/vertical), and brightness (dark/light). Starting with S+ and S- stimuli that differed in all 4 of their dimensional values, in three consecutive steps, we progressively added S- stimuli that entailed 3, 2, and 1 dimensional disparity from the S+. Critically, in the first step, the pigeons could have attended to any of the 4 dimensions (separately or together) to solve the discrimination. Our results disclosed that all of the pigeons attended to only 1 dimension to solve the discrimination in the first step, and they added one more dimension in each successive step. Notably, all of the pigeons discriminated the dimensions in the same order: they attended to brightness in the first stage, they added line orientation in the second stage, they added size in the third stage, and they added shape in the last stage. This ordering corresponds with the discriminability of these dimensions, as observed in previous studies involving these same stimuli.

Disentangling the within-trial time courses of motor IOR and „attentional" IOR

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When a lateralized target is preceded by a spatially valid cue with SOA > 100 ms, mean correct RT is longer than for invalid cues (inhibition-of-return, IOR). The first explanation in terms of attentional withdrawal has been contested by motor and (working) memory interpretations. Here we present a cue display (valid, invalid, no cue), followed by a central cue display (present/absent), and finally a target display (a square on the left or right), each with some SOA. Participants had to indicate the target location by pressing a left or right button within 400 ms. Because the mean conceils the within-trial time course of the effect of an experimental manipulation, we employ discrete time hazard functions of response occurrence and conditional accuracy functions, that is, event history analysis (Panis & Schmidt, 2016; www.researchgate.com). We find that (a) the first responses are time-locked to the cue (and 100% correct for a valid cue and 0% correct for an invalid cue), (b) when the central cue is absent, IOR appears in the hazard functions around 240 ms after target onset (i.e., a higher hazard for invalid compared to valid cues), and lasts 80-120 ms, while all responses emitted after 240 ms are error-free, and (c) when the central cue is present, IOR can also appear temporarily in the conditional accuracy functions (i.e., a higher accuracy of emitted responses for invalid compared to valid cues), time-locked to central cue onset, and followed by two IOR periods in the hazard functions.

The role of articulation in transparent layer scene constancy

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Perceived properties of a transparent filter should ideally not depend on the colours of the background against which it is seen. It is natural to assume that this type of constancy improves with the number of (partially) occluded background colours, that is, with an increase in the articulation of the scene. Increasing the number of colours in the scene has been found to improve colour constancy, but it is unclear whether this result can be generalized to the filter situation, where changes in the background do not only affect the neighbourhood of the filter but also the set of colours seen through it. We investigated the effect of changes in the number of (overlaid) background surfaces on the degree of transparent layer constancy. We defined a standard scene by simulating a wide range of reflectances under a neutral illumination. From this set we randomly selected subsets of 2 or 10 colours for the test scene. Subjects performed a matching task by adjusting hue, saturation, value, and clarity of a filter in the standard scene to match the filter in the particular test scene. We indeed found higher degrees of scene constancy with higher articulated scenes. However, this effect vanished if mean and luminance contrast in the subsets were controlled to counter sampling biases. These findings suggest that not numerosity itself but the resulting sampling biases are responsible for the effect.

A motor recalibration influence on Color-Motion Asynchrony (CMA) effect size in a visuo motor paradigm

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CMA refers to an apparent perceptual asynchrony of visual features when repeatedly oscillating moving dots change colour and motion direction simultaneously at the same rate (Moutoussis & Zeki, 1997). It has been demonstrated that a single direction change is enough to induce CMA in cross-feature correspondence tasks (Linares & Lopez-Moliner, 2006). Following a recent study, where Stetson et al (2006) have shown a reversal effect in the subjective order of simultaneous action and sensation after subjects were adapted to a delayed sensory feedback regime, here, we examined whether such visuo-motor temporal recalibration is sensory-feature-specific and transferrable to multi-feature-stimuli in correspondence tasks such as CMA. We first measured the effect of visuo-motor recalibration in an experiment where subjects judged the temporal order of a voluntary key-press and a change in the motion direction of an achromatic dot array following a delayed (100ms) sensory feedback adaptation in response to causal action. For those of subjects, who showed significant adaptation effects, we then conducted the main experiment using a single-direction-change CMA paradigm, where direction change was induced by voluntarily generated key-press and subjects were asked to report the predominant motion direction of target colour. Compared to baseline condition, we found that CMA was significantly reduced for the delayed sensory feedback adaptation condition. Control experiments showed that visuo-motor adaptation effects are not observed when the change in direction occurred independent of subject's key-press, which together show a temporal recalibration effect in a visuo-motor CMA paradigm due to voluntary action.

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Neurodynamical model for the adaptation of neurons in area IT

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Neurons in inferotemporal cortex (are IT) show adaptation effects, which potentially for the basis of psychophyiscal high-level after effects and fMRI repetition suppression effects. New physiological results provide significant constraints for the underlying computational mechanisms. We propose a neurodynamical model that reproduces the experimental observations by biophysically plausible neural circuits. Our model augments a recurrent network of shape-selective IT neurons by the following adaptation mechanisms: (i) spike-rate adaptation; (ii) input fatigue, modeling adaptation in afferent synapses; (iii) firing-rate fatigue adaptation that models adaptation dependent on the output firing rates of the neurons. A single model with a fixed set of parameters accounts jointly for a spectrum of recent electrophysiogical results on adaptation of IT neurons, which are highly constraining for possible underlying computational mechanisms (time course, selectivity for effective and ineffective adaptator stimuli) (Sawamura et al. Neuron, 2006; de Baene et al., Cereb. Cortex, 2010). Specifically, the model accounts also for the fact that the strength of adaptation seems to be largely independent of the duration of the adaptor, but not from the number of adaptor repetitions. The independence of adaptation strength on adaptor duration cannot be reproduced by most popular models for adaptation at the single-cell level. This suggests that adaptation in IT neurons is significantly influenced by several biophysical processes with different spatial and temporal scales.

Influence of visual prism adaptation on acoustic space

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Viewing through wedged shaped prism glasses shifts the visual input sideways producing a discrepancy between the visual versus felt arm position. Adaptation to the prismatic shift eliminates this discrepancy, realigning hand movements with visual input. Whether this realignment concerns exclusively the visuo-motor system or whether it generalizes to acoustic inputs is controversial. We here tested whether visual adaptation affects auditory localization. More precisely, we examined whether an adaptation takes place in auditory space representation proper or whether changes in testing auditory localization can be attributed to external influences. Participants performed rhythmic pointing movements towards a central target under varied light conditions (dark or light) and with different prism glasses (right- or left-shifting). Three different identified components of adaptation were separately measured: subjective gaze direction, felt arm position and acoustic localization proper. These include measurements of a) the subjective head straight ahead, b) the subjective visual straight ahead, c) the subjective hand proprioceptive straight ahead, d) the subjective non-proprioceptive auditory straight ahead and e) the subjective proprioceptive auditory straight ahead. The results show that visual adaptation significantly affects the perceived direction of the acoustical source, but this adaptation relies mainly on a subconscious head rotation and/or adaptation in the proprioceptive system of the hand when pointing to the acoustic source is used to measure adaptation. We conclude that the change in auditory localization following prism adaptation was wrongly attributed to an adaptation in the auditory system.

Typical real-world locations impact object coding across the visual field

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Visual information in our everyday environments is structured. Objects often appear at typical locations in space: for example, lamps hang from the ceiling, whereas carpets lie on the floor. As a consequence, these objects repeatedly occupy similar visual field locations. The long-term experience with such spatial regularities prompts the hypothesis

that the visual system is tuned to such retinotopic object locations. A key prediction is that typically positioned objects should be coded more efficiently. To test this prediction, we recorded electroencephalography (EEG) while participants viewed briefly presented objects appearing in their typical locations (e.g., an airplane in the upper visual field) or in atypical locations (e.g., an airplane in the lower visual field). Multivariate pattern analysis applied to the EEG data revealed that typically and atypically positioned objects evoked reliably different response patterns. This difference was related to enhanced processing for typically positioned objects: object identity could be decoded more accurately for typically positioned objects, as compared to atypically positioned objects. Crucially, this difference emerged within the first 200ms of visual processing and was most pronounced when the objects were best discriminable, suggesting that early object processing is tuned to typical retinotopic locations. Our results thus confirm the prediction that long-term experience with objects occurring at specific retinotopic locations leads to enhanced processing when these objects appear in their typical locations. The observed processing enhancement may indicate a neural mechanism for efficient natural scene processing, where a large number of regularly positioned objects needs to be processed.

Brain responses to unpredicted changes in the structure and clarity of unpredicted visual input: Visual mismatch negativity to orientation and contrast changes in upper and lower visual fields

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The brain automatically processes unpredicted visual input, yielding the visual mismatch negativity (vMMN). The vMMN is larger for inputs from the lower visual field than from the upper visual field. One possible explanation is that the lower visual field, containing the ground we walk on and most objects we encounter, is more important for survival than the upper visual field, containing mainly the sky and more distant objects. To test this notion, we compared the vMMN from unpredicted changes in orientation and contrast in lower and upper visual fields. We expected vMMN in the lower visual field would be larger to orientation changes than to contrast changes because orientation changes signal a change to the structure of the visual scene, such as a snake that suddenly appears in the path, whereas contrast changes signal a change to the clarity of the visual scene, such as blurring of the eyes. We expected no difference from the upper visual field. Sequences of identical Gabor patches appeared in lower or upper visual field. Occasionally a patch differing in contrast or orientation interrupted the sequence (yielding the oddball paradigm). Differences in orientation and contrast comprised equal JNDs; participants responded to changes in a central fixation cross. Results showed that orientation changes do not yield a larger vMMN than contrast changes in the lower visual field. We conclude that the larger vMMN in lower visual field is unrelated to functional necessity.

Visual crowding in clutter: It all depends on the target's nearest neighbours

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Decades of research using sparse target and flanking displays have established that visual crowding is most profound when flanking stimuli are presented within close proximity of the target, and reduces gradually with increasing separation. Recently, we investigated crowding in densely cluttered displays using genetic algorithms. Participants were instructed to identify the orientation of a target line (tilted 5° to the left or right from vertical; 6° eccentricity) among 284 distractor lines. Displays supporting highest accuracy were selected ("survival of the fittest") and combined to generate new displays. Performance improved over generations, predominantly driven by the emergence of horizontal flankers within 1° of the near-vertical target, but with no evidence of interference beyond this radius. We concluded that it is the identity of the targets' nearest neighbours which determines whether crowding occurs or not, rather than their distance. In the present study, we used similar densely cluttered flanker arrays and systematically manipulated the identity of the nearest neighbours (all vertical or horizontal) and the heterogeneity of the remaining distractors (i.e., the ratio horizontal/vertical distractors). Identification was impaired when the nearest neighbours were vertical relative to when they were horizontal. Interestingly, the identity of the remaining distractors yielded no effect at all, except for the condition that all the 284 distractors were the same. The present study supports the notion that crowding in cluttered displays is caused by the nearest neighbours, and is in line with other studies suggesting that grouping plays a significant role in crowding.

The thin building illusion and amodal volume perception

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We investigated an illusion of amodal volume perception, where observers experience the 3D shape of a tall vertical pillar as radically different depending on the vantage point from which it is observed. The ground plan of the pillar is an isosceles right triangle, but the pillar is perceived as just a thin plane when viewed from some vantage points. Viewed from other vantage points, it is perceived as having a square or rectangular ground plan. The main results of our study are: (1) In most cases, observers have a compelling amodal impression of the invisible backside of the pillar, and this illusory impression persists even when the observers know the true shape of the pillar. (2) Even though the perceived 3D shape of the pillar changes dramatically with the vantage point, the experienced ground plan can be described as rectangular (a square, a rectangle, or a very thin rectangle/line) in almost all cases. (3) The immediate amodal impression of the pillar's backside seems to be more compelling and definite when viewed from some of the vantage points and less compelling and definite when viewed from other vantage points. This is also reflected in the variability between the observers' 3D shape judgements. Our findings suggest that the visual

system uses a preference for rectangularity (or symmetry) to determine the 3D shape of objects. We also discuss how variants of this illusion are used as a powerful tool in stage magic.

Action capacity does not directly influence visual perception: Evidence for the cognitive impenetrability of vision

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The action-specific account of perception suggests that we literally see the world in terms of our ability to act (Proffitt & Linkenauger, 2013; Witt, 2016). According to this account, our body provides us with perceptual rulers which transform and scale visual information into units appropriate for our intended actions. For example, perceived object size is claimed to scale according to apparent grasping capacity. We tested the claims of the action-specific account in several tasks. We found that participants rapidly and appropriately recalibrated their perceived action capacity following changes to the functional morphology of their body, but that this did not modulate visual perception. For example, reducing grasping capacity by taping fingers together did not increase size estimates for to-be-grasped objects (Collier & Lawson, 2017). Also increasing maximum reach did not increase distance estimates to targets. Finally, being hungry did not increase size estimates for food products. Furthermore, when we did find effects consistent with the action-specific account (e.g., apertures being estimated as smaller when participants wore gloves which increased their hand width, objects being estimated as smaller when placed next to a magnified hand), these could be explained by demand characteristics or as visual illusions. Our results provide evidence against the action-specific account and suggest that visual perception of spatial qualities is not directly influenced by top-down factors such as beliefs about our action capacity. Our results therefore support the notion that vision is cognitively impenetrable.

Sensory mechanisms of perceptual uniformity

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Visual experience results from integration of the coarsely defined information received through the visual periphery with the detail of the comparatively tiny fovea. We examined the mechanisms of this integration by employing the recently described uniformity illusion, in which a pattern with different characteristics in fovea and periphery appears to uniformly take on the properties of the fovea.

We presented a grid of Gabors of a single, uniform orientation within the central visual field and variable orientations in the periphery – producing an illusion of uniform orientation across the visual field. We investigated whether the tilt after-effect produced at specific peripheral locations was consistent with the local, physical adapting orientation or the illusory global percept. We found that the resultant tilt-aftereffect was consistent with the local adapting orientation, - even in trials where illusory uniform orientation was persistently reported during adaptation. Conversely, in a control experiment in which a truly uniform grid was presented for the duration of illusory uniformity reported by each subject, the direction of the aftereffect did depend on the time of presented uniformity.

As the tilt aftereffect occurs within low-level visual processing, our results suggest that the uniformity illusion for orientation is not associated with alteration in orientation coding in primary visual cortex. We are currently investigating the perceptual dimensions of motion, spatial frequency, and density in order to understand the bases of perceptual uniformity across different sensory dimensions.

Perceptual judgments of a ball rolling down an incline

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A large literature documents that the tilt angle of a surface is generally misperceived, while the acceleration of a target is poorly discriminated. To test the hypothesis that perception can be accurate when these two variables are processed jointly, we used wide-field virtual reality to present a 3D sphere rolling down a plane tilted towards the observer. In experiment 1, participants were asked to find the slope that matched the observed acceleration of the rolling ball, so as to result in the motion that looked most natural. Imposed ball acceleration was randomly chosen from one of three possible values, compatible with a tilt of 19°, 39° or 60°. In experiment 2, instead, participants were asked to find the acceleration that matched the observed slope. The latter was randomly chosen from one of three possible values, corresponding to 19°, 39° or 60°. In these two experiments, we found that participants were accurate at finding the correct match between slope and ball acceleration, but there was a systematic effect of the initial conditions, accuracy decreasing with increasing distance of the starting condition from the natural combination of tilt and acceleration. To control for the effect of the initial conditions, we carried out a third experiment similar to experiment 1, but avoiding the coincidence of starting condition and target. Accuracy in this experiment was high. We conclude that the dynamic context of a scene can facilitate perception of both tilt and acceleration.

Voluntary spatial attention influences feature biases in object correspondence

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We live in a continuously changing world. Nevertheless, our visual system is able to maintain the identity of an object and establish associations between images across time, i.e. solving the correspondence problem. Since different higher-level factors, such as visual working memory content, can influence how the correspondence problem is solved, it has been suggested that attention might play a role for correspondence. We instructed participants to voluntarily direct attention to individual elements of the Ternus display. In this ambiguous apparent motion display, three elements are presented next to each other, shifted by one position from one

frame to the next. The visual system solves correspondence either by perceiving all elements moving together (group motion) or as one element jumping across the others (element motion). In addition to the classic Ternus display, in which all elements are identical, we changed the color of the elements in such a way that the percept was biased towards element motion for one color and towards group motion for another color (competitive bias). We expected that a stronger weighting of the attended element's color and thereby its bias should lead to a change in the proportion of perceived group or element motion in the competitive biased Ternus, but not in the classical Ternus. We found this pattern of results suggesting that voluntary attention can influence object correspondence.

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The effect of limited-lifetime duration and dynamic relocation of elements on symmetry perception

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Symmetry is believed to be encoded by specialized visual mechanisms. Recent evidence suggests that limiting the lifetime of pattern elements improves performance by increasing the number of element-locations (Sharman & Gheorghiu 2017, Scientific Reports, 7, 45679). Here we investigate the effect of lifetime duration and spatial relocation of elements on symmetry perception. Stimuli were dynamic random-dot patterns containing different amounts of mirror-symmetry about the vertical axis. We varied the lifetime of the pairs of elements between 55ms and 290ms while elements were: (i) relocated to several successive, but random locations, (ii) relocated between the same two positions, (iii) not relocated but the contrasts of the pairs of elements were counter-phased at different temporal frequencies. There was also a static condition where one single pattern was presented at full contrast. In all conditions, the overall stimulus presentation duration was the same (400ms). We manipulated the amount of positional symmetry by varying the proportion of symmetrical dots and measured symmetry detection thresholds using a two-interval-choice (2IFC) procedure. We found that when elements were dynamically relocated to several successive, but random positions performance improved in comparison to the static condition and thresholds decreased monotonically with longer element lifetimes. Thresholds were also lower when elements were counter-phased in contrast compared to the static control, irrespective of temporal frequency. However, there was no improvement when elements were relocated between the same two positions. We conclude that both dynamic relocation of element pairs and counter-phasing elements' contrasts improve mirror-symmetry detection.

Pleasure integration

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In everyday life, pleasing images are rarely isolated. Yet, experiments on aesthetic pleasure usually present only one image at a time. Here we ask whether people can reliably report the pleasure of an image even if another image is presented simultaneously. Participants (N=20) viewed 36 OASIS-3-database images that uniformly span the entire range of pleasure and beauty. On each trial, the observer saw two images simultaneously for 200 ms. The two images were presented to the left and right of the central fixation cross. A cue (randomly for left or right) indicated of which image the observer should report the pleasure (the target), while ignoring the other (the distractor). In half the blocks, a pre-cue came before the images. In the other half, a post-cue came after. We model the post-cued pleasure report as a weighted average of pre-cued target and distractor pleasures. If observers can independently retain pleasure from two images, ratings in pre- and post-cued blocks should be the same. Consequently, in the modeled average, the target weight should be nearly 1. Otherwise, if averaging is compulsory, target weight should be about 0.5. A majority of our observers (12/20) selectively reported pleasure from a post-cued target (weight > 0.85). Only two observers showed compulsory averaging (weight < 0.60). The remaining reports fell in between. Thus, most people can independently retain pleasure from two stimuli for later report of either. So, averaging of pleasure is not compulsory.

The effect of number of colours and luminance-polarity on the electrophysiological response to mirror-symmetry

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Event-related potential (ERP) studies of mirror-symmetry showed that amplitude in posterior electrodes is lower for symmetric than quasi-random patterns from 200ms after stimulus onset, resulting in a difference-wave termed the Sustained Posterior Negativity (SPN). Recent studies found that mirror-symmetry detection mechanisms, while sensitive to colour-correlations and luminance-polarity across the symmetry axis, are not selective to colour or luminance-polarity (Gheorghiu et al, 2016). Here we investigated how the number of colours and luminance-polarity modulated the SPN. Stimuli consisted of a fixed number of Gaussian blobs arranged either symmetrically or quasi-randomly. In the luminance-polarity experiment, there were three conditions: (1) anti-symmetric –symmetric blobs were of opposite luminance-polarity across the symmetry axis; (2) polarity-grouped –symmetric blobs were of the same luminance-polarity on one side of the symmetry axis and opposite luminance-polarity on the other; (3) unsegregated –symmetric pairs were of both luminance polarities in equal proportions. In the colour experiment, the patterns consisted of either two, three or four colours. Participants performed a two-interval-forced-choice task indicating which interval contained the symmetrical pattern. We found:

(a) comparable SPN responses for anti-symmetric, polarity-grouped and unsegregated patterns, with no ERP differences between these conditions; (b) a gradual increase in performance from anti-symmetric to polarity-grouped to unsegregated; (c) an SPN for two, three and four-colour symmetry stimuli with ERP amplitude decreasing with the number of colours; (d) similar performance with two, three and four-colour stimuli. We conclude that the SPN is modulated by the number of colours in the stimulus and not perceptual grouping by luminance-polarity.

Increased visual metacontrast masking in migraine using a novel global shape task: No evidence for a lack of inhibition in extrastriate cortex in migraine.

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Metacontrast masking refers to the reduction in visibility that preceding, or subsequent, non-overlapping stimuli can have on the detection of a target (forward/backward masking, respectively). Numerous accounts of these effects implicate inhibition at various stages within the visual system. An early study on backward masking in migraine reported decreased effects, which was presented as evidence for a lack of cortical inhibition. Subsequent studies have failed to replicate this result, yet this "lack of inhibition" model remains in the migraine literature. The earlier studies used stimuli with explicitly oriented edges, possibly anchoring performance to activity in early visual areas (V1). This study employed a novel global shape task so that performance differences could be attributed to processing in extrastriate areas. Global shape discrimination has been associated with nonverbal ability, so participants also completed Wechsler's Block Design task.

Migraine and control participants discriminated between left/right pointing target arrows, comprised of three widely spaced dots. Masks were either larger left/right pointing arrows (compatible or incompatible), comprised of six annuli, or eight annuli in a rectangular configuration. There were five lags between the 10ms targets and masks (stimulus onset asynchronies, SOAs).

Impaired performance was found for expected SOAs. Masking was greater in migraine overall, but significant group differences occurred only for backward masking and rectangular masks. Target discrimination accuracy correlated positively with block design scores. These results do not support models of migraine involving a lack of cortical inhibition. The association between masking and nonverbal ability requires further research.

Different development of visual acuity and crowding effect

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The measurement of visual acuity (VA) is influenced by crowding, the perceptual phenomenon in which the recognition of a target is influenced by adjacent stimuli. Crowding has been found in peripheral vision and also in fovea. Previous studies used experimental setup, instead of psychometric tools, to assess the influence of foveal crowding on visual acuity in primary school children. Our purpose was to verify the efficacy of a tool for the clinical assessment of crowding, by means of different VA eye charts with different level of interstimuli spacing. A total of 257 children of 1st, 3rd and 5th grade were assessed with VA eye charts using SLOAN letter optotypes with 100%, 50%, 25% and 12.5% inter-optotype distances. Each level of crowding was measured three times with different tables and using a letter by letter VA testing procedure. Results show an interaction between crowding and grade. The performance to the 100% standard VA was not significantly different among grades. Conversely, the acuity at 12.5% VA improved through grades. Taken together these results show the feasibility of application of crowded VA tables, which permit to measure crowding also in clinical practice. The different evolution of acuity with crowded and (relatively) uncrowded tables suggests that a mechanism able to reduce crowding develops later than VA and that it is influenced by more variables than previously considered.

Combining eye-tracking and EEG: Some updates to the EYE-EEG toolbox

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Parallel recordings of eye movements and EEG are useful in various research contexts. One application is to analyze the EEG time-locked to fixation onsets during free viewing situations, yielding fixation-related potentials or -oscillations. Other applications include fixation control, the analysis of EEG contributions from fixational eye movements or the enhancement of ocular correction procedures. This poster summarizes a few recent updates to EYE-EEG, an open-source EEGLAB extension for integrated analyses of eye-tracking and EEG data (http://www2.hu-berlin.de/eyetracking-eeg). Among the new features are a cross correlation-based method to validate the alignment of the recordings, extended options for message import and data rejection, new functions for data visualization, an algorithm to match oculomotor covariates across different experimental conditions, and an automated procedure to determine the variance threshold for the eye tracker-based identification of ocular ICA components (see Plöchl et al., 2012). EYE-EEG now also supports "Tobii Pro" eye-trackers and I will show synchronization results for these and other systems in combination with different EEG hardware. The updated ICA procedure will be evaluated based on two large co-registration datasets from natural reading and scene viewing experiments.

The effect of overall stimulus configuration on crowding

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The standard framework to study vision is typically hierarchical and feedforward, which facilitates deconstructing complex mechanisms into smaller, more tractable problems. However, this framework can fail when elements are presented in context, as they are in every-day life. In crowding, peripheral discrimination is hindered by nearby elements, as for example a Vernier embedded in a square is more difficult to discriminate than when presented alone. However, adding additional flanking squares can, counterintuitively, ameliorate this deleterious effect (Manassi et al, 2013, J Vis). Clearly, in order to understand low-level vision, we must also understand higher-level processing. Here, we take a step toward goal by characterizing the effect of flanker configuration on crowding in a theory-agnostic manner. Previous studies have examined a small number of experimenter-selected configurations; here, we made no assumptions about which configurations should affect crowding. We placed a Vernier embedded in a square at the centre of all possible 3x5 arrays with an equal number of squares and stars (3432 total). Observers discriminated this Vernier in the presence of each configuration, repeating each until responding incorrectly or achieving six correct responses. In this way, we were able to quantify the effect of all possible configurations on performance. Among the interesting patterns in our data set, we observed a strong positive correlation between the number of clustered square elements and performance. More generally, our data suggest that configurations encouraging separate grouping of target and flanker elements ameliorate crowding, using a paradigm in which grouping was not explicitly manipulated.

An overview of the transcendental psychology approach to the study of perceptual generative processes

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At the Psychological Institute and MSUPE (Moscow) a Transcendental Psychology Approach (A.I. Mirakyan) to the study of perception has been developed since 1990. This approach assumes that in perception and unconscious part of the psyche there are so-called structurally-generative processes that are realized outside their mediation by conceptual data of cognitive categories. To study these transcendental processes, it is proposed to use an axiomatic methodology based on a natural principles that provide conditions and possibilities for form creation. As a result of the studies, a number of general principles were developed and justified. These principles include structure-process anisotropy and formation of symmetric relations, spatial-temporal discreteness, co-presentation and some others. They are, on the one hand, explanatory for the generative process of perception and, on the other hand, are the direct object of further specification and verification. Thus for the first time in psychological science, the study of perception processes is carried out without identifying the process of perception with the results of its reflection. Multiple experiments of form-creation processes in vision and touch modalities revealed the structural-system and procedural specifics and other characteristics of visual perception of the shape, color, stability and movement of objects and spatial extent. The approach as a whole implied and developed many specific concepts like: dynamic scientific viewpoint, anisotropic homogeneity of system structures, coexistence of perceptual features, time as factor of spatial perception. A general description of transcendental psychology in English is partly presented in (Artemenkov & Harris 2005). Funding: RFHS # 16-06-00574.

Presenting visual stimuli with ultra-high temporal resolution using gaming monitors and G-Sync

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Vision unfolds as an intricate pattern of information processing over time. Studying vision and visual cognition therefore requires precise manipulations of the timing of visual stimulus presentation. While current standard computer display techniques offer great accuracy and precision of visual presentation, their temporal resolution is limited. This limitation stems from the fact that the presentation of rendered stimuli has to wait until the next refresh of the computer screen. We present a novel method for presenting visual stimuli with ultra-high temporal resolution (< 1 ms) on newly available gaming monitors. The method capitalizes on the G-Sync technique, which allows to present stimuli as soon as they have been rendered by the computer's graphics card, without having to wait for the next screen refresh. That this method indeed allows to present stimuli with ultra-high temporal resolution was confirmed by external measurements using a photodiode sampled by an oscilloscope. Moreover, a psychophysical experiment revealed that the ultra-high temporal resolution impacts on human visual performance. Specifically, observers' object recognition performance improved over fine-grained increases of object presentation duration. Taken together, the present study shows that the G-Sync-based presentation method enables to investigate visual processes whose data patterns were concealed by the low temporal resolution of previous techniques. Therefore, this new presentation method may be a valuable tool for experimental psychologists and neuroscientists studying vision and its temporal characteristics.

A new mechanism of visual perception of spatial extent, based on the temporal characteristics of standardizing the size of the stimulus

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Within the framework of the Transcendental Psychology Approach (A.I. Mirakyan, Psychological Institute, Moscow), a new mechanism for generating visual perception of spatial extent is proposed. Instead of correlating spatial size of stimulus with other visual spatial features, the mechanism is based on the idea of measuring the procedural duration of the sub-sensory process, provided the rate of this process is constant. Hypothetically, the duration of this internal process, which is increasing the small-sized retinal images to a certain standard value, is measured within perception. At a constant speed, this duration grows proportionally with the

decrease in the size of the retinal image. It has been experimentally shown that the exposure time of an object, which is necessary for its adequate identification, turns out to be shorter the larger the size of the object and this dependency is practically linear in a large range of its sizes. As the stimuli in the recognition experiment, numerals 0,1,3,4,5,7 and capital letters L,N,R,S,V,Z were used. Fonts were black colored on gray background, had 9 equal step size gradations within 14-70 angular minutes. Each presentation was a combination of a certain sign of the stimulus, its size and exposure time: 22-43 msec. The sample included 38 adult subjects. The obtained experimental results indirectly support the proposed new mechanism. Thus, the process for generating visual perception of spatial extent of objects can be mediated only by temporal characteristics of perceptual process and be obtained in the absence of a specialized spatial analyzer. Funding: RFHS # 16-06-00574.

Exploring the effect of short-term plasticity on postoperative binocular visual function recovery in intermittent exotropia

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Objective: To explore the effect of short-term plastic training on postoperative binocular visual function recovery in intermittent exotropia, the binocular visual functions were examined with visual perceptual methods, integrating with all clinical manifestations, aiming to establish and validate the viable solutions for patients to recover the normal binocular visual functions after surgery.

Methods: 22 intermittent exotropia cases were examined for visual function quantitative examinations following surgery, including static and dynamic stereopsis, binocular fixation stability and binocular alignment. Acoording to the results showing different defects corresponding to differnent models, the patients were going on short-term visual plastic training individually. The binocular visual functions were re-examined, and all the data were analyzed statistically.

Results: The mean value of ocular alignment deviation was 240pix following surgery and 69pix after training,the correlation between the two was significant ($p<0.01$). The mean value of fine stereopsis acuity and dynamic stereopsis grade was 654s and 2.0 following surgery, 412s and 3.9 after training, the correlation between the two was significant ($p<0.05$). There were 3 of 22 cases had abnormal wide-range coarse stereopsis, and could be improved after short-term visual plastic training.

Conclusion: The patients following surgery were orthophoria, however, their ocular perceptual alignment, dynamic and fine stereopsis were still dysfunctional. Most following surgery had normal wide-range coarse stereopsis function. So we deduced that all of the binocular visual functional recovery were synchronized, and had some linear relationship.

Depth and context modulate the cortical activation to object size

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The perceived object size can be modulated by perceived depth and size of context elements (as in Ebbinghaus illusion). Few investigated how the two factors interact in perceived size. We investigated how the perceived size of a target, as well as the corresponding cortical activation, were modulated by the depth and the element size of the background texture. The disk target (diameter 135') was placed on either a blank or a background texture composed of disks of various elements. The disk placed on a blank served as a reference. The perceived depth of the image elements was modulated through binocular disparity. The background was either texture composed of small (diameter 67.5') or large (diameter 270') disks, or blank. The disparity was either near (-0.15 deg) or far (0.15 deg). The observers' task was to compare the perceived size of the target and the reference presented on the opposite side of the visual field. The behavior result showed that the perceived target size appeared larger in the far than the near, and with the background of small elements than with big elements. At all distances, the V1 BOLD activation to the target was proportional to the target physical size but inversely proportional to background element size. The target activation in the far was greater than that in the near when the target was on texture background and smaller when on blank. Our result suggests an intermodulation between context and depth effect occurring as early as V1.

Visually induced motion sickness: Accumulation and adaptation in repeated and extended exposures

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Visually Induced Motion Sickness (VIMS) is often elicited by a visual stimulus when the vestibular or proprioceptive feedback is inappropriate (Bles et al., 1998). This occurs in everyday situations (e.g. sea-sickness) or in specific experimental designs. We focus on repeated and/or continuous exposure, which affects the amount of elicited VIMS and its decay over time. Previous research (e.g. Shahal, Hemmerich, & Hecht, 2016) has shown a dependence of VIMS level on the stimulus-sequence and an accumulation over repeated exposures. An understanding of these factors would facilitate research into measures counteracting VIMS—an area gaining importance with the emergence of consumer-oriented virtual reality headsets. A total of 40 subjects were exposed in the lab to two 10-minute-long VIMS-eliciting stimuli in a 2×2 repeated-measures design with Inter Stimulus Interval as the between-subjects factor. Stimulus sequence was counterbalanced across all subjects. The degree and time course of VIMS during and after exposure was measured by the Fast Motion Sickness Scale (Keshavarz & Hecht, 2011). In order to complement the subjective evaluation of VIMS, a postural stability measurement was conducted immediately before and after each exposure using the Nintendo Wii Balance Board.

A new non-linear mapping function between visual space and physical space

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In 2010 I presented a generalized projective transformation as the mapping function to describe the mapping between physical and visual spaces. It was effective to find the non-Euclidean property of visual space. However it was still a linear transformation. In the present research I present a quadratic formed transformation as the mapping function. It is the mapping from a curved surface to a curved surface. This makes us to enable to describe a curved surface as an instinctive property of non- Euclidean space. For example,a new mapping function describes the mapping from a square to an ellipse. The new mapping function makes us to change from an one form to another form. It will make us to find a function to create beautiful forms also. In the presentation, simulated configurations will be mainly used to demonstrate the effectiveness of the new mapping function. Finally, the new mapping function is mathematically described in the following: u=(a1*x*x+a2*y*y+a3*x*y+a4*x+a5*y+a6)/(b1*x*x+b2*y*y+b3*x*y+b4*x+b5*y+b6)+eu, v=(c1*x*x+c2*y*y+c3*x*y+c4*x+c5*y+c6)/(d1*x*x+d2*y*y+d3*x*y+d4*x+d5*y+d6)+ev, where u and v show the coordinate values of visual space, x and y the coordinate values of physical space, 24 coefficients the parameters to be estimated, eu and ev error terms.

Anisotropy in visual space with near and far Landmarks

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It is well known that visual space is non-Euclidean space in case of small-scale space. This study investigated how visual space had geometrical property in small and large scale of space. The locations O and A were fixed at O (0, 0) and A (0, 198 m). Twenty-eight landmarks were called the locations X_1 to X_28. These locations X were separated into two spaces depending on whether distance OX was shorter than distance OA or not. Small-scale space had twelve locations X_1 to X_12. Large-scale space had sixteen locations X_13 to X_28. Thirty-six participants binocularly observed each location X from location O in the bright. Participant's task was to judge the absolute distance OX and the absolute angle AOX. We fitted a mapping function of linear transformation between visual and physical space in each scale individually. The mean values of basic vector in the linear transformation equation were (1.002, 0.849) in small-scale space and (0.952, 0.911) in large-scale space. A two-way ANOVA with axis direction and scale of space as factors was conducted on the values of basic vector in the linear transformation equation. The main effect of axis direction was significant. The main effect of scale of space was no significant. The interaction between axis direction and scale of space was no significant. It was found that visual space was narrower toward depth direction than toward lateral direction, regardless of scale. Furthermore, visual space had an anisotropic property, regardless of scale.

The common perceptual effects of crowding in amblyopic, developing, and peripheral vision

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Visual crowding is the disruptive effect of clutter on object recognition. In adult peripheral vision, crowding produces systematic perceptual effects: the target object has been found to appear averaged with the identities of the surrounding flankers (assimilation), replaced by the flanker identities (substitution), or both. Although crowding also affects central vision in strabismic amblyopia and developing vision, it is unclear whether these instances share a common mechanism with the adult periphery. If so, then the errors in amblyopia and developing vision should be similarly systematic. In contrast, a different pattern of errors (e.g. random) would indicate a distinct mechanism. To investigate this, we tested children with strabismic amblyopia and unaffected vision, aged 3-9, using an orientation-matching task. Children reported the perceived orientation of a PacMan target (similar to a Landolt-C) by rotating an identical reference stimulus. Target orientations were randomly selected, while flankers (when present) differed by ±30 or ±90-degrees. We observe that crowded errors in amblyopia and developing vision are predominantly systematic, resembling those of the adult periphery. With 30-degree target-flanker differences, children with amblyopia primarily reported the flanker orientation (substitution), while children with unaffected vision reported orientations between the target and flankers (assimilation). With 90-degree target-flanker differences, there was a reduction in errors for both groups; when errors occurred they matched the flanker orientation (substitution). We present a population-coding model that accounts for these systematic perceptual effects in both amblyopic and developing crowding using 'pooling' operations resembling those of the adult periphery.

Indirect visual influence on different spaces around the body

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Several studies support the idea that vision has a pivotal role in developing spatial cognition. A recent approach, based on sensory calibration, provides evidences regarding the role of vision in calibrating hearing in spatial tasks. Blind individuals have indeed impairments during the spatial bisection task. However, vision is available only in the frontal space, leading to a "natural" blindness in the back. Spatial representation in the back space is still poorly investigated. If the visual information is important for the calibration of audio spatial perception, this calibration should be enhanced where vision can act, namely in the frontal zone. In this study, we investigated this point by comparing frontal and back audio spatial representations. Our hypothesis is that auditory frontal space is better represented than back auditory space, as vision had the possibility to calibrate hearing. Twenty-four sighted subjects performed a bisection spatial task in four different spaces around the body: frontal and back space, both at eye and feet levels. A control task, minimum audible

angle (MAA), was employed in order to check that people were similarly able to discriminate sounds position in every space considered. While no differences were observed between frontal and back space in the MAA, a significant difference was found in the bisection task, where a better performance was reported in the frontal space. Results support the idea that vision is important to develop auditory space: subjects were indeed more precise in the frontal space than in the back.

Crowding limits reading performance in children with infantile nystagmus

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Objectives: Crowding refers to the diminished ability to identify an object when it is surrounded by clutter. It puts a limitation on peripheral and, to a lesser degree, foveal vision. The goal of the current study was to compare reading performance of children with infantile nystagmus (IN) with normal controls and evaluate how foveal crowding affects reading in children with IN. Methods: Thirty-five 6-11 year-old children with IN participated of which 18 had idiopathic IN and 17 had oculocutaneous albinism. Age-matched children with normal vision (n = 11) were included. Outcome measures were: visual acuity, crowding and reading performance. Multiple linear regression analyses were used to assess the contribution of uncrowded distance visual acuity, crowding intensity and crowding extent on the variability in reading performance. Results: Maximum reading speed did not differ between children with IN (idiopaths: 101 ± (SE) 8 wpm; albinism: 110 ± 8 wpm) and normal vision (129 ± 10 wpm). The acuity reserve also did not differ between groups. Children with IN did have poorer reading acuity and critical print size than children with normal vision. Distance visual acuity and crowding intensity explained the variability in reading acuity (89%). Variability in acuity reserve was explained by differences in distance visual acuity and crowding extent (31%). Variation in critical print size was explained by differences in crowding extent (47%). Conclusion: Our results indicate that foveal crowding, in addition to visual acuity, is a significant factor limiting spatial (not temporal) aspects of reading performance in children with IN.

Prioritization of temporal regularities for visual awareness

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What makes a dynamic stimulus stand out from others during their competition for visual awareness? Using the binocular rivalry paradigm, we demonstrated that visual awareness is spontaneously biased toward dynamic information with regular temporal structure. Specifically, stimulus sequences with temporal regularities arising from rhythmic changes of a basic visual feature (e.g., shape) had longer dominance durations than the physically matched but temporally randomized sequences. More interestingly, this effect could be generalized to semantic-level regularity extracted from a serial presentation of four-character Chinese idioms, when the idiom sequences rivaled with sequences consisting of the same characters presented in random order. However, the prolonged dominance effects observed with the successive idioms and rhythmic shape sequences may not be accounted for by a single-level mechanism, as only the former, but not the latter, was immune to the randomization of stimulus duration within the sequences. The current findings suggest that visual awareness of dynamic events pivots on the temporal structure of the sensory inputs. Meanwhile, extraction and encoding of structural information may entail prioritization of temporal regularities at different levels for conscious experience.

Autistic individuals show typical use of prior information during interrupted visual search

Owen Parsons, Jan Freyberg & Simon Baron-Cohen

Introduction: Visual perception is influenced by prior experiences and learned expectations. One example of this is the ability to rapidly resume visual search after an interruption to the stimuli. It has been suggested that atypical visual perception in autism spectrum conditions (ASC) can be explained by attenuated use of prior information during perception.

Objectives: We used an interrupted search paradigm to assess whether rapid resumption is intact in ASC. We hypothesize that attenuated use of prior information would lead to a reduced ability to rapidly resume searches after interruption.

Methods: Participants with (N=20) and without ASC (N=20) were asked to complete a visual search task in which search displays were periodically interrupted by blank displays. Participants were required to locate a target and report its colour. During trials the search display would only be visible for 100ms presentations separated by a 900ms blank display. Participants completed a total of 300 trials, divided across 10 blocks.

Results: Distributions of responses immediately following the first exposure differed significantly from distributions of responses following subsequent exposures ($p<.001$) in both groups, suggesting a significant effect of prior exposures on task performance in both groups. Furthermore, no differences in the distributions of responses occurring following subsequent exposures were found between the two groups ($p>.250$).

Discussion: Our results suggest that rapid resumption is unimpaired in ASC. These findings are in contrast to the hypo-priors account, suggesting that prior information is used normally by individuals with ASC during visual search.

Temporal predictability changes the perception of the onset and offset of a visual stimulus, but not its duration

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According to the early onset hypothesis of temporal attention, participants should perceive the presence of a visual

stimulus earlier when they can predict the temporal occurrence of this stimulus. We tested this prediction by requiring either a response to the onset or to the offset of shortly presented visual stimuli (33 to 100 ms). Temporal predictability was manipulated by a foreperiod (FP) paradigm, in which the time interval between a warning tone and the visual stimulus is manipulated, either being short (800 ms) to allow high predictability of stimulus occurrence or being long (2,400 ms) allowing lower predictability. The difference between onset- and offset responses was more pronounced in the short FP than in the long FP, mainly because onset responses were fastened in the short FP. This pattern of results strengthens the early onset hypotheses and suggests that temporal attention prolongs visual persistence of the stimulus. To test this idea directly, we asked participants to compare the duration of two successively presented visual stimuli (first standard for 100 ms, then comparison for 50 to 150 ms) and manipulated the FP in the same way as before. Contrary to the prediction, the duration judgment was uninfluenced by the FP condition. We discuss this result in terms of potential differences in time processing modes evoked by temporal attention, which might have affected the standard and the comparison in the judgment task simultaneously. Taken together, temporal attention influences the perceived temporal attributes of a visual stimulus, most probably by enhancing its persistence.

Adaptation to visual numerosity can affect time perception but not the other way around

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The theory of magnitude suggests number and time are linked by a common cortical metric, and their specialisation develops from a single magnitude system. We investigated the presence of a common processing mechanism underlying numerical and temporal perception using unimodal and cross-modal adaptation. We conducted four experiments, each using a rapid adaptation protocol (100 trials; average trial duration: 1.2 sec) and a 2AFC adaptive staircase method. In a two by two adaptation and discrimination task design, participants adapted to either numerosity or duration and subsequently performed a numerosity or duration discrimination task. Each adaptation-task combination was presented in a separate block. Data analysis revealed that adapting to a high numerosity (80 dots) led to underestimation of the reference numerosity (40 dots), while adapting to a low numerosity (20 dots) led to overestimation of the reference numerosity presented in the adapted location. Similarly, adapting to a long duration (600 ms) led to underestimation of the reference duration (333 ms), whereas adapting to a short duration (67 ms) led to an overestimation of the reference duration. In the cross-modal adaptation conditions, numerosity adaptation affected time discrimination in 60% of the subjects, where adaptation to a high and low numerosity resulted in an underestimation and overestimation of the reference duration respectively. There was no effect of time adaptation on numerosity discrimination. These results indicate that both numerosity and time are susceptible to rapid adaptation, and provide only limited support for the existence of a common magnitude system in numerical and temporal perception.

Contextual motion and transients disrupt visual timing performance

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Visual temporal order judgments can be profoundly disrupted by the mere presence of irrelevant distractor events elsewhere in the visual field. The unique spatial distribution of this remote temporal camouflage (RTC) effect distinguishes it from other contextual phenomena such as motion-induced blindness, surround suppression and crowding. In this study we examine the causal role of motion and visual transients. The task required subjects to report which of two vertically oriented drifting target Gabors, located left and right of fixation, changed direction first across a range of stimulus onset asynchronies. Each target was surrounded by eight vertical distractor Gabors, which were either static or drifting. In the drifting conditions, distractors all moved either in homogeneous or heterogeneous directions, remaining either constant or abruptly switching direction simultaneously. Thresholds were significantly higher in the drifting relative to the static distractor conditions. Of these drifting conditions, performance was poorest when distractors changed direction prior to the target signals. For the non-switch conditions, performance appeared equivalent in homogeneous and heterogeneous direction conditions. Surprisingly, we find that when homogenous distractors move in the same direction as the targets prior to the first target change, performance improves to near static distractor levels. This combination of results implies a causal role for both distractor transients and motion segmentation in RTC.

How the aesthetics of the urban space might shape our implicit attitudes towards brands: The role of artistic „Subvertising“ via modified brand logos

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On closer observation of Street Art it is assumed, that the visual composition of the urban space has partly artistic aspects (Riggle, 2010). Among others the so called „Subvertising“ is seen as art that tries to remove advertising appeal and binge shopping behavior by deliberately sabotaging public advertisements (Harold, 2004). One modification can be the manipulation of a logo design, which generates a negative impact for the brand itself. In the present study (N=32) we examined whether the close to reality presentation of briefly presented, modified brand logos (taken from various sectors: computer, fast food and soft drink) had already an impact on the implicit attitudes towards the associated brands. We controlled for mere exposure effects by pairing companies with similar products for which one set (k=3) was modified and the other (k=3) left unmodified. Implicit attitudes related to these brands, assessed by employing a multi-dimensional implicit association test (md-IAT; Gattol et al., 2011) did not find any change of attitudes when using modified brand logos, at least with the given power which was generally able to detect medium-large effect sizes. This raises the question, whether the actions of the activists really do have the intended effect on the consumers. The paper discusses further possibilities or changes of artistic strategies to be more successful.

Fear alters audio-visual temporal synchrony: A time-course analysis

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The role of emotion on perceptual processing has emerged as an essential factor influencing how stimuli associated with a rewarding or aversive value are perceived, processed and reacted to. In the present study, we investigated whether audio-visual synchrony judgments were affected by stimulus valence. During a classic fear-conditioning paradigm, either the auditory or the visual modality was associated with the possibility of receiving an electric shock. The conditioning paradigm was preceded and followed by a synchrony judgment task. On each trial of this task, participants saw the same auditory and visual event (as in the conditioning paradigm) across a range of stimulus onset asynchronies (SOAs) and judged whether these events were presented simultaneously or not. Gaussian functions were fitted through the synchrony judgment distributions to estimate the point of subjective simultaneity (PSS) before and after conditioning. Findings indicated that fear conditioning resulted in a shift in PSS towards the conditioned modality, showing that fear-conditioned stimuli are processed faster than unconditioned ones. However, a time-course analysis of this effect revealed the shift in PSS was stronger and more stable if the auditory modality was conditioned, rather than the visual. Together, these findings indicate that the valence of a stimulus can affect temporal processing.

The influence of music on watching paintings: An eye movement study

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We have studied the influence of music excerpts on the way observers look at paintings. We selected paintings from five different famous painters representing different styles (Mondriaan, Rembrandt, Dali, Monet, Kandinsky). The music excerpts comprised pieces of 10 seconds, also clearly representing different styles (Beethoven, Miles Davis, Vangelis). The main aim of these selections was to construct painting-music combinations that would fit or would not fit. In a first experiment we presented all painting-music combinations and asked the observers to judge how well painting and music fitted (using a 7-point Likert scale). The result showed clear congruencies (e.g. Rembrandt/Beethoven; Kandinsky/Miles Davis) and incongruencies (e.g. the opposite combinations). In the second experiment the combinations with the most extreme ratings were chosen, but such that from each painter a painting was included in both the fit and the no-fit condition. In a similar way, the music styles were equally divided between the fit/no-fit conditions (also controlling for music tempo). In this experiment the painting combinations were presented for 10 seconds while registering the observers' eye movements. The eye movements differed between the fit and the no-fit conditions: for fitting combinations a larger area of the painting was scanned and more eye fixations were made. The results suggest that, at least for the current painting-music combinations, congruency between painting and music leads to an increase in the visual exploration of the paintings.

Variance of features in artworks and other image categories

Anselm Brachmann, Erhardt Barth & Christoph Redies

Friedrich-Schiller-Universität Jena

In computational aesthetics, multiple algorithms that can distinguish between different artistic styles or discriminate photographs according to their aesthetic appeal have been proposed. While these algorithms work well with regard to their applicability, they provide little insight into the question of what makes an artwork pleasing to look at, or generally speaking, what makes artworks visually more appealing than other image categories. In the present work, we derive a set of features that capture the variance of filter responses of a widely used Convolutional Neural Network, called AlexNet, which was trained on millions of photographs of objects in order to recognize classes of objects in images. Among these features, we identify a set of only two features that allow for a classification accuracy of 93.0% when distinguishing traditional artworks (Western, Islamic and Chinese) and diverse categories of non-art images. By analyzing these features more deeply, we identify two distinct properties, which tend to be associated with traditional artworks. First, the artworks tend to be rich in visual structure, meaning that they are filled with pictorial elements across the entire image, and second, artworks show a high variability, meaning that the artist minimizes repetition of pictorial elements across the image.

Predicting visual complexity of abstract patterns: Edges, corners, compression rate, and mirror symmetry

Andreas Gartus & Helmut Leder

University of Vienna

Visual complexity is a concept relevant for many fields that range from usability of technical displays or websites to studying aesthetic experiences. Consequently, many attempts have been made to calculate the visual complexity of pictures from objective image properties. It has been argued that visual complexity is a multidimensional construct mainly consisting of two dimensions: A quantitative dimension (e.g., number of elements) that increases complexity and a structural dimension (representing order) negatively related to complexity. The objective of this work is to study human perception of visual complexity using two large independent sets of abstract black-and-white patterns. To reassess existing models of visual complexity, a large number of computerized measures of complexity was calculated and combined using linear models as well as machine learning (random forests) to predict human evaluations of image complexity. Our results confirm the adequacy of two-factor models of perceived visual complexity consisting of a quantitative (compression rate of edge and corner image) and a structural factor (mirror symmetry) for both of our stimulus sets. In addition, a non-linear transformation of the symmetry predictor giving more influence to small deviations from symmetry greatly increased explained variance in one of the two stimulus sets. Thus, we demonstrate the multidimensional nature of human complexity perception and present comprehensive quantitative models of the visual complexity of abstract black-and-white patterns, which might be useful for future experiments and applications.

Watching contemporary dance choreographies: Relationship between observers' somatic reactions and aesthetic experience

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The present study investigated the relationship between observers' body reactions and the aesthetic experience while watching contemporary dance choreographies. In the study participated 38 students from the University of Novi Sad. Stimuli consisted of eight video records of choreographies that were performed within American televised dance competition show 'So You Think You Can Dance'. Participants judged their body reactions when observing dance on 12 dichotomous scales describing three dimensions: Focus (I hold my breath, I get goosebumps, I won't look away, I don't blink), Excitement (My heart beats faster, I have butterflies in my stomach, I feel vibrations in my body, I mimic the movements while I sit) and Embodied Anticipation (My knees buckle, I get teary-eyed, I shake, My muscles clench). Aesthetic experience participants rated on the three dimensions of aesthetic experience of dance: Dynamism (7-step scales: expressive, powerful, strong, exciting), Exceptionality (scales: eternal, unspeakable, unique, exceptional) and Affective Evaluation (scales: delicate, elegant, seductive, emotional). The multiple regression analyses have shown that the dimensions of somatic experience of observed dance significantly predict the Dynamism (R2=.200). Analyses indicated that the dimension 'Focus' is significantly better predictor of Dynamism (β=.500): the higher the 'Focus' the higher the Dynamism. The results of this study are in line with the previous findings which suggest an important role of body response concerning observers' aesthetic experience of dance choreographies. Results reveal that the higher the 'Focus' the choreography is experienced as more powerful, exciting, strong and expressive.

Failed perception, false truths in Bruce Nauman's art

Adi Louria Hayon

Tel Aviv University

Since 1968 American artist Bruce Nauman is exploring the relation between the body, perception, technology, and the production of knowledge. From experimentations with sensual perception, through his critique of the reliability of sight, Nauman's work exhibit the doubtful reign of epistemological equipment to produce knowledge. My aim is to demonstrate the historical roots and the empirical operation of the inconsistency of the technological modus operandi radically reshaping knowledge. This paper will show how Nauman exhibits the doubtful validity of attaining knowledge by the senses as well as the shared devices of perception and the arts, such as linear perspective, reflection, trompe-l'oeil, anamorphosis and other contraptions that touch upon documentation and illusionism.

Rooted in the Cartesian discourse of methodic doubt, Nauman's works fail the apparatuses of the senses to differ their operation from thought by disrupting perception. The works perform how the impeded sensual senses perpetually separate mind from the production of knowledge without allowing a resolution. A comprehensive analysis of these modes in the works of Descartes and Nauman shows that while the French philosopher cast doubt to give primacy to the cogito, the American artist performs the failure of the senses and their technological contraptions to maintain the separation of the senses from thought as well as the separation maintaining the differentiation of the senses themselves. I will prove how Nauman's failing mechanisms expose their difference, their autonomy and withdrawal from the mind, while foregrounding the body through sensuous aesthetics that exceed the search for certitude to sustain doubt.

The importance of behaviour as an aesthetic feature

Alessandro Soranzo

Sheffield Hallam University

In this study we measured aesthetics of interactive objects (IOs), which are three-dimensional physical artefacts. By means of an Arduino Mini board fitted with a motion sensor to detect the objects being picked up, IOs can exhibit autonomous behaviour when handled. These stimuli therefore activate more than one sense at the time, in compound stimulation. The main aim of this research was to test the hypotheses that behaviour is an aesthetic feature. Corollary aims were to investigate whether aesthetic preference for distinctive objects' structures emerges in compound stimulation to investigate whether aesthetic preference for distinctive objects' structures emerges in compound stimulation; secondly, to explore whether there exists aesthetic preference for distinctive objects' behaviours; and lastly, to test whether there exists aesthetic preference for specific combinations of objects' structures and behaviours. The following variables were manipulated: 1) IOs' contour (rounded vs. angular); 2) IOs' size (small vs. large); 3) IOs' surface texture (rough vs. smooth); and 4) IOs' behaviour (Lighting, Sounding, Vibrating, and Quiescent). Results show that behaviour influenced aesthetics preference more than any other characteristic; Vibrating IOs were preferred over Lighting and Sounding IOs, supporting the importance of haptic processing in aesthetics. Results did not confirm the size and smoothness effects previously reported in vision and touch, respectively; this suggests that, for some stimulation, the aesthetics preference that emerges in isolated conditions may be different in compound stimulation. Results corroborate the smooth curvature effect. It is concluded that behaviour can be considered an aesthetic primitive.

Individual differences in the visual preference for curved contours

Manuel Belman[1], Tommaso Currò[2], Guido Bartolomé Corradi[1], Jaume Rosselló[3], Marcos Nadal[1] & Enric Munar[1]

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People tend to prefer objects with curved contours to objects with sharp contours (Bar & Neta, 2006; Palumbo & Bertamini, 2016). Nevertheless, as with other aesthetic features (Jacobsen, 2004), there are also considerable differences among

people in the extent to which they prefer curvature. The aim of the research presented here was to explore the possible reasons for such differences. Specifically, we sought to determine whether individual differences in preference for curvature were explained by participants' interest in art, studies, openness to experience, intelligence or sex. Thus, we asked 56 participants to perform a 2AFC preference for curvature task (Munar, Gómez-Puerto, Call & Nadal, 2015), answer questions of a Visual Art Interest and Education Scale (VAIES), Raven's intelligence test and answer the openness to experience scale from the NEO-PI-R (Costa & McCrae, 1992). Linear mixed effects modeling was used to predict participants' preference for curvature using their experience with art, openness to experience, studies, and sex as predictors.

Tuesday August 29th Oral presentations

Current and future goals warp object category space in opposite directions

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Previous studies demonstrated that only representations of currently task relevant goals can be decoded from brain activity. However, it is still unclear how and where representations of future goals are instantiated in the brain. Here, we measured fMRI of human participants while on each trial we presented two real-world objects from different categories serving as targets for two consecutive visual search tasks. We manipulated the relevance of the objects with a cue that indicated which object to look for first (current), and which second (prospective). We used multi-voxel pattern analysis to decode the dynamical changes in representational space of the object categories in object-selective cortex throughout the trial, as a function of current versus prospective task relevance. As predicted, we observed better category decoding for the currently relevant than for the prospectively relevant category right before the first search. Additionally, when we trained the classifier on the currently relevant category and tested on the prospectively relevant category or vice versa, classification was below-chance during both searches. This indicates that current and future object categories are represented in opposite corners of the representational space. Indeed, representational similarity analyses confirmed that as a trial unfolds, object representations move from object category space (e.g. a cow) into relevance space (e.g. current target), where current and prospective targets of the same category are represented by opposite representational patterns. Taken together, our results demonstrate how the brain shields current from future targets and vice versa, by pushing the representational space into opposite directions.

Serial dependence in visual search

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Recent studies showed that percepts can be strongly biased toward previously seen stimuli (Fischer & Whitney, 2014; Taubert et al., 2016; Cicchini et al., 2014). These serial dependencies are usually interpreted as purposeful and adaptive in an autocorrelated world: by smoothing out fluctuating and noisy visual input over time, we can derive a more stable percept. However, serial dependence could be harmful in certain situations, such as during search for tumors in radiographic images, because it alters object (tumor) appearance. Here, we tested whether serial dependence can influence search and classification of objects in critical tasks such as tumor recognition. We created three objects with random shapes (A/B/C) and generated 48 morph objects in between each pair (147 objects in total). On each trial, subjects were presented with a random object at a random location in a superimposed noisy background, and were asked to locate the object and classify it as object A/B/C. Subjects made consistent perceptual errors when classifying the shape, seeing it as more similar to the shape presented on the previous trial. This attraction exhibited temporal and spatial tuning: it lasted up to 15 seconds back in time and occurred only when current and previous shapes were presented within a spatial window of 10-12.5°. Control experiments showed that the serial dependence does not reflect a response bias. Taken together, our results show that serial dependence can be detrimental when fine object recognition is needed, for example when searching and classifying tumors in radiography.

Transfer of object information between the periphery and fovea; an MEG study.

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This study investigated the flow of visual information from the periphery to the fovea utilising discriminant cross training of neural activity recorded via MEG. Thirteen participants fixated a central point and completed a one back, object category repetition task. The objects were either 'spikeys' or 'smoothies' and presented in one of five locations; the fovea or four peripheral locations. MEG data was used to train a series of classifiers to identify the object category and location. Classification errors were examined, specifically, times the classifier identified the correct object identity but the incorrect location at test. Overall classification accuracy peaked between 100 to 150 ms post stimulus onset. The most frequent location-only errors were those when the object was presented in the periphery but the classifier identified the object as being at the fovea. These errors occurred at 120ms and 150 ms post stimulus onset, when the overall performance was very high. The classification errors toward the fovea are suggestive of an object identity and location signal occurring at these times that is sufficiently similar to that of the same object presented to the fovea, even though it is presented in the periphery. We interpret this pattern as indicative of transfer of information about the identity of the object from peripheral receptive fields to foveal receptive fields during the visual task.

Object appearance, but not semantics, is represented in the human category-selective cortex.

Stefania Bracci, Ioannis Kalfas & Hans Op De Beeck

KU Leuven - University of Leuven

Human visual cortex represents objects categories, and in particularly the animate-inanimate division. Recent results converge showing that object visual properties such as shape cannot account for the animate-inanimate organization. Here we extend on this by asking whether visual cortex indeed represents object semantic properties or how an object looks like. We compiled a stimulus set that included 9 different triads containing one animate object (e.g., a cow), one inanimate object (e.g., a mug), and then, crucially, one inanimate object that looked like the animate object (e.g., a cow mug). Neuroimaging data was acquired in 17 subjects by means of an event-related design and multi-voxel patterns were analyzed for all 27 images. Results revealed that the animate-inanimate division is not the primary organizational principle in ventral visual cortex: activity patterns of inanimate objects that look like animate entities were significantly closer to the corresponding animal (e.g., cow mug and cow) as compare to the corresponding object (e.g., cow mug and mug). The surprising nature of this finding is enhanced by the fact that (1) deep neural networks (DNNs), (2) human overall similarity judgments, and (3) task requirements during scanning showed the opposite pattern: a clear separation between the animate (animals) and inanimate (objects and objects that look-like animals) category. In conclusion, the category-based organization in ventral visual cortex is primarily driven by relative high-level object visual properties such as how an object looks like rather than more abstract object semantic and category membership properties.

The influence of auditory cues on visual size aftereffect

Alessia Tonelli, Luigi F. Cuturi & Monica Gori

Size perception can be influenced by several visual cues such as spatial (e.g. depth or vergence; Murray et al., 2006; Sperandio et al., 2012) and temporal contextual cues (e.g. adaptation to steady visual stimulation; Pooresmaeili et al., 2013). Nevertheless, perception is generally multisensory and other sensory modalities, as auditory, can contribute to functional estimation of objects'size (Gallace and Spence, 2006; Jaekl et al., 2012; Takeshima and Gyoba, 2013). In this study, we investigate whether auditory stimuli at different sound pitch can influence visual size perception after visual adaptation. To this aim, we used an adaptation paradigm (Pooresmaeili et al., 2013) in three experimental conditions: visual-only, visual-sound at 100 Hz and visual-sound at 9 kHz. We asked the participants to judge the size of a test stimulus in a size discrimination task. First, we obtained a baseline for all conditions. In the visual-sound conditions, the auditory stimulus was concurrent to the test stimulus. Second, we repeated the task by presenting an adapter (twice as big as the reference stimulus) before the test stimulus. We found that the low frequency sound decreases and a high frequency sound increases the effect of visual adaptation. A significant difference between 100 Hz and 9 kHz conditions was observed. Results suggest that auditory cues not only contribute to functional estimation of size perception, but can also influence the effect of visual size adaptation, by reducing or enhancing the aftereffect depending on sound frequency.

Attending to motion-in-depth modulates fMRI responses in striate and extrastriate visual areas

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Motion-in-depth (MID) stimuli defined by changing disparity (CD) or inter-ocular velocity differences (IOVD) appear to drive motion-responsive regions in extrastriate cortex. However, the neural pathways involved in the perception of MID above simple visual responses to its components remain unclear. We probed these pathways using fMRI and an attentional manipulation.

Subjects switched attention between three different tasks (MID modulation, contrast dimming and fixation change) while viewing a constantly-presented random-dot stimulus containing either CD or IOVD cues. 500ms events of all three task types were randomly interleaved within each scan. Every 15 seconds, participants (N=6) were cued to detect one of these event types, and ignore the others. Whilst attentional state changed systematically throughout the scan, the stimulus did not.

Attending to contrast or MID resulted in greater modulations in V1, V2, V3 and V4 than the fixation task. Responses in early visual areas were greater when attending to MID changes than to contrast changes. This pattern was also observed in areas V3A/B, MT and MST. Additionally, we observed differential activation within these motion-selective areas depending on whether MID was conveyed by CD or IOVD. Activity in V3A/B, MT and MST was strongly modulated by attending to the CD stimulus, whereas attending to the IOVD stimulus resulted in smaller modulations within area MT.

These results suggest that early visual cortex and motion-selective areas are causally involved in the perception of MID. Attentional modulations in motion-selective areas can be differentiated depending on the cue type that conveys MID.

Adaptive serial dependence of visual estimates

Fraser Aitken & Justin Ales

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Serial dependence is a phenomenon in which peoples perceptions of current stimuli values depend on previously seen stimuli. However, it is still poorly understood which aspects of a stimuli affect the amount of serial dependence observed. One theory is that the visual system makes an estimate of what is in the environment based of fixed weighting of past and current stimulus values. Another explanation is that the visual system weights current and past stimulus values adaptively. When stimuli are clear more weight is attached to new values. In contrast, in unclear conditions more weight is attached to past values. Here we test both models by using a paradigm that has previously shown serial dependency in the

perception of orientation (Fischer & Whitney, 2011). Participants viewed randomly oriented gabors embedded in noise and indicated the stimulus orientation by adjusting the orientation of a line. In order to assess whether the amount of serial dependence depends in stimulus visibility we manipulated the contrast of our stimuli (5%, 10% and 20%). We found no significant amount of serial dependence for any contrast level. However, because the orientation was uncorrelated across trials any amount of stimulus averaging would actually reduce accuracy. In a second experiment we introduced a correlation in the orientation across trials and tested 5% and 10% contrast levels. In this experiment we found that the amount of serial dependence now changes when the visibility of the stimulus changes. Supporting the theory that the visual system uses an adaptive weighting of information.

Objective visual acuity estimation in amblyopia: The case of distorted vision

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Standard psychophysical estimation of visual acuity is unreliable in some patients, for instance in cases of suspected malingering. Objective acuity estimation based on visual evoked potentials (VEPs) is a valuable tool in such cases. However, the VEP technique overestimates acuity in Amblyopia. It has been suggested that this is due to visual distortions, which affect optotype recognizability while leaving VEP responses largely unaffected. This distinguishes amblyopia from most other visual impairments. To test this hypothesis, we introduced artificial optical distortions in healthy participants by inserting a patterned glass pane in front of the stimulus monitor, thereby imitating amblyopia. In 28 participants VEP-based acuity estimates were obtained, and in 26 participants the P300 of the event-related potential was recorded to optotype stimuli. Stimulus degradation through wide-angle scattering (frosted glass panes) served as a reference condition. Both types of stimulus degradation were equalized with respect to standard psychophysical optotype-based acuity. With distorted stimuli, the VEP consistently overestimated acuity, as in real amblyopia. Acuity estimates based on P300 responses to optotypes were in good agreement with psychophysical acuity. In the reference condition (wide angle scattering), both methods performed well. The data corroborates the hypothesis that perceptual distortions make VEP-based acuity estimates unreliable, as suggested for the case of amblyopia. P300-based techniques with optotype stimuli provide a solution to this problem.

Inferring animacy from mid-level shape features

Filipp Schmidt, Mathias Hegele & Roland W. Fleming

Justus Liebig University Giessen

Visual classification of objects into superordinate categories such as "animal", "plant" or "mineral" is computationally challenging because radically different items (e.g., "octopus", "dog") must be grouped into a common class ("animal"). Learning superordinate categories therefore should teach us not only the membership of particular (familiar) items, but also should teach us about general features that are shared across class members to classify novel (unfamiliar) items. We investigated general visual shape features associated with animate and inanimate classes. First, a group of participants viewed images of 75 unfamiliar animals, plants, and minerals and provided separate ratings of how much each image looked like an animal, plant and mineral. Results show systematic tradeoffs between the ratings, indicating a class-like organization of items. Second, another group of participants rated each image in terms of 22 mid-level shape features (e.g., "symmetrical", "curved"). Together, the results of both groups confirm that superordinate classes are associated with particular shape features (e.g., "animals" generally have high "symmetry" ratings), and that K-means clustering based on the 22-D feature vectors predicts the perceived classes approximately as well as the ground truth classification. These findings suggest that a set of general mid-level visual shape features forms the basis for superordinate classification of unfamiliar objects along the animacy continuum.

Granger causality analysis reveals the role of the hippocampal complex in the memory functions of primary visual cortex

Lora Likova

Background. Our previous studies have implicated the primary visual cortex (V1) as the putative visuo-spatial 'sketchpad' for working-memory, but in a supramodal form. To elucidate this memory-related role for V1, we need to assess the significance and direction of its interactions with hippocampal complex structures, such as the hippocampus per se and the perirhinal cortex (PRC, which has direct anatomical connection to V1). We therefore ran Granger Causality analysis between these structures. Methods. Functional MRI was used to assess changes in brain activity in blind subjects before and after a unique training intervention based on memory-guided drawing (5 days of Cognitive-Kinesthetic training). Three tasks (20s each) were run: tactile exploration of raised-line drawings of faces and objects, tactile memory retrieval via drawing, and a scribble motor/memory control.

Results. Comparative pre/post Granger Causality analysis of the fMRI data revealed a significant increase in causal influences from hippocampus and PRC to V1 after training with the memory-drawing task, but not during the control task, indicating that the drawing-from-memory training strengthened the top-down effects on visual cortex from these hippocampal complex structures.

Conclusion. This is the first study to demonstrate causal connectivity from the hippocampus and PRC to V1. That this happens as a result of a memory-training intervention supports our hypothesis of the role of these memory structures as a top-down source for the cortical reorganization of V1 in the blind, consistent with its proposed function as a supramodal working-memory 'sketchpad' for the active processing of detailed spatial information (Likova, 2012).

Visual processing capacity in multiple sclerosis: New implications for clinical assessment

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Cognitive impairment is a frequent problem in multiple sclerosis (MS). It can be present from the beginning and has detrimental effects on quality of life. Early and valid detection is, therefore, of utmost importance. The present study assessed visual processing capacity in MS based on the mathematically formalised 'theory of visual attention' (TVA, Bundesen 1990, 2005). This approach provides parameter estimates for quantifying separable components of the individual efficiency of visual information uptake: perceptual threshold, iconic memory, processing speed, and visual short-term memory (VSTM) storage capacity . A clinically representative sample of 75 consecutive patients with MS were tested in a TVA-based whole report task and compared to 75 healthy controls matched for gender, age and education. Clinically relevant variables assessing the disability status (EDSS, MSFC) were also assessed, and two standard cognitive screening instruments , PASAT-3 and MoCA, applied. Significant changes of all four TVA-based parameter estimates in MS-patients were found. VSTM storage capacity was revealed to be the only parameter estimate that was unaffected by age, disease duration, and disability status. Furthermore, the TVA-based method detected deficits in visual processing capacity even in high functioning MS patients who were unimpaired in terms of MoCA and PASAT-3 scores. In summary, TVA whole report appears as a promising tool for grasping core aspects of cognitive impairment in MS even at an early disease stage.

The contribution of active suppression to efficient visual working memory: An ERP study

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A large body of studies has shown that both the prioritization of relevant information and the suppression of irrelevant information contribute to efficient selective visual attention. Given the close relationship between visual attention and visual working memory (WM), we examined how active suppression may also contribute to visual WM. We adapted a classical change detection task (Luck & Vogel, 1997) to include both relevant items to be memorized (targets) and irrelevant items to be ignored (distractors). Critically, targets and distractors were systematically lateralized, enabling us to use ERP components that solely reflect either prioritization or suppression of this information from WM. Specifically, we were interested in an N2pc subcomponent, the distractor positivity (PD). The PD is typically observed in visual search tasks in which salient items need to be actively suppressed (Hickey et al., 2009). We hypothesized that this ERP component would be implicated in this WM task, given that active suppression was required. We found that the PD component increased with the number of distractors that needed to be suppressed from WM. In additional experiments, we showed that perceptual grouping of distractors facilitates suppression from WM and increasing the number of targets impedes suppression. Interestingly, individuals with high WM capacity showed more suppression. In sum, our study shows that active suppression of irrelevant items contributes to the maintenance of relevant information in WM; Actively suppressing irrelevant information may help to overcome increased filtering needs.

Deconstructing peripheral appearance

Daniel R. Coates, Zeynep F. Yildirim, Natalia Melnik & Bilge Sayim

University of Bern

Object perception in the periphery is impaired by crowding, the harmful effect of flankers on target discrimination. The magnitude and spatial extent of crowding has been exhaustively measured using target identification experiments. However, the impact of crowding on stimulus appearance has received far less attention. Therefore, our goal was to capture appearance in peripheral vision and crowding directly, by letting observers adjust spatial properties of probes to perceptually match complex multiline configurations. Subjects adjusted the number, position, orientation, and size of the line segments. Items were presented in the fovea and at 10 degrees in the periphery. There were three location conditions: foveal match to peripheral target, peripheral match to foveal target, and peripheral match to peripheral target (in opposite visual fields). Each condition was tested both with and without flankers ('X's). General error patterns resembled those seen with traditional methods, including feature mislocalizations such as the perception of flanker elements at the target location. With foveally-viewed targets, peripheral matches were poorly positioned, but contained accurately sized and oriented segments. For peripherally-viewed targets, segments were typically shortened and often omitted (ie, target diminishment) from both peripheral and foveal matches. Whole element omissions were most frequent when the overall Gestalt of the target did not rely on the missing segment (quantified by the vertices leading to minimal change in the convex hull). By letting subjects make highly flexible feature adjustments to match their percepts, our results capture phenomenologically valid representations of peripheral vision, and reveal fundamental properties of form perception.

Pupillary response indicates target identification in visual search

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Lomonosov Moscow State University

In this study it was checked whether there is a specific pupillary response indicating the cognitive event of target identidfication. Twenty subjects (12 females, 18-22 years, normal vision) participated in two experiments. In experiment 1, the subjects performed a visual search for a target stimulus (red horizontal bar) within a display of distracters (red vertical and green vertical-horizontal bars). Fixation-aligned baseline-normalized pupillary responses were registered with an Eyleink 1000 eyetracker. During target fixations pupil started to dilate quickly reaching a peak about 300-400 ms. During distracter fixations, the increase in pupil dilation was less pronounced. Pairwise Student's t-tests revealed a difference in pupil size profiles between 100 and 500 ms from fixation onset. In experiment 2, the visual search task was

made more complex by adding a singleton distracter (a yellow horizontal bar) to a half of the trials. Here, pupil also dilated more pronounced during target fixations but significant differences in pupil size profiles were observed between 300 and 500 ms from fixation onset. Larger pupil dilation during target fixations possibly reflects the accumulation of visual evidence for the presence of a target and the subsequent decision about the presence of a target. Making this task more complex leads to the postponement of the decision about the presence of the target. Systematic increases in the pupil size may be used to automatically detect the cognitive event of target identification. This work was supported by RFBR, grant no. 17-06-00652.

Time is used to infer space in visually impaired individuals

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Many works have demonstrated enhanced auditory processing in blind individuals, suggesting that they compensate for lack of vision with greater sensitivity of the other senses. Few years ago we demonstrated severely impaired auditory precision in congenitally blind individuals in an auditory metric task. Their thresholds for spatially bisecting three consecutive, spatially distributed sound sources were seriously compromised, ranging from three times typical thresholds to total randomness. Here we demonstrated that the deficit disappears if blind individuals are presented to coherent temporal and spatial cues (short space associated with short time and vice-versa). More interestingly when the audio information is presented in conflict for space and time (short space associated with long time and vice-versa) while sighted individuals result unaffected by the perturbation, blind individuals were strongly attracted by the temporal cue with in most cases the psychometric function resulting inverted. EEG results support our behavioral results by showing an opposite trend for the spatial and temporal audio bisection task in sighted and blind individuals. When temporal and spatial information are presented in conflict we observed a lateralized visual activation for the spatial audio signal in sighted participants and contrarily a lateralized visual activation for temporal audio signal in blind individuals. This result suggests that blind participants use temporal cues to make audio spatial estimations and that the visual cortex has a functional role on such perceptual task.

Out with the new, in with the old: Attracting attention to locations without new events

Eric Taylor[1], Matthew Hilchey[2] & Jay Pratt[2]

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Experiments researching the orienting of attention traditionally involve measuring speeded responses to the sudden presentation of new objects defined by transient light, a paradigm that we call the new-event approach. Most models of exogenous orient reserve a role for transient-sensitive, low-level visual pathways that activate the orienting system, as though its sole purpose is the detection of new events. Recently, we showed that attention can be captured at a location containing completely intransient stimuli – or 'old' events. In this presentation, we provide evidence that locations containing completely intransient stimuli can orient attention exogenously in an adapted version of the Posner-style cueing task. Using our adapted array, we observed canonical patterns of facilitation and inhibition emerging from locations containing a static cue. This is a decidedly surprising pattern of results for practitioners of the new-event approach (in whose company we belong), because there is no obvious manner in which our cue stimuli could activate the transient-sensitive pathways that are substrate to exogenous orienting. Additionally, we provide evidence that attentional capture by these intransient stimuli exhibits the spatial gradient typical of genuine attention, whereas a visually equivalent-but-transient version of our array instead generates a non-spatial distractor cost indicative of effects on the response. Taken together, these findings show that a completely static stimulus, with no obvious resemblance to the target, can attract attention in a canonical manner despite complete intransience and despite being perceptually 'old'.

EEG correlates of priority switches in working memory-driven visual search

Ingmar De Vries, Joram Van Driel & Christian N.L. OliVers

Vrije Universiteit Amsterdam

Visual search is assumed to be guided by an active visual working memory representation of what we are currently looking for. This attentional template of the search target can be dissociated from accessory memory representations that are needed prospectively, for a future task. Little is known about how the brain sequentially prioritizes consecutive task goals. We report evidence showing that such flexible prioritization is captured by posterior alpha-band (8-14 Hz) dynamics. We measured EEG while observers performed two consecutive working memory-guided visual searches. During the first delay, leading up to the first of the two searches, posterior alpha power was suppressed contralateral relative to ipsilateral to the memory item. Importantly, these lateralized alpha dynamics were stronger if the lateralized item was the imminent search target (the current template), than when the item was the subsequent search target (the prospective template). In a second study, we more closely investigated the switch in priority between search tasks. Importantly, in 40% of trials an auditory cue replaced the first search. At this point the first template could be dropped, in favor of now prioritizing the second, prospective template. Interestingly, dropping the first template resulted in clear alpha enhancement, while making the former prospective template the current search target resulted in alpha suppression, contralateral to the respective memory item. This switching occurred around 200 ms after the auditory cue. Together, these findings reveal a crucial role for alpha-band oscillations in the prioritizing of and switching between current and future goals for visual search.

Increased stimulation of ipRGCs affects achromatic spatial contrast sensitivity

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Intrinsically photosensitive retinal ganglion cells (ipRGCs)—the recently discovered third receptor type in human retina—affect circadian rhythm and pupillary light reflex, suggesting that ipRGCs encode irradiance information of surroundings. Although how background illumination influences spatial vision and how ipRGCs contribute to non-imaging forming functions in rodents have been intensively studied, little is known about the contribution of ipRGCs to human spatial vision. Here we measured human spatial contrast sensitivity function (CSF) to investigate how ipRGCs contribute to spatial vision. A Gabor test stimulus with variable spatial frequencies was presented either at the left or at the right side of the fixation. Achromatic contrast thresholds were measured using two-alternative forced-choice procedure. We manipulated two metameric backgrounds with high-ipRGC and low-ipRGC stimulations, respectively, and their luminance and color were the same using silent-substitution technique. Results revealed different shapes of CSF with high- and low-ipRGC backgrounds: The contrast sensitivities at middle spatial frequencies increased in high-ipRGC background compared to those in low-ipRGC background, indicating that ipRGC stimulation enhances spatial tuning. Further analysis of the CSF curves reflected the receptive-field structures: Radiuses of center and surround receptive fields were different between the two backgrounds. These results suggest that ipRGCs influence the receptive field structure of ganglion cells in the magnocellular pathway that convey luminance information to the brain.

Perceiving the softness and plasticity of deformable materials

Vivian C. Paulun, Filipp Schmidt & Roland W. Fleming

Justus Liebig University Giessen

We have previously shown that non-rigid materials appear softer, the larger their average deformation (Paulun, Schmidt, van Assen, & Fleming, 2017). Here we investigated if perceived softness is also influenced by whether the deformation is permanent (i.e. plastic, such as Play-Doh) or rapidly reverses (i.e. elastic, such as rubber). More specifically, we tested whether softness and plasticity of a material are perceptually linked. For this purpose, we simulated and rendered five short (1 sec) scenes in which a target object was deformed by one or two rigid objects. The target objects were non-rigid and either plastic or elastic, i.e. deformations were permanent or not, and of high or low compliance. Fifteen observers rated the apparent softness, plasticity and maximal deformation of the target objects. As expected, objects that remained in their deformed shape were rated as more plastic and objects with higher compliance were rated as softer. However, these two dimensions were not independent from another: Objects were rated softer if their deformation was permanent (plastic) rather than elastic even though the maximal deformation was the same. The pattern of results was constant across different scenes. When asked to rate the maximal deformation of a time sequence, observers were biased towards the time-averaged deformation of that sequence. Both softness and elasticity ratings are in line with a model observer that takes into account the directional average deformation. The resulting model predictions have been validated with a new set of stimuli.

Involuntary orienting to sound can retrospectively improve visual perception

Daphné Rimsky-Robert[1], Matteo Lisi[2], Charlotte Delporte[1], Viola Störmer[3] & Claire Sergent[1]

[1]Université Paris Descartes & CNRS; [2]City, University of London; [3]UC San Diego

It is well known that the occurrence of a stimulus in one sensory modality can influence subsequent processing of a second stimulus in another. In particular, involuntary orienting to a peripheral sound enhances perceptual sensitivity of a subsequent visual stimulus that appears at the same location (McDonald et al., 2000). In the visual modality, attentional cueing can enhance perceptual processing even when the cue is presented after the target stimulus is gone (Sergent et al., 2013). However, this effect likely includes both attentional and non-attentional mechanisms such as low-level visual interactions between cue and target. In the present study, participants performed a simple detection task of visual stimuli (Gabor patches) at threshold contrast while listening to auditory cues which occurred either before or after target appearance. Our study was aimed at (1) assessing the contribution of supra-modal attention (vs. low-level sensory interactions) to the retrospective cueing effect and (2) evaluating the effect of retrospective cueing on response time. Results show that both auditory pre- and retro-cueing improved detection sensitivity of the visual target in a similar fashion and decreased target detection times. These results extend retrospective cueing effects to cross-modal attention, showing that involuntary orienting to sound can retroactively evoke consciousness of visual stimuli at threshold, and reveal new insights into the effects of post-cueing on consciousness and overt behavior through the analysis of response time to post-cued stimuli.

The interacting influence of alpha amplitude and instantaneous frequency on visual perception

Stephanie Nelli, Sirawaj Itthipuripat & John Serences

UC San Diego

Rhythmic neural activity in the alpha band (8-13 Hz) is thought to play an important role in the selective processing of visual information. Typically, modulations in alpha amplitude, phase and frequency are thought to reflect independent mechanisms impacting dissociable aspects of visual information processing. However, these metrics are not independent in complex systems with interacting oscillators, suggesting that alpha amplitude and frequency may reflect a common underlying mechanism. We record electroencephalography (EEG) in human subjects and show that both alpha amplitude and frequency predict behavioral performance in the same visual discrimination task. Consistent with a formal model of coupled oscillators, we then show experimentally that fluctuations in frequency predict

alpha amplitude on a single trial basis, empirically demonstrating that these two metrics are not independent. Furthermore, we replicate this interdependence in other unrelated experiment, indicating it is not specific to idiosyncrasies of our original experiment. This interdependence suggests that changes in amplitude and frequency reflect a common change in the excitatory and inhibitory neural activity that regulates alpha oscillations and thus visual information processing.

Serial-dependencies in the perception of orientation, number, faces and bodies

David Charles Burr[1], Guido Marco Cicchini[2] & Kyriaki Mikellidou[3]

[1]University of Florence; [2]CNR Institute of Neuroscience; [3]University of Pisa

It is well known that the perception of stimuli depends strongly on spatial and temporal context. One clear example of temporal contextual effects is serial dependence, the influence of preceding stimuli on the perception of current stimuli in a sequential display. We suggest that serial dependence reflects an optimal encoding strategy, combining an internal model of the world derived from past experience with current sensory experience, well modelled by an intelligent, adaptable Kalman filter. The Kalman filter model makes clear predictions of how the magnitude of serial dependence should vary with the sensory precision of the current and past stimuli, and the physical difference between the two stimuli. We tested these predictions for the perception of orientation, numerosity, faces, facial expression, and bodysize. In all cases, the parameter-free Kalman filter model predicted the results, qualitatively and quantitatively. To relate this work to the previous literature, we also measured reaction times. Reaction times were fastest when the current stimuli were most similar to the previous, and the magnitude of the advantage of reaction time correlated well with the magnitude of serial dependence, across subjects. The pupillary response also varied, in a similar way to reaction times (less for most similar stimuli). All this data is consistent with the notion that perception depends strongly on internal models of the world, which are constantly updated from sensory experience.

The size of the attentional window when measured by the pupillary response to light

Shira Tkacz-Domb & Yaffa Yeshurun

University of Haifa

This study explores the size of the attentional window when attention is narrowly focused, with a measurement that is independent of performance - pupillary response to light (PLR). Previous studies demonstrated that when spatial covert attention is deployed to a bright area the pupil contracts relative to when attention is deployed to a dark area, even though display luminance levels are identical. We used these attentional modulations of the PLR to assess the spread of attention. Specifically, we examined how far light/dark task-irrelevant disks can be from the attended target and still affect pupil size. We presented a square with a rotating letter to the right and left of fixation (eccentricity: 6.75°). Task-irrelevant disks surrounded each square with varying inter-stimuli distances (1°, 4°, 7°, 11°). The disks' luminance was bright on one side and dark on the other. A central cue instructed observers to attend the right or left letter. With the 1° and 4° distances, pupil size was smaller when the target was surrounded by bright than dark disks, but this effect emerged later with the 4° distance. Critically, this attentional effect on the PLR was eliminated at the third distance, suggesting that only disks presented up to a distance of 4° fell within the attentional window. Moreover, the magnitude of the attentional modulation of the PLR decreased as the inter-stimuli distance increased suggesting that attention is not uniformly spread across its window. Currently, we examine this effect with a finer scale around the edges of the attentional window.

The perceptual consequences of serial dependencies

Guido Marco Cicchini[1], Kyriaki Mikellidou[2] & David C Burr[3]

[1]CNR Institute of Neuroscience; [2]University of Pisa; [3]University of Florence

Serial Dependencies occur in many visual tasks indicating that perception and perceptual decisions are based upon a running history which spans up to tens of seconds (Fischer & Whitney, 2014, Cicchini et al 2014). Recently a distinction has been made suggesting that the past stimuli have an attractive effect only upon perceptual decisions whereas perceptual judgments undergo a repulsive effect (Fritsche et al 2017). Here we show several datasets which demonstrate, however, that under many circumstances also perceptual judgments have a strong attraction towards the previously presented stimuli. In a first series of studies we show that when stimuli are similar (i.e. less than 12 degrees orientation apart) strong attractive effects are found. Further we find stronger effects with oblique stimuli as opposed to cardinal stimuli, replicating previous work that related serial dependencies to sensory reliability. Interestingly our data are consistent with an optimal integration model which prescribes conspicuous integration over time only if successive stimuli are similar and at higher levels of stimulus uncertainty. In a second dataset we show that when stimuli are similar even if every second trial the response requested to the subject is changed there is a conspicuous serial dependency. What matters is stimulus orientation regardless of post-perceptual assignments. We thus conclude that serial presentation is capable of producing robust and reliable perceptual effects provided some simple conditions are met.

References: Fischer and Whitney (2014) Nature Neuroscience Cicchini, Anobile and Burr (2014) PNAS Fritsche, Mostert and de Lange (2017) Current Biology

The influence of relative context on transient attention shifts vs sustained dwelling and their effects on awareness

Aimee Martin & Stefanie Becker

The University of Queensland

Visual attention selects important information, and is believed to be instrumental for awareness. According to the relational account, attention is tuned to the relative rather than the physical features of a target, so that relatively matching

distractors (e.g., bluest, largest) can capture attention more strongly than physically target-matching items. While previous studies supported the relational account, the evidence is limited to transient attention shifts, and it is unknown (1) whether relational tuning also influences sustained attention (i.e., dwell), and (2) how transient vs. sustained attention affect awareness. The present study examined these questions by examining the effects of different distractors on visual search, and probing participant's awareness of the distractor location on rare trials. A first, eye movement study revealed that target-dissimilar distractors that matched the relative colour of the target (e.g., bluest) captured the eyes most strongly, in line with the relational account. However, dwell times were longest on the target-similar distractors. Awareness depended both on the initial transient attention shift and sustained dwelling on the distractor, but correlated more strongly with capture. A second, EEG study revealed a larger N2pc to relatively matching rather than physically matching distractors, indicating that the N2pc reflects attentional capture rather than sustained dwelling. Still, the N2pc did not predict awareness as well as behavioural measures. These results show that the relational account can be fruitfully extended to awareness, and highlight the importance of the context in determining top-down tuning of attention, orienting and awareness.

Spatially specific working memory improvements in the vicinity of visual landmarks

David Aagten-Murphy & Paul M Bays

University of Cambridge

Visuo-spatial working memory (VWM) allows us to retain sensory information about visual objects even when they are no longer visible. This is essential when comparing transient stimuli, such as two flashes of light, or when localising an object that has been occluded. In this way VWM contributes to our continuous and stable percept of the world. Here we investigated the effect of visual landmarks, stimuli that remain visible across memory delays, on the precision of visual localization. We found that localisation was more precise for stimuli occurring near a visual landmark, with the benefit decreasing as the distance between the landmark and the probed stimulus increased. The mere presence of a landmark during encoding conveyed no benefit, suggesting that the improvements were not driven by attentional cueing of the neighbouring stimuli by the landmark. However, the benefit remained present even when the landmark was temporarily blanked during the delay period, indicating that the continuous presence of the landmark was not essential. We found no evidence of a performance cost for items far from the landmark, suggesting that the addition of relative spatial information from the landmark did not compete for storage with absolute locations. A model of optimal integration, treating absolute and relative spatial information as independent cues, accurately captured human performance across multiple set sizes. Overall, these results demonstrate an important contribution of relative spatial information to VWM that is likely to be critical for spatial localisation in more naturalistic settings which contain an abundance of visual landmarks.

The typical advantage of object-based attention reflects reduced spatial cost

Einat Rashal[1] & Yaffa Yeshurun[2]

[1]EPFL; [2]University of Haifa

In Egly, Driver, and Rafal's (1994) seminal study an attentional precue appeared either at the target location (valid), a different location within the same object (invalid-same), or on another object (invalid-different). Performance was best in the valid condition, reflecting the advance allocation of spatial-attention. Additionally, performance was better in the invalid-same than invalid-different condition, reflecting object-based attention allocation. However, previous studies that employed this paradigm did not include a baseline condition in which neither a specific object nor a specific location was indicated. It is, therefore, not clear whether this object-based effect reflects a 'genuine' performance benefit over baseline, or a reduction of the cost inflicted by allocating spatial attention to the wrong location. To examine these possibilities we performed three experiments in which we added a neutral condition to the classical paradigm. The typical results were replicated, but performance was worse in the invalid-same than neutral condition. Hence, attending an object only reduced the cost of allocating attention to the wrong location. Importantly, because the different theoretical accounts of object-based effects generate different predictions regarding performance in the neutral condition, these findings pose various constraints on the different accounts. Specifically, our results fit well with the attentional shifting account. The other accounts – attentional prioritization and attentional spreading/signal enhancement – require additional assumptions in order to accommodate our finding.

Independent effects of eye and hand movements on visual working memory

Nina Maria Hanning & Heiner Deubel

Ludwig-Maximilians-Universität München

Both eye and hand movements have been shown to bind visual attention to their goal locations during movement preparation, and it has been suggested that eye and hand targets are selected by independent, effector-specific attentional mechanisms. Furthermore, both saccades and reaches have been shown to selectively interfere with visual working memory, presumably due to the deployment of spatial attention to action goals. Given the assumption of independent attentional mechanisms for the selection of eye and hand targets, the question arises whether the two effector systems also separately interact with visual working memory. To approach this issue, we investigated spatial memory performance in combined eye-hand movements. In a dual task paradigm, participants memorized several locations and performed eye, hand, or combined eye-hand movements during the maintenance interval. Subsequently, we tested working memory performance at motor goals and action-irrelevant locations. We found that for single eye and single hand movements, working memory performance was increased at the motor target compared to the action-irrelevant locations. Remarkably, the same amount of benefit was found at both the eye and hand target for combined eye-hand movements – with no memory tradeoff between the two targets. We

conclude that both effector systems independently enhance visual working memory at their goal location. This is line with the finding that eye and hand targets are selected by separate attentional mechanisms.

Tuesday August 29th Symposia presentations

Visual Modulation of Auditory Processing During Speech

David Brang

University of Michigan

How do we understand natural speech in the presence of auditory noise or overlapping voices? This talk will highlight the mechanisms through which visual information enhances speech perception, particularly in instances when sensory information is available to one modality earlier than to another (e.g., initial lip movements typically precede speech onset). Using measures of local synaptic activity acquired from intracranial electrocorticographic (ECoG) recordings in humans along with convolutional neural networks, I will show results from a series of studies examining how visual signals modulate auditory networks in expectation of specific sounds. In particular, these data indicate that knowledge of what an individual's voice sounds like and the content conveyed during lipreading (speechreading) both refine the spectral-temporal properties of auditory cortical networks in preparation for specific auditory content (e.g., the frequencies associated with a speaker's voice or the frequencies associated with specific phonemes) prior to the onset of any auditory stimulus. These data point to a general model of multisensory processing in which precursor multisensory information enables the encoding of stimulus specific information across a variety of sensory systems in expectation for redundant or complementary signals, leading to facilitated perceptual and cognitive processes.

Sound-induced activation of the visual cortex influences visual perception

Steven Hillyard

University of California

Recent studies have found that peripheral sounds activate the visual cortex of the contralateral cerebral hemisphere, even in the absence of visual inputs or a visual task. This activation is manifested electrophysiologically as a slow Auditory-evoked Contralateral Occipital Positivity (ACOP) and a concurrent desynchronization of the occipital alpha rhythm (McDonald et al. 2013; Störmer et al. 2016). This talk will report studies showing the behavioral consequences of these sound-induced activations in visual cortex. Consistent with the hypothesis that the modulations in visual cortex index the cross-modal orienting of visual attention to the location of the sound, it was found that a preceding sound affects the perceptual processing of visual stimuli presented at the sound's location in a variety of tasks. In particular, these perceptual effects include an enhancement of brightness contrast, improved pattern discrimination, and speeded entry into perceptual awareness of the co-localized visual stimulus. For each of these effects, trial to trial variation in visual perception was predicted by the amplitude of the preceding ACOP and changes in alpha activity. Together, these results indicate that visual perception is directly affected by the prior occurrence of auditory stimuli.

The multisensory scaffolding for perception across the lifespan

Micah Murray

University of Lausanne

This talk summarizes our efforts to identify the spatio-temporal brain mechanisms and behavioural relevance of multisensory interactions in humans and the consequence such has had on our understanding of the organization of the brain, the functional selectivity of low-level cortices, and plasticity across the lifespan. Across studies we have used combinations of psychophysics, ERPs, fMRI and TMS, taking advantage of innovations in signal processing to yield greater mechanistic interpretability of the data. Several general conclusions are supported by the collective data. First, (near) primary cortices are loci of multisensory convergence and interactions. Second, these effects occur at early latencies (i.e. <100ms post-stimulus onset). Third, these effects directly impact behaviour and perception. Fourth, multisensory interactions are context-contingent. One the one hand, they affect not only current stimulus processing, but also later unisensory recognition. Current unisensory (auditory or visual) object recognition and brain activity are incidentally affected by prior single-trial multisensory experiences; the efficacy of which is predictable from an individual's spatio-temporal dynamics of multisensory interactions. We then extend such findings across the lifespan to show how multisensory processes may be yoked together. Finally, examples of multisensory processes at the service of rehabilitation are presented. Together, these data underscore how multisensory research is changing long-held models of functional brain organization and perception across the lifespan.

On the interaction of temporal expectation and multisensory interplay

Toemme Noesselt

Magdeburg University

Previous studies focusing on attention in multisensory contexts have often investigated the effects of spatial attention or attention to modality. The effects of temporal attention - and, more specifically, temporal expectations derived from rhythmic sequences - has not been studied extensively yet. In my talk I will present evidence for an interaction of multisensory stimulation and temporal expectation. In a series of experiments we tested how well multisensory and unisensory targets embedded in a sequence of distractors could be discriminated under varying levels of stimulus reliability. Importantly, implicit temporal expectations were manipulated by changing the likelihood of early/late target occurrence blockwise. Our results indicate that perceptual sensitivity is enhanced for expected relative to unexpected targets. Importantly, MSI preserves temporal expectations in situations with reduced stimulus reliability. We propose that enhanced informational content enables the extraction of temporal regularities.

Aberrant neural oscillations reflect altered multisensory processing in schizophrenia

Daniel Senkowski

Charité Berlin

Electroencephalography and magnetoencephalograhy studies have shown aberrant neural oscillations during unisensory processing in schizophrenia. Moreover, recent behavioral studies have demonstrated altered multisensory integration in this patient group, but the neural mechanisms underlying these alterations are not well understood. In this talk, I will present a series of high-density EEG studies investigating whether aberrant neural oscillations contribute to altered multisensory processing in schizophrenia. During multisensory processing we found aberrant neural oscillations in various frequency bands in patients compared to healthy controls. Our studies provide first evidence that aberrant neural oscillations relate to altered multisensory processing in schizophrenia.

Salient sounds activate visual cortex

Viola Störmer

University of California

Several studies have shown that hearing a sound can influence visual processing of a subsequent stimulus at the same location. In this talk, I will examine the neural mechanisms underlying these cross-modal interactions using EEG. First, I will present data showing that a salient sound increases the perceived contrast of a visual stimulus by enhancing neural activity evoked by that stimulus in early visual processing pathways. Next, I will show that a salient sound activates the visual cortex by itself – even in the absence of visual stimulation. In particular, I will show that a lateralized salient sound elicits a slow positive deflection over posterior scalp sites that is larger over the hemisphere contralateral to the sound. This Auditory-evoked Contralateral Occipital Positivity (ACOP) is accompanied by a contralateral decrease of the occipital alpha rhythm – a brain oscillation that has been closely linked to visual-spatial attention. Together, these results suggest that a salient sound captures visual-spatial attention and subsequently biases visual activity in a spatially specific manner, possibly suggesting that spatial attention is inherently visual.

Shape from specular flow

Dicle Dövencioglu, Ohad Ben-Shahar & Katja Doerschner

The human visual system can infer 3D shape from motion information generated solely by moving specularities (specular flow). However, this process appears to yield different 3D shape information than classic structure from motion would predict. Where for objects with matte-textured surface material the flow of visual information is mostly driven by the global motion direction of the object, for specularly reflecting objects, changes in the specular flow are based on both, the object motion and the second order properties of its shape. Moreover, specular surface reflectance elicits non-rigid deformations in the optic flow that violate the requirements to solve structure from motion. Here we present evidence that perceived local 3D shape is indeed different for specular and matte-textured objects, and that estimates of 3D curvature are more reliable when judging specular objects. To understand how local and global shape information are extracted from deformations in the visual information is important from both, perceptual and computational perspectives. This work highlights the critical role of surface reflectance in shape estimation.

Jelly and Goop: Visual Perception of Non-Rigid Materials

Roland W. Fleming, Vivian C. Paulun, Jan Jaap Van Assen & Filipp Schmidt

Justus Liebig University

Many materials in our environment move and change shape in characteristic ways, from liquids—which flow, splash and ooze under gravity—to gelatinous materials that bulge and wobble when poked. The specific motion patterns and shape deformations are the result of complex interactions between the material's intrinsic properties (shape, viscosity, elasticity, mass, etc.) and the external forces to which it is subjected. Thus, to infer a material's physical properties, the visual system must somehow decompose the observed motion and shape changes into the relative contributions of intrinsic and extrinsic factors. From a computational perspective, this causal segmentation problem is highly challenging, and yet under typical viewing conditions we usually enjoy an extremely rich subjective visual impression of materials' physical properties, and can make intuitive predictions about their likely behaviour. Here, I review a series of studies we have performed using computer simulated non-rigid materials, including fluids and jellies. The findings suggest that the human visual system draws on a wide range of mid-level shape and motion cues to infer material properties. Although individual cues are highly ambiguous, their combination often yields extremely accurate predictions of human judgments, including both failures and successes of material perception. Application of machine learning methods to large numbers of simulations reveals statistical regularities that may enable unsupervised learning of shape and motion cues simply from observing examples of material behaving.

Shatter and splatter: The contribution of optics, shape, and motion to the perception of non-rigid, breaking soft and hard materials

Alexandra C. Schmid & Katja Doerschner

Justus Liebig University

Surface optical qualities like gloss, colour, and transparency can tell you whether your glass contains water, milk, or wine, but until you hit the top of a crème brûlée with a spoon, you can't tell whether the caramel is satisfyingly brittle (shatters), or disappointingly sticky (splatters). Non-rigid materials and their qualities are determined visually through a mixture of surface appearance (optical information) and the way they interact with the environment (mechanical information). It remains unclear how these sources of information contribute

to the perception of non-rigid materials, e.g. does one override the other, or do they contribute separately or interactively? Here, we present a series of experiments that investigate how optical information and two sources of mechanical information – shape and motion – influence the perception of non-rigid, breaking materials. We created novel simulations of materials ranging from soft to hard bodies that broke apart differently when dropped (mechanical properties manipulation), and rendered them with surfaces ranging from translucent glossy to opaque matte under a natural illumination field (surface optics manipulation). In addition to these "full-cue" stimuli, several other stimulus conditions were designed to isolate static cues (shape and optics) and motion cues. Observers rated each substance on several material attributes. Analyses of these ratings revealed interactions between optics, shape, and motion, demonstrating a critical dependency between these cues in the perception of non-rigid materials. Furthermore, analyses of motion information suggested that motion provides a unique contribution above shape cues, which could be reflected in the higher order statistics of velocity.

Seeing materials from movements: motion cues in perception of cloth in dynamic scenes

Bei Xiao & Wenyan Bi

American University

Humans can decide whether the cloth is stiff or flexible by observing its movements under applied force. We study how well humans use motion cues to infer mechanical properties under varying forces. We created cloth animations containing a hanging fabric under external wind force and vary parameters controlling both intrinsic mechanical properties and external wind force. Observers judge bending stiffness and mass of the cloth under wind forces of different strengths in a paired-comparison task. Our results show that estimations of both bending stiffness and mass are positively correlated with physical parameters, indicating that humans are able to recover both properties under variation of external forces. Moreover, we find that the estimation of bending stiffness is not affected by strengths of wind. But this is not true for estimating mass. In order to reveal what motion statistics are correlated with the perception, we analyzed a variety of optical flow statistics based on the animated videos and computed how well they correlate with both the perceptual results and the physical parameters. We discover that the average and the standard deviation of the motion speed are predictive of the estimated bending stiffness. But different sets of statistics are predictive of estimating mass from estimating bending stiffness, suggesting that humans might rely on different motion cues to estimate bending stiffness and mass. A linear regression model based on these motion statistics correctly predicts the perceptual results. This suggests humans use motion statistics to estimate cloth mechanical properties under variation of external forces.

Transparent surface formation from non-rigid image deformation

Takahiro Kawabe & Shin'ya Nishida

NTT Communication Science Laboratories

When a transparent medium which refracts light has a curved surface, the medium tends to cause the image deformation of its background. When the surface dynamically and non-rigidly changes, for example, in a wave of water, the background image also dynamically and non-rigidly deforms. We will review our three studies which showed that human observers utilize the dynamic image deformation as a cue to the presence of a transparent layer and/or transparent material. In the first study, we manipulated the spatiotemporal frequency of image deformation, and found that the specific bands of the frequency were strongly linked with a transparent layer perception. In the second study, we focused on the magnitude of image deformation that a simulated fluid flow produced, and observed that the smaller and larger magnitude of the deformation biased material percepts toward hot air and water, respectively. Finally, we found that the deformation-defined junctions connecting deforming with undeforming regions were the strong determinant of transparent layer perceptions. We will discuss how the visual system utilizes dynamic image deformations to interpret the presence of a transparent surface.

Shape deformations are ubiquitous in images: how do we tell that objects are deforming?

Qasim Zaidi & Erin Koch

State University of New York

Many objects in the world are rigid and many non-rigid. The retinal image of an object deforms if it moves or if the viewer moves, so how do observers decide that a viewed object is rigid or non-rigid? We examine both cases for 3-D objects and their 2-D images. We created a scene of two bodies lying with limbs at different angles to the viewer, and used a similar spatial configuration for rectangular bricks. Images of the scenes were acquired from 5 different camera angles, and each image was seen from 5 viewpoints. Observers judged the 3-D orientation of 10 "limbs" for each of the images in three repetitions. By correcting for camera-angle and viewpoint for each observation, we can compare the estimated 3-D orientation of each limb with the physical orientation. We can also compare estimated angles between adjacent limbs to physical angles. This method enables us to measure perceptual distortions for 3-D scenes and their images, in a richer way than done previously. We analyzed the reported perceptual distortions for 3-D scenes as a function of camera-angle. These distortions can be large, and we simulate possible perceptual assumptions that are used to infer physical layout. Distortions are smaller for 2-D images with changing viewpoint, but are still very noticeable. We are testing whether a simple function of the angle of the limb wrt the camera can explain perceived distortions in 2-D images. This study helps us understand which deformations in retinal images can be discounted and which cannot.

Effects of locomotion on the activity of the mouse visual system

E. Mika Diamanti, Daisuke Shimaoka, Mario Dipoppa, Kenneth D Harris & Matteo Carandini

University College London

Sensory responses in the eye and lateral geniculate nucleus are highly repeatable, and predictable by simple models of image processing. In cortex, however, responses also depend on signals originating within the brain, which vary from trial to trial, and depend on ongoing behavior. For instance, visual cortical responses depend strongly on locomotion. We record from the brains of head-fixed mice walking on treadmills while viewing simple stimuli or navigating virtual environments, using a variety of methods including extracellular recording, two-photon calcium imaging, and widefield imaging of the entire dorsal cortex. Our measurements in primary visual cortex (V1), indicate that locomotion diversely affects different cell classes (excitatory neurons vs. different types of inhibitory neurons), giving rise to changes in visual preferences and spatial integration that go beyond a simple change in gain. Moreover, locomotion interacts with vision to affect responses during navigation, perhaps to help the animal estimate is own movement. Beyond V1, locomotion does not affect all regions equally: it has different effects on visual, auditory, and somatosensory cortex. In visual areas beyond V1 toward parietal cortex, visual signals are transformed to encode variables relevant to navigation. Locomotion thus seems to have multiple effects on sensory responses, from a general modulation similar to arousal to specific effects on individual neurons, which may be related to the estimate of self-motion or to the localization of the animal in a particular point in space.

Altered sensitivity and tuning in visual cortex during defensive mobilization: Evidence from autonomic physiology and multimodal imaging

Andreas Keil

University of Florida

Visual scene processing is modulated by semantic and motivational factors, in addition to physical scene statistics. Motivational aspects of the visual scene, such as aversive responses to threat, also result in robust modulation of autonomic (peripheral) physiological processes, including heart rate and skin conductance. In this presentation, we discuss experimental explorations of autonomic and visuo-cortical dynamics as observers learn that a novel, initially unengaging, stimulus is motivationally relevant. Combining the steady-state visual evoked potential and autonomic signals with hemodynamic neuroimaging techniques, we find that sensitivity and tuning of neural masses in lower-tier visual cortex changes as a function of motivational relevance acquired through Pavlovian fear conditioning. The temporal dynamics of these visuo-cortical changes, their extent, and the pattern of brain regions establishing flexible links with visual cortex reflect the specific behavioral and environmental demands to which observers adapt. Findings challenge the notion of a unitary attention mechanism linking arousal to vision. Results will be discussed in a theoretical framework that views defensive engagement as a set of flexible mechanisms that include sensory and autonomic adaptations, aimed to maximize the likelihood of survival.

Visual input signaling threat gains preferential access to awareness

Surya Gayet, Chris L. E. Paffen, Artem V. Belopolsky, Jan Theeuwes & Stefan Van Der Stigchel

Utrecht University

The present study addresses the question whether visual information that signals threat gains preferential access to awareness. We combined a fear conditioning procedure with a breaking continuous flash suppression (b-CFS) task. In this task, participants were presented with high contrast dynamic masks to one eye, and a target grating presented to the other eye (suppression condition) or to the same eye (no-suppression condition). Participants were asked to report the orientation of the target as soon as it became visible. Target gratings were surrounded by a blue or red annulus, one of which was repeatedly paired with an electrical shock during the acquisition phase (from now on the CS+), while the other color was not (CS-). Subsequently, participants completed four blocks of b-CFS trials. The results revealed that target orientation was reported faster on trials with CS+ annuli than with CS- annuli. This difference in response time reflected a difference in suppression duration rather than response speed, as no difference in response time was observed in the no-suppression condition. This pattern of findings is particularly striking, as (1) participants knew that no shocks would be administered during the b-CFS task, (2) the colored annuli were irrelevant for participants' behavioral task and (3) participants were unable to distinguish suppression from no-suppression trials. Taken together, these results demonstrate that visual information that was previously paired with aversive stimulation, and thus signaled threat, is prioritized by the perceptual system such that it more readily breaches the threshold of awareness.

Acute exercise modulates visual responses in human cortex

Tom Bullock, James C. Elliott, Hubert Cecotti, John T. Serences & Barry Giesbrecht

UC Santa Barbara

An organism's current behavioral state influences ongoing brain activity. Nonhuman mammalian and invertebrate brains exhibit large increases in the gain of feature-selective neural responses in sensory cortex during locomotion, suggesting that the visual system becomes more sensitive when actively exploring the environment. This raises the possibility that human vision is also more sensitive during active movement. To investigate this possibility, we recorded electroencephalography (EEG) while participants sat on a stationary bike and responded to visual stimuli at rest and during bouts of low- and high- intensity cycling exercise. In the first experiment (n=12), we observed increased amplitude in the parieto-occipital P1 ERP component evoked from stimuli presented in an RSVP stream during low-intensity exercise relative to rest, suggesting that exercise may influence the sensory gain mechanism in human cortex. In the second experiment (n=18) we used an inverted encoding model (IEM) technique to estimate feature-selective neural responses from data acquired from participants performing an orientation discrimination task. Here we observed increased gain and reduced bandwidth in the reconstructed feature-selective tuning profiles observed during

the low-intensity exercise condition relative to the other conditions, suggesting that exercise-induced sensory gain can be feature-specific. Thus, despite profound differences in the visual pathways across species, our data provide preliminary evidence that sensitivity in human visual cortex may also be enhanced during locomotive behavior. These results contribute to our understanding of how global behavioral states modulate neural representations in human sensory cortex and provide valuable evidence linking the neural mechanisms of behavior state across species.

Arousal state enhances contrast sensitivity under conditions of exogenous attention

Rosanne L. Rademaker, Sam Ling & Alexander T. Sack

Physiological arousal is often assumed to "heighten the senses", but how does arousal influence basic perceptual processing? Arousal state could prompt a wholesale modulation of the entire sensorial environment, or act exclusively on behaviorally relevant information. Here we investigated this question by measuring contrast sensitivity under physiological stress, induced via exposure to ice water (Cold Pressor Test). Specifically, we aimed to distinguish mechanisms of attention and arousal: Does arousal mimic the effects of visual attention on contrast sensitivity, or do attention and arousal interact? We estimated contrast psychometric functions for thirty participants who discriminated the orientation of peripherally presented gratings at eight contrast levels. Exogenous attention was manipulated using a transient cue that briefly appeared prior to grating presentation either at fixation (neural cue) or adjacent to the upcoming grating (attention cue). Critically, participants performed this task under two conditions: Once while their foot was submerged in comfortably warm water (36ºC) and a second time when the water was near freezing (3ºC). Consistent with prior work, exogenous attention increased the gain of the contrast psychometric functions. However, contrast functions were unaffected by water temperature in the unattended condition, demonstrating that arousal itself did not boost visual sensitivity. Interestingly, in the attended condition cold water increased visual sensitivity beyond the gain increase already observed with warm water, indicating that arousal can amplify effects of exogenous attention. Taken together, these results suggest that arousal acts to prioritize processing of behaviorally relevant visual information by innervating and acting on the exogenous attentional system.

The neuroanatomical basis of the functional properties of the dorsal and ventral pathways

Dwight Kravitz

George Washington University

Since their inception the dorsal and ventral pathway framework has had a profound impact on the study of the neural correlates of vision. Briefly, the framework proposed that cortical vision was organized in two distinct pathways emerging from early visual cortex. The dorsal pathway was proposed to be involved in spatial vision, while the ventral pathway was specialized for object vision. More recently, the functional characterization of the dorsal pathway has been updated to focus on vision for action. This talk will present a neuroanatomical framework based on the last 30 years of tracer studies done in monkey. This detailed look at the two pathways reveals a rich internal structure and many distinct external connections emerging from each pathway. This framework argues that each pathway is a complex circuit whose functions are constrained by their common retinal input and divergent external connections. Further, empirical functional evidence from human will also be presented showing that the detailed nature and topography of representations within the pathways is predictable from their internal connectivity (e.g. retinotopic effects on extrastriate object representations) and external projections.

Two streams or a delta? Neuroimaging contributions to interpreting the two visual streams hypothesis

Jody C. Culham

University of Western Ontario

In 1992, Goodale and Milner proposed a dichotomy between visual streams for perception and action in occipitotemporal and occipitoparietal cortex, respectively. Coincidentally, 1992 was also the publication year for the first papers to employ functional magnetic resonance imaging (fMRI) to measure activation of specific regions within the human brain. In the 25 years since these developments, fMRI has been applied to test many aspects of the two-streams hypothesis. While early fMRI studies that focused on activation levels provided support for the hypothesis, more recent studies that focus on patterns of activation and connectivity between areas have suggested extensive cross-talk between streams that is modulated by the task. I will review fMRI data from the classic neuropsychological patient DF as well as neurotypical participants to show both evidence for the dichotomy and a deeper recognition of the complexities underlying specific phenomena. Considering the "wiring diagram" of the brain, including the many connections between the streams, I will argue that perhaps the analogy of two distinct "streams" may be better replaced by a river "delta" with cross channels. I will also argue that the field should move beyond debates on the veracity of the model toward richer interpretations that better reflect the complexities of the brain, as revealed in part by human fMRI.

Perception-action dissociations: The status of a long-lasting debate

Volker H. Franz[1], Karl K. Kopiske[2], Nicola Bruno[3], Constanze Hesse[4] & Thomas Schenk[4]

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Goodale and Milner's two visual systems hypothesis (TVSH) posits a fundamental difference between visual processing for action and visual processing for perception. Important evidence for the TVSH has been the famous finding

that certain visual illusions (most prominently the Ebbinghaus/Titchener illusion) deceive perception but not grasping. I will describe a large, international, pre-registered study that targeted at resolving the 20-year long debate of whether or not this is true (Kopiske, Bruno, Hesse, Schenk, & Franz, 2016, Cortex, 79, 130-152). The study is the by far largest study ever conducted on this topic. We ran the same experiment in parallel in four different labs (total N=144), replicated previous studies, and tested grasping as well as multiple perceptual tasks and control conditions. The design, methods and statistical analyses were pre-registered and peer-reviewed before data collection and not altered thereafter. Data and statistical analyses are open available. We used classic Fisherian ('frequentist') statistics as well as Bayesian methods (with essentially unequivocal results). Results show that grasping is affected by the Ebbinghaus illusion and that these effects are similar to those on perception. Albeit some researchers might now believe that the results of the many studies on this topic were simply contradictory, I will argue that the results of all those studies are quite consistent, giving a surprisingly coherent picture: Grasping seems to be affected by the Ebbinghaus illusion to a similar degree as perception. These results cannot easily be reconciled with the traditional TVSH.

The Two Visual Systems Hypothesis: Updates from Neuropsychology and Pictorial Illusions

Robert L. Whitwell , James T. Enns , Melvyn A. Goodale [1 2]

[1]The University of British Columbia, Vancouver, BC, Canada; 2 The University of Western Ontario, London, ON, Canada

The two visual systems hypothesis (TVSH), originally put forward by Goodale and Milner (1992) over twenty-five years ago, characterized the functional roles of the ventral and dorsal pathways as 'vision-for-perception' and 'vision-for-action', respectively. A core feature of the TVSH is its theoretical emphasis on the requirements of the different behavioural systems the two pathways serve. This feature has been conserved in subsequent, expanded accounts of the anatomical and functional organization of the visual system (e.g., Kravitz, Saleem, Baker & Mishkin, 2011; Rizzolatti & Matteli, 2003), and it is notable that these later proposals highlight the complexity and heterogeneity of the dorsal stream in particular. In this talk, I review recent evidence from studies of normally-sighted populations and of two patients, DF and MC, who possess large lesions to the ventral stream and largely sparing the dorsal stream that supports this core feature of the TVSH. In accordance with the predictions of the TVSH, both patients show gross deficits in vision-for-perception when discriminating objects but largely preserved vision-for-action when they reach out to pick those objects up. In normally-sighted populations, studies of the Ponzo and Sander illusions support a role for the dorsal stream in error-minimization, movement updating, and, more generally, unconscious sensorimotor learning. That is, learning that updates motor output but does not alter conscious experience of the visual displays. I also offer a rebuttal to the assertion that evidence from visual form agnosia patient DF cannot be used as valid support for the core feature of the TVSH.

The Neuropsychology of perception and action

Thomas Schenk

Ludwig-Maximilians University Munich

The visual brain of primates and humans consists of two systems. These two systems are anatomically distinct and operate functionally in largely independent ways. One, the ventral system, creates a visual representation of the external world, the other, the dorsal system, uses visual information to guide our actions. In support of this model findings from anatomy, physiology, and psychophysics were presented. However the most compelling evidence for this hypothesis comes from the field of Neuropsychology. Milner and Goodale, who introduced the dual-systems hypothesis, regarded the contrasting deficits of patients with visual form agnosia and optic ataxia as the most compelling piece of evidence for their model. Patients with visual form agnosia and patients with unilateral neglect produce near-normal visuomotor behavior despite profound perceptual deficits. Patients with optic ataxia show the opposite behavioral pattern. Milner and Goodale argued that it is hard to explain this double-dissociation unless you assume some form of neuroanatomical division of labor between perception and action. In this talk I wish to present findings from visual form agnosia, unilateral neglect and optic ataxia in an effort to show that it might not be that difficult to account for the neuropsychology of perception and action without adopting the dual-systems hypothesis.

Wednesday August 30th Poster presentations

Behind optical factors in anisometropic aniseikonia

Gabriele Esposito, Alessio Facchin[1], Marta Maffioletti[2], Silvio Maffioletti[3], Angelo Gargantini[4], Silvia Bonfanti[4], Francesco Bonsignore[5] & Paolo Nucci[5]

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Aniseikonia is a binocular condition in which the apparent sizes of the images seen by the eyes are unequal. Aniseikonia is commonly associated with anisometropia, moreover the perceived size can be influenced by other factors such as spacing of retinal elements and some degree of perceptual factors. The aim of this study is to test the degree of aniseikonia in induced anisometropia by ophthalmic lenses (OL) and contact lenses (CL).We have measured aniseikonia using a new instrument in 52 isometropic participants inducing an anisometropia of +1.50,+3.00 and +4.50 dioptre with OL and CL. As expected, the results show that aniseikonia is larger for ophthalmic lenses; however it is different from zero when induced by CL. When induced by OL, the aniseikonia is larger than the value predicted by optical formula. Because there is great variability between subjects at baseline and in aniseikonia induced by lenses, there is some kind of perceptual influence on perceived aniseikonia. These results show that aniseikonia is not only influenced by the optical factor but there are more perceptual aspects as previously hypothesized.

A novel way to quantify non-stationary aspects of multi-stable perception.

Stepan Aleshin & Jochen Braun

Otto-von-Guericke University

The dynamics of multi-stable visual perception has been studied extensively for decades. 'Dominance periods' are stochastic, typically Gamma distributed, and weakly correlated over a few reversals. Whether dominance sequences are stationary (i.e., exhibit constant n-th order densities and auto-correlation) or non-stationary over intermediate time-scales remains unclear.

To address this issue, we established reversal sequences with a standard 'binocular rivalry' display (5 observers, 5 contrasts) and computed their statistics (mean, variance, skewness, kurtosis, autocorrelation lag 1 and lag 2). For comparison, we generated shuffled sequences with identical statistics. To characterize longer-term fluctuations, we divided both observed and shuffled sequences into bins of fixed duration and counted reversals per bin. For each bin size, we compared the coefficient of variation (CV) of this count to its expected distribution (obtained from scrambled sequences). Expressing observed CVs in multiples of the standard deviation of the expected CVs yielded a novel 'burstiness index' (BI).

Observed sequences showed large 'burstiness' (BI 6), peaking at intermediate contrast and for bin sizes of 6 dominance periods. Shuffled sequences showed no significant burstiness. To our knowledge, this represents the first quantification of non-stationarity at intermediate time-scales in multi-stable perception.

To demonstrate that 'burstiness' is informative about the underlying mechanism, we reproduced the observed statistics by fitting the model of Laing & Chow (2001). Artificial sequences proved less bursty and did not depend on contrast.

We conclude, firstly, that dominance statistics fluctuate significantly at intermediate time-scales and, secondly, that these fluctuations constrain the generative mechanism of multi-stable perception.

Stereoscopic acuity as a function of (optically-modified) interpupillary distance and additional monocular cues to depth

Anne-Emmanuelle Priot, Florian Doumergue, Charles-Antoine Salasc, Justin Plantier & Pascaline Neveu

Institut de recherche biomédicale des armées

When binocular disparity is the only cue to depth, stereoscopic acuity is proportional to the interpupillary distance (IPD). Telestereoscopic viewing which increases the effective IPD by a factor of N is expected to increase binocular disparity (and as a result, stereoscopic acuity) by the same factor N. Our study sought to investigate stereoscopic acuity under telestereoscopic viewing when secondary visual cues to depth are available. In that case, depth is specified by conflicting altered binocular disparity and unaltered monocular cues. Stereoscopic acuity was assessed using a Howard-Dolman test. 31 participants had to set a vertical rod to appear in the same frontal plane as another fixed rod placed at three meters. Stereoscopic acuity was assessed for three effective IPD (unchanged, two and four times the participants' natural IPD), in two testing conditions: A standard test condition (standard use of Howard-Dolman test), and an enriched test condition in which several monocular cues to depth (motion parallax, relative size and shadows) were introduced. In the standard test condition, increasing the effective IPD significantly increased stereoscopic acuity. For the multiplying factors x2 and x4 of IPD, stereoscopic acuity increased by factors of 1.2 and 1.6 respectively. The lower than expected gains were likely due to residual monocular cues in the standard Howard-Dolman test. Conversely, stereoscopic acuity did not depend on effective IPD in the enriched test condition. We ascribe the absence of telestereoscopic viewing effect in the enriched test condition to a down-weighting of disparity contribution relative to those of the monocular cues.

Sensitivity to binocular cues to motion-in-depth in adults with common impairments of binocular vision in childhood

Ryan T. Maloney[1], Milena Kaestner[1], Alison Bruce[2], Marina Bloj[3], Julie M. Harris[4] & Alex R. Wade[1]

[1]University of York; [2]Bradford Institute for Health Research and University of York; [3]University of Bradford; [4]University of St Andrews

There are two known binocular sources of information available for the perception of motion in depth: changes in disparity over time (CD), and interocular velocity differences (IOVD). While CD requires the accurate computation of small spatial disparities, IOVD could, in principle, be computed with a much lower-resolution signal. It is possible, therefore, that IOVD signals might still be available in conditions with limited or no stereopsis, eg. amblyopia (Maeda et al., 1999, IOVS). We measured sensitivity to these two cues independently in adults who had undergone eye patching or extraocular muscle surgery to correct childhood misalignment or amblyopia. We used a 2-interval forced choice (2IFC) paradigm where participants selected the interval containing a smoothly-oscillating MID "test" stimulus from a control stimulus. Test and control stimuli were identical at the monocular level but the control did not provide information adequate to produce percept of smooth motion-through-depth. Thus the task was only possible if information from both eyes was combined. Those participants with no static stereoacuity displayed no evidence for sensitivity to either CD or IOVD, while those with static stereoacuity thresholds of 110 arcsec or better displayed a pattern resembling that of populations with no history of binocular impairment: some were more sensitive to one cue over the other, or showed similar sensitivity for both (Allen et al., 2015, IOVS; Nefs et al., 2010, Front Psychol). In summary, we found no evidence for sensitivity to IOVD in individuals with a history of binocular vision impairment and no static stereoacuity.

Stereothreshold estimates from a Bayesian staircase versus post hoc fitting of a psychometric function

Kathleen Vancleef[1], Ignacio Serrano-Pedraza[2], Graham Morgan, Craig Sharp, Carla Black, Therese Casanova, Jessica Hugill, Sheima Rafiq, Michael Clarke & Jenny Read[1]

[1]Newcastle University; [2]Universidad Complutense de Madrid

Measuring stereoacuity in children can be challenging. A typical psychophysical experiment is usually too long to keep children engaged. Clinical tests have low reliability, require 3D glasses and a fixed viewing distance. We have developed an Accurate STEReotest On a mobIle Device (ASTEROID) that uses a Bayesian staircase procedure for efficiency, a dynamic random-dot stereogram to eliminate monocular cues, real-time viewing distance correction and game animations to keep children engaged. Here, we compared two different ways of analysing ASTEROID data. 551 (63%) of 873 children between 2 and 11 years old showed a good understanding of the task in the practice trials and were therefore testable. We calculated the threshold estimate after 20 trials in two different ways: (i) the mean of the posterior probability density function after the last trial; (ii) the threshold of a psychometric function fitted post hoc to all trials. With the staircase (i), the median stereothreshold was 348", with 158 (29%) of estimates >1000", i.e. in the range considered stereoblind; the median for the 393 thresholds <1000" was 199". With the fitting (ii), the median stereothreshold was 89", with 117 (21%) >1000"; the median for the 434 thresholds <1000" was 62". Thus, fitting to all data generally yields lower thresholds, which are more in line with other estimates of stereoacuity. We conclude that post hoc fitting of a psychometric function to all data recorded for a given subject results in more realistic estimates than the final posterior of the Bayesian staircase.

Evaluation of the residual stereopsis following implantable Collamer lens implantation in patients with cataract-a pilot study

Hua Liu[1] & Hang Chu[2]

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Objective: We have investigated two biological models, binocular dynamic stereopsis and extensive stereopsis model, which is manipulated by high-level visual cortex and paths, to explore the correlation between clinical manifestation and residual stereoscopic vision following implantable Collamer lens implantation in patients with cataract. Methods: 31 congenital or traumatic cataract patients, ageing from 4 to 14, who underwent implantable Collamer lens implantation between December 2015 and February 2017, were examined for ophthalmology routine visual function examinations and novel stereopsis tests based on the two models between 1 week and 3 month after surgery. We realized binocular vision separation by using polarized glasses, and recorded patients' residual stereoscopic vision data in two models, including suppression, gazing stability, distant and near stereopsis, fine and coarse stereopsis, and dynamic and second-order stereopsis. All the data were analyzed statistically. Results: 31 patients(100%) had no stereopsis existed in routine visual function examinations, 8 patients had binocular dynamic stereopsis, 15 had extensive stereopsis existed and 8 had no stereopsis existed in the two models tests. Conclusion: The patients' binocular visual functions remained suffered severe defects after implantable Collamer lens implantation, and it is a great challenge to restore. Our residual stereopsis models can be used to measure binocular stereopsis energy relationship in patients, especially for the visual functions severe defects patients, help to understand the binocular visual functions from the high-level optic center and paths, what's more, it present a new way for visual perceptual targeted therapy and personalized medicine.

The luminance-depth gradient in 3D clutter: When does dark mean deep ?

Michael Langer & Milena Scaccia

McGill University

Darker surfaces tend to appear further away but this cue can be easily overridden by other depth cues. Here we examine the dark-means-deep cue for foliage-like scenes which consist of thousands of small surface facets randomly distributed in a 3D volume. Under natural lighting, deeper surfaces in 3D clutter have lower luminance since deeper surfaces tend to be more shadowed. However, occlusion cues can override this dark-means-deep rule. Here we present an experiment that examines when the sign of the luminance-depth gradient in 3D clutter quantitatively affects the perceived depth of surfaces embedded in the clutter. We measured depth discrimination thresholds under monocular viewing of two target surfaces that were embedded in a 3D field of distractors i.e. clutter. We used two independent variables: the sign of the luminance-depth gradient, and the color saturations of the targets and distractors. We found that when the color saturations were the same, depth discrimination thresholds also were the same for positive and negative luminance gradients, and so the dark-means-deep rule was not used. However, when the color saturations differed, thresholds were elevated when brighter surfaces in the clutter were deeper, suggesting a dark-means-deep rule was used and worsened performance. To summarize, a luminance-depth gradient in 3D clutter has a greater influence on the perceived depth of targets if the targets and clutter have the same color. Possible applications in 3D visualization will be discussed.

Perceived depth reversal in a motion parallax display with common motion

Kenzo Sakurai[1], Shihori Furukawa[1], William Beaudot[2] & Hiroshi Ono[3]

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When an intersection of visual axes is not on the screen of an observer-produced motion parallax display, a head movement adds common motion to the stimulus elements on the retinae. We investigated whether this common motion affects the perceived depth order. The random-dot patterns subtended 8 deg x 7 deg, which produced apparent sinusoidal 3.5 cm depth corrugated surface with 3 cycles of curvature. The amounts of common motion were -4, -2, -1, 0, +1, +2, +4 cm on the screen whose signs represent same (-) and opposite (+) directions to head movements. Negative values of common motion correspond to the surfaces locating 57, 19, 8.1 cm farther than the screen, and positive values correspond to the surfaces locating 6.3, 11.4, 19 cm nearer than the screen. Ten observers monocularly viewed the random-dot patterns at a viewing distance of 57 cm and moved their heads back and forth 8 cm laterally. The task was to report whether the region immediately below the fixation point appeared convex or concave. In the conditions of -4 and -2 cm common motions the apparent depth order was opposite to that defined by the motion parallax alone; in the conditions of 1, 2, 4 cm common motions, the apparent depth order of more than 75 % responses was as same as that defined by the motion parallax alone. These results suggest that the visual system uses the difference in retinal velocity or different extent of retinal motion as a cue to depth.

Exploring the binocular stereopsis energy model in strabismus patients after surgery

LI YAN, Hang Chu & Shasha Pang

National Engineering Research Center for Healthcare Devices

Objective: To explore and determine postoperative binocular visual performance, especially stereoscopic vision, which is the advanced visual function and manipulated by the high-level optic center and visual paths,we have investigated two binocular stereopsis biological model, motion parallax stereopsis model and distant fine stereopsis model,in 212 patients with the best corrected vision and normal eye alignment after strabismus surgery.

Methods: The biological models stimuli was generated by matlab algorithm, displayed in a three-dimensional polarized monitor (D2343p, LG). We realized binocular vision separation by using polarized glasses, and recorded patients' stereoscopic vision data in two models. All the data were analyzed statistically.

Results: We found that 197 cases (92.9%)had distant fine stereopsis function impairment and 153 cases (72.1%)high-speed motion parallax stereopsis function impairment,but 9 cases displayed slow-speed motion parallax stereopsis function.

Conclusion: Most patients appearing the distant fine stereopsis impairment after strabismus surgery, manifests the parvocellular -ventral(P-V) pathway of the visual system seems to be impaired. Some patients appearing motion parallax stereopsis under slow-speed energy, indicates magnocellular-dorsal (M-D) pathway of the visual system remains to work. In the stereopsis energy model view, it is very important for strabismus patients to get normal eye position by surgery, and more, they should also pay attention to the postoperative binocular vision function recovery, based on the visual perceptual stereopsis function evaluation, so that ensure the effectiveness of surgery and visual quality in the long run.

Perceived depth from disparity depends on inter-ocular contrast difference

Pei-Yin Chen & Chien-Chung Chen

National Taiwan University

The perceived depth from disparity in random dot stereograms depends on luminance contrast in the image (Chen, Chen & Tyler, 2016). Here, we further investigated whether interocular contrast difference can influence the perceived depth from disparity. The test stimuli were rectangular random dot stereograms (1.27 x 3.44 degree) whose binocular disparities were modulated horizontally to generate the percept of a single cosine surface (0.29 cycle/deg). The maximum test disparity ranged from 0 to 20 arc min while the luminance contrasts of the left- and right-eye image were assigned independently from 5% to 80%. The observers' task was to adjust the length of a horizontal bar to match the perceived depth difference in the test stimuli. In all conditions, the magnitude of perceived depth was an inverted-U function of disparity. When both eyes received the same luminance contrast, both amplitude and peak position of the inverted-U function increased with luminance contrast. However, both amplitude and peak position decreased with the interocular contrast difference even the sum of contrast remained constant. Thus, perceived depth from disparity depends on not only the overall luminance contrast but also interocular contrast difference. Such results suggest a non-linear binocular contrast summation in depth perception.

Is spatial scale selection sub-optimal in developmental dyslexia?

Timothy Ledgeway, Richard Johnston, Nicola Pitchford & Neil W. Roach

University of Nottingham

Adult poor readers, including those with developmental dyslexia, often exhibit visual perception difficulties that extend beyond reading. However the underlying perceptual impairment is the subject of much debate. We have recently shown that relatively poor readers have impaired sensitivity on tasks requiring spatial segmentation of local visual motion. When discriminating a random-dot display divided into spatially discrete segments, defined by opposing motions, from a spatially uniform display, relatively good and poor readers performed differently. The smallest discriminable segment size (acuity) was independent of reading ability, but the rate of improvement in coherence thresholds with increasing segment size was shallower for the poorest readers. Modeling the results suggests that readers with dyslexia use sub-optimal visual mechanisms, in terms of the spatial scale over which they operate, to perform this task. That is, although segment size was fixed and predictable within any one block of trials, relatively poor readers may not exploit this knowledge to perform optimally. This hypothesis predicts that relatively good readers, should resemble relatively poor readers, when scale uncertainty is introduced into the segmentation task. In the current study we tested this by measuring thresholds for good readers when segment size was made either predictable (identical) or unpredictable on successive trials. Results showed that when segment size was randomised on each trial, so consistent information about scale was unavailable to the skilled readers, their performance mimicked that of relatively poor readers. These findings are consistent with the novel hypothesis, that spatial scale selection is sub-optimal in developmental dyslexia.

Adaptation of depth ordering preferences during motion transparency

Byung-Woo Hwang & Alexander C. Schütz

Philipps-Universität Marburg

Previous studies revealed that there are idiosyncratic depth order preferences to perceive certain motion directions in front during motion transparency depth rivalry (Mamassian & Wallace, 2010; Schütz, 2014). We investigated whether the adaptation of stereoscopic motion alters individuals' depth order preferences.

Participants performed three consecutive experimental phases. In the pre-adaptation phase, we measured depth

order preferences for each participant during motion transparency. The transparent motion consisted of two opposite motion directions of coherently moving dots and participants had to report which motion direction they perceived in front. In the adaptation phase, stereoscopic motion adaptation was embedded in each trial before measuring depth order preferences. The adaptor comprised of two opposite motion directions with negative and positive disparities in which the motion direction at the front coincided with the preferred direction measured in the pre-adaptation phase. In the post-adaptation phase, we measured depth order preferences in the same manner as in the pre-adaptation phase. We calculated depth order preference functions for each phase based on a cosine model that relates a certain motion direction with the probability to perceive it in front (Mamassian & Wallace, 2010; Schütz, 2014).

After adaptation, the preferences of some participants rotated strongly away from their original preference. The remaining participants showed a distortion of their preference function close to the adapted direction with little rotation from their original preference. These results imply that there could be two qualitatively distinctive consequences of stereoscopic motion adaptation: an overall rotation of the preference function and a distortion of the preference function.

The effect of naturalistic speech production on the functional field of view

Robert Davies & Angela Young

Nottingham Trent University

The negative effect that speaking on a mobile phone has while driving is one which has been extensively researched. Perhaps a surprising finding is that these effects are found in hands-free conversations so are not due to physical limitations of holding the phone. Further, this is true even when the speech is relevant to the driving task. This congruency in tasks suggests that the negative effect of speaking is not wholly attributable to dual-task costs. One potential explanation for the detriment is that the act of speaking limits the amount of information which is perceived.

This project aims to investigate the impact that speech may have on perception within a driving context. Specifically, this project will investigate if the functional field of view (FFOV) is reduced during a concurrent speech task. If speech does cause a reduction in FFOV, does this provide part of the explanation for poorer hazard perception while talking? How a reduced FFOV contributes to the distracted driving debate will be discussed.

Stimulus-response compatibility in depth: Comparison among depth cues

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The compatibility effect is observed among stimulus and response (S-R), such as the Simon effect, and among stimuli (S-S), such as the Stroop effect. These effects have been studied mainly for a two-dimensional plane. The present study focused on them in three-dimensional (3D) spaces. Particularly we aimed to compare the effects among depth cues those yield 3D perception. Experiment 1 was designed to investigate the S-R effect. In each trial a target, colored with red or green, appeared near or far from observers with the depth cues of binocular disparity, rich pictorial cues, or poor cues. The observers were asked to respond the color by tapping a key located near or far from themselves. As a result the compatibility effect was significant in disparity condition, whereas not in poor cues condition. The effect can be greater if 3D structure is perceived clearly. Experiment 2 was designed for the S-S effect. A target was a word of "near" or "far", set to appear near or far with binocular disparity or pictorial cues. The response keys were arranged side by side. Consequently, the compatibility effect was weak but clearer in the pictorial cue condition than the disparity condition. These results suggest a qualitative difference among the depth cues. That is, the disparity can yield intuitive information of location in depth, while the pictorial cues contains symbolic information coded to be interacted with that originated from words.

A view to a click: Pupil size changes as input command in eyes-only human-computer interaction

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Pupil diameter provides a large amount of implicit data as it features unspecific autonomic activity changes that may be associated with various cognitive and affective processes. In a recent study (Ehlers et al., 2016) we applied real-time feedback on pupil size changes and subjects deliberately expanded diameter beyond spontaneous baseline variations; albeit with varying degrees of success and over differing durations. The current study explores whether participants are able to transfer implicit events (here: pupil dilations) into explicit input requests during human-computer interaction (HCI). In a first step, we determined individually adjusted strategies to deliberately expand pupil diameter. Subsequently, pupil dilations were applied as command input in a visual search-and-select task. Varying threshold values ensured different level of cognitive load necessary to exceed the particular selection criteria. Results show that adequate time to explore the mechanisms of action enables all subjects to effectively manipulate sympathetic activity indexed by pupil size changes. Thereby, average diameter was extended even beyond implicit dilations induced by a demanding arithmetical task. During pupil-based object selection a strict criterion (presupposing strong pupil expansions) was associated with prolonged selection times and a considerable amount of time-outs. In contrast, a soft criterion correlated with fast selection times at low mental requirements but not with larger numbers of false positive selections. It can be concluded that pupil diameter does not simply label autonomic activity but also depict a user's true intention. To this end, pupil size changes may constitute an appropriate selection mechanism in HCI.

Right hemispheric specialization for faces in pre-reading children

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The developmental origin of the human right hemispheric lateralization for face perception remains unclear. According to a recent hypothesis, the increase in left lateralized posterior neural activity during reading acquisition contributes to, or even determines, the right hemispheric lateralization for face perception (Behrmann & Plaut, 2013). This view contrasts with the right hemispheric advantage observed in few months old infant. Recently, a Fast Visual Periodic Stimulation paradigm in EEG showed that periodically presented faces among objects lead to strongly right lateralized face-selective responses in 4-6 months old infants (de Heering & Rossion, 2015). Here we used the same paradigm in EEG to study the lateralization of responses to faces in a group (N=35) of 5 years-old pre-school children showing left-lateralized responses to letters (Lochy et al., 2016). Rather surprisingly, we found bilateral face-selective responses in this population, with a small positive correlation between preschool letter knowledge and right hemispheric lateralization for faces in preschoolers (rho=0.30; $p<0.04$), but no correlation between the left lateralization to letters and the right lateralization to faces. However, discrimination of facial identity with FPVS (Liu-Shuang et al., 2014) in these pre-reading children is strongly right lateralized, and unrelated to their letter knowledge. These findings suggest that other factors than reading acquisition, such as the posterior corpus callosum maturation during early childhood as well as the level required by the perceptual categorization process (i.e., generic face categorization vs. face individualization), play a key role in the right hemispheric lateralization for face perception in humans.

Perceptual distortions in curved screens

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The increasing number of curved screens (TVs, monitors, etc.) has created a debate about the presence of perceptual distortions given that images are in general captured in flat devices. A recent study has shown differences in light reflections and perceptual differences between curved and flat screens (Zannoli & Banks, 2015, VSS). We have extended this study using one flat and one curved screen TV (R4200) (both 55"). First, we measured (for multiple positions) the field of view, light reflections, the size of the reflections on the screen, and also we computed the retinal ratios (for vertical and horizontal dimensions) of an annulus presented in both screens in order to obtain a percentage of geometrical distortion. Second, we measured perceptual distortions in a visual experiment. Subjects had to match the shape and the size of an annulus presented on the sides of both screens with an annulus presented in the center. Our results show that: a) there are minimum differences in field of view between both screens; b) there is a significant reduction of the space from which light reflections can be seen in the curved screens; c) the size of the reflections on the curved screen are bigger than in the flat screen; d) retinal ratios predict strong geometrical distortions on the sides of the curved screens; and e) psychophysical results show that subjects adjusted the size and shape according to the local-slant prediction, and the adjustments were significantly different for both screens predicting visible geometrical distortions in the curved screens.

Changes to eye-hand coordination with healthy ageing

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Although there are notable changes to visual processing and motor control with healthy ageing, there is currently limited evidence about how it affects eye-hand coordination during goal directed movements that require sensorimotor integration. To address this, we quantified differences in eye-hand coordination between older and younger people during online updating. Participants completed a double-step reaching task implemented under time pressure where target perturbations could occur at different times during the reach (200, 400 and 600ms). We measured eye position and hand position throughout the trials and used chronometric, kinematic and gaze position analyses. Both groups could compensate for a target perturbation that occurred at 200 or 400ms into the reach but demonstrated incomplete online updating for the 600ms perturbation. Older participants showed a greater effect of perturbation time, with significantly increased movement times and decreased pointing accuracy compared to younger participants for the 600ms perturbation. Saccade latencies were also generally longer for older participants, despite shorter eye-hand latencies. Longer saccade latencies meant that a saccade to the perturbed target location occurred later in the reach and may have limited the time available to process the new target location. The shorter amount of time available to process new target information may also have contributed to the observed increase in movement time and decrease in accuracy for the older participants. Overall, the pattern of results suggests that online control of movements may be qualitatively different in older participants.

Perceptual load and subitizing: Distractor interference depends on subitizing capacity

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We apply the load theory framework (Lavie, 1995) to the phenomenon of subitizing (the ability to 'instantly' perceive the number of stimuli for small set sizes) to predict distraction during enumeration. In Load Theory, perceptual processing is capacity limited but runs in an automatic parallel fashion within capacity. Much research has demonstrated that involuntary processing of distractors occurs only within perceptual capacity limits in support of this proposal. Previous enumeration research has demonstrated that subitizing is also a parallel process with limited capacity (becoming serial for set sizes beyond capacity), it appears to draw on perceptual capacity as conceived in load theory. This led us to predict that irrelevant distractor processing during enumeration tasks will occur within people's subitizing range, but not beyond. Participants reported the number of shapes from

brief displays. On 33% of trials an irrelevant distractor (cartoon image) that participants were instructed to ignore, was also presented. Distractor interference effects on enumeration accuracy and response times were found for set sizes within the subitizing range (1-4 items) but not higher. Furthermore, the lowest capacity quartile showed a significant reduction in distractor interference between low (1-2) and high (3-4) set sizes, while no such reduction was found for the highest capacity quartile, suggesting that distractor processing only occurs within an individual's subitizing capacity. Overall these findings support our hypothesis that subitizing capacity can be modelled on the basis of load theory proposals and demonstrate the impact on susceptibility to distraction during enumeration processes.

Comparing the results of the application of moving and stationary sinusoidal gratings in the functionally assisted treatment of meridional amblyopia

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Background: The aim of the present work was to investigate the influence of visual exercises implemented into computer games, which contained moving circular gratings as compared to such of stationary gratings, on the visual acuity development in patients with meridonal amblyopia. Methods: Overall, there were two groups of patients who were selected according to the age structure and types of their type of disturbance. Using a cross-over design, the first group was alternately exercized 10 days with the moving vs. 10 days with the stationary grating stimulus, and the second group was alternately exercized 10 days with the stationary vs. 10 days with the moving grating stimulus, i.e. in reverse order. Results: In the measurements of the corrected visual acuity along four meridians, a maximum improvement was found with alignment of the directional optotypes close to the meridian with minimal ametropia, and the minimal change in the orientation perpendicular thereto. In the patients of the both groups, the corrected visual acuity had significantly increased as a result of the treatment performed in the stage with a series of exercises with the moving circular sinusoidal grating. After the stage of treatment using the stationary grating, there was found no statistically significant improvement. Conclusions: Exercises using special computer programs that contained a moving circular sinusoidal grating resulted in a statistically significant positive dynamics of visual acuity in the highest ametropic meridian. No statistically significant improvement was observed after exercises with the stationary grating.

Oscillated temporal expectation as a unified account for the visual priming effects of response times

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The visual priming task, where the response time (RT) of identifying the target is influenced by a precedent cue, has provided rich information about the temporal dynamics of the brain. Four effects were reported in previous studies. (1) RTs decrease exponentially with SOA (the cue-to-target delay). (2) Positive priming: In the unmasked priming task (no mask after the cue), RTs are shorter when the cue and the target are congruent instead of incongruent. (3) Positive priming followed by negative priming: In the masked priming task (the cue is masked), the congruent RTs are shorter than the incongruent RTs at short SOAs, but longer than the latter at long SOAs. (4) Theta-band oscillation: Both the congruent and incongruent RTs vary periodically with SOAs at a frequency of 3–5 Hz, but in the reverse phases. In a new masked priming experiment where SOA and temporal uncertainty of the target—two factors that usually co-vary—were separated, we found that the visual priming effects of RTs were moderated by temporal uncertainty as well as by SOA. We developed a computational model that can account for all these effects. The basic idea is that the observer has a constantly updated, probabilistic expectation for the onset time and identity of the incoming target, which determines the RT via its influence on the rate of motor preparation. The expectation, modulated by an attentional gain that oscillates with time, is oscillated itself. Positive priming and negative priming arise as emergent properties of the oscillated temporal expectation.

Sustained feature-based selective attention within one object modulates the steady-state visual evoked potential

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Feature-based selective attention has recently been proven to exist as a discrete selection unit of visual attention. Yet, research comparing feature-based and object-based attention is sparse and conflicting theories dominate the state of science. This study challenges the integrated object account, and instead postulates the preferred processing of selectively attended features within one object. For this purpose, we employed a novel stimulation technique which enables us to simultaneously measure the allocation of attention to two distinct features (rotation and color) within one object, by driving two distinct steady state visual evoked potentials (SSVEPs). Participants were instructed to monitor the stimulus for changes in only one or in both features, or to ignore the stimulus in a control task. SSVEP-amplitudes across the two feature dimensions, standardized by the SSVEP-amplitudes of the control task, were selectively modulated by feature-based attention. This modulation was

indicated by higher SSVEP-amplitudes for task relevant compared to task irrelevant features. Considering the feature dimensions separately, this effect was apparent for both features. SSVEP-amplitudes of attending both features were in between the ones for the relevant and the irrelevant feature. Overall, the neural correlates of attention to a certain feature indicate that processing can indeed take place selectively within one object rather than being necessarily integrative for all features of that object. Finally, the possibility to drive multiple SSVEPs with only one stimulus offers valuable information on how SSVEPs are generated and provides a novel way of studying non-spatial mechanisms of selective attention in human EEG.

Modelling response times in multi-alternative categorization with TVA

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Based on the Theory of Visual Attention (TVA; Bundesen, 1990, Psych Rev) we have developed a response time (RT) model for visual categorization. We propose that stimulus confusability leads to noise in the categorization process and that this noise can be countered by repeated categorization. Visual identifications are made conclusively in favor of one alternative over the other(s) once the number of tentative categorizations favoring this category exceeds the number favoring any other category by a critical amount (the response threshold). In a categorization task with only two alternatives, evidence accumulation follows a simple random walk with exponentially distributed interstep times. This Poisson random walk model is general enough to provide predictions for both correct and error RT distributions. The model is mathematically well tractable and allows for interesting generalizations, such as trial-to-trial variation in the Poisson processing rates and an extension of the random walk to n-alternatives. In an empirical test of the model we fitted the random walk model to data of a binary and a four-alternative orientation discrimination task. In both cases, the model predictions closely matched observed RT distributions. The agreement between theory and data is particularly remarkable in the multi-alternative case given the constraint that the model must explain RT distributions of correct and three different types of error responses simultaneously. The RT model inherits favorable properties of TVA such as well interpretable parameters of the visual identification process and the parameter estimates of the identification process resemble those obtained in classical TVA experiments.

Consciousness at a price: The attentional blink is a cost of awareness

Eyal Alef Ophir, Guido Hesselmann & Dominique Lamy

Conscious perception of an event has long been associated with favorable processing of that event. However, recent findings from our lab has shown that conscious perception may also come at a price for subsequent stimulus. Under the exact same stimulus conditions, observers are much poorer in recognizing a target when a cue that precedes it is consciously perceived than when it is not. We suggest that this cost reflects a processing limitation that is unrelated to an attentional bottleneck or a response selection limitation but instead emerges in the aftermath of the conscious perception of an event. We compare this effect to the attentional blink, and examine separately the roles of attentional capture, conscious perception, and explicit awareness reports in creating it. We suggest that attentional blink findings may be accounted for (at least in part) as an "awareness cost" rather than as an attentional limitation. In contrast to awareness, attentional capture does not inflict a cost on processing of subsequent stimuli. Taken together, our data demonstrates a pervasive perceptual limitation that is directly associated with conscious perception.

Odd man out in perceptual averaging: How do outliers influence judgments?

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Visual systems can rapidly extract information from complex scenes. An example of this is perceptual averaging (the ability to estimate averages of many simple visual features). There is still considerable debate whether this process is invariant to stimulus distribution, or contains an inferential component with some items given more weight than others. To examine this, participants were asked to judge the average orientation of ten items that either varied only in orientation (gray-scale Gabor patches) or in both orientation and color (colorful ellipses). Orientation values in both stimulus types were drawn from a circular normal distribution with a random mean and a standard deviation of 10°. On half the trials, an outlier stimulus was introduced with an orientation value that was far (45° or 65°) from the true mean. The outlier's effect on perceptual decisions was dependent on the stimulus type. We found up-weighting (judgments were biased towards the outlier value) for Gabors and down-weighting (judgments were biased away from the outlier) for colorful ellipses. We suggest that the treatment of outliers depends on the degree to which they are attentionally salient. Indeed, for the stimulus with an irrelevant dimension (color in ellipses), participants were less able to report the presence/absence of an outlier in an outlier detection task, suggesting that outlier saliency depends on display heterogeneity. These findings demonstrate that perceptual averaging is not automatic nor robust to the stimulus, but is affected by attentional saliency and contains an inferential process that cares about the feature distribution.

First Person Shooter (FPS) games enhance ability to ignore task-irrelevant information

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Although many studies have reported that playing first person shooter (FPS) games improves useful field of view (UFOV), it is possible that the expansion of UFOV by FPS game play also facilitate the shift of attention to irrelevant peripheral stimuli. As a result, the acquisition of information in the central vision may deteriorate when irrelevant peripheral stimuli are present. To examine this possibility, we

compared performance on flanker task and UFOV task between FPS players and non-FPS players. In the flanker task, participants indicated the direction of target (right or left arrow) presented in the central vision as soon and accurately as possible. The central target was flanked by stimuli that were identical to or different from the central one. We manipulated the number of flanker stimuli. In the UFOV task, participants identified a letter presented in the central vision, while localizing a target presented in the peripheral vision. Result of flanker task showed shorter reaction time among FPS players than among non-FPS players. Reaction times did not differ by the number of flanker stimuli among FPS players, while they increased with the number of flanker stimuli among non-FPS players. Results of UFOV task showed higher performance in peripheral task among FPS players than non-FPS players. These results suggest that, although the size of UFOV is larger in FPS players than in non-FPS players, FPS players can accurately ignore peripheral information irrelevant to tasks required.

Why does distractor cueing impair visual search? An experimental test of a feature inhibition account.

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It is a well-known finding that performance in visual search tasks benefits from cueing target features. In contrast, cueing distractor features - such as a distractor's color – has been shown to impair search performance. In the present study, I investigated whether this effect is due to active feature inhibition being applied to the cued distractor. To measure feature inhibition, I combined a visual search task with a probe task. In the search task, participants indicated the identity of a colored target letter (either a B or F), which was presented among colored distractor letters. One of the distractor letters was compatible or incompatible with the target identity, and the color of this distractor was either cued or not. In a subsequent probe task, participants responded to a probe having either the same color as the distractor or a neutral color. As expected, search task performance was impaired by cueing the distractor color. Furthermore, probe task performance was impaired for probes in the same color as the distractor. Importantly, this effect was not specific to probes in the cued distractor color, as predicted by a feature inhibition account. Instead, it was specific to probes presented after incompatible search trials. In sum, these results are not consistent with active feature inhibition being caused by distractor cueing. Instead, they are more consistent with explanations in terms of processing load or attentional shifting.

A Bayesian model of intertrial effects in visual search

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Many previous studies on visual search have found intertrial effects, i.e. observers respond faster when the same target properties are repeated compared to when they change between trials. This could reflect trial-to-trial updating of the observers prior beliefs about the upcoming target. We propose a computational model of such updating where the prior probability of the relevant target property is updated according to Bayes' rule and determines the starting point of an evidence accumulation process based on the LATER (Linear Approach to Threshold with Ergodic Rate) model. To test our model we performed three visual search experiments, where the target differed from the distractors in terms of either orientation or color and the task was to report either whether a target was present (experiments 1 and 3) or the target dimension (experiment 2). In the first two experiments we varied the ratio of target present/absent trials (experiment 1) or color/orientation targets (experiment 2) across blocks. In the third experiment the target types occurred with equal probability. For each type of trial (target present/absent, color/orientation target) RTs were faster in blocks were such trials occurred with higher probability. We also replicated the intertrial effects that have been found in previous studies. Our model predicts both the intertrial effects and the effect of the blockwise probability manipulations. This suggests that intertrial effects are likely a consequence of the (approximately Bayesian) updating of prior probabilities which determine the starting point of an evidence accumulation process on each trial.

Target feature selection leads to facilitation in repeated visual search in crowded displays.

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In a previous study we found that searching for different targets in the same set of 72 items did no facilitate search for other items within the same set. In this study we analyzed whether participants could restrict their attention to a subset of elements from the same crowded display and whether this lead to location learning and facilitation in visual search. In each trial a target letter was presented at fixation for 1 second, followed by the search display. Participants pressed the space bar when the target letter was found. The search display was made of 72 colored letters (12 letters x 6 colors) and was the same for all searches (repeated visual search). Twelve different letters of the same color (orange) were used as targets. Location was constant for each target, but targets differed in eccentricity. Over the experiment, each target was searched for 6 times. RT and eye movements were registered in each trial. RT and search fixations decreased significantly with target repetition, although the degree of facilitation differed among target letters. Analysis of eye fixations over the whole experiment showed a significant negative correlation between number of previous fixations on each target letter and RT. This suggests that participants could acquire some information about target locations and perform a more efficient visual search. [Research supported by grant PSI2013-43742.]

Feature comprehensive inhibition processes in distractor induced blindness

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In a rapid serial visual presentation task, inhibition processes cumulatively impair processing of a target that possesses distractor properties. This phenomenon - distractor induced blindness- has thus far only been demonstrated using dynamic visual targets, such as motion and orientation changes. Since motion related stimuli are processed primarily in the dorsal visual stream, it remains unclear whether features that are rather processed in the ventral stream also evoke the blindness effect. As distractor induced blindness is proposed to be due to a central, feature comprehensive inhibition, we expected the effect to be evoked by visual object features (i.e. color), too. In the present study we conducted two EEG experiments to test for this assumption. In the first experiment, participants were instructed to indicate whether or not they had detected a color change (target) in the periphery whose onset was signaled by a central cue. Presentation of irrelevant color changes prior to the cue (distractors) resulted in a reduced target detection, accompanied by a frontal ERP negativity that increased with an increasing number of distractors. In the second experiment color distractors in the pre cue epoch were replaced by short episodes of coherent motion of all bars. These incongruent distractors did neither affect accuracy nor did they evoke the characteristic frontal negativity. Results of the two experiments show that distractor induced blindness is also triggered by visual stimuli predominantly processed in the ventral stream with the distractor effect being exclusively evoked by congruent distractors.

Effects of acute stress on the attentional network and working memory.

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Acute stress alters cognitive functioning (McEwen & Sapolsky, 1995). The change in attention processes and working memory resulting from exposure to acute stress is uncertain (cf. Helton et al., 2009 and Scholz et al., 2009). Here we investigate the influence of performing the Socially Evaluative Cold Pressor Task (Schwabe et al., 2008) on performance in the revised Attentional Network Task (ANT-R; Fan et al., 2009), and the n-back WM task (Shackman et al., 2006).

Baseline performance measures were taken before exposure to the stressor (or comparable control). A battery of psychological and physiological measures demonstrated successful stress induction.

Participants repeated the ANT-R task in two testing phases (starting immediately after [early phase] and twenty minutes [late phase] post the stressor) post exposure to the stressor. The n-back task was repeated only in the late testing phase. The early and later testing phases broadly reflect activation of two physiological reactions to stress: the Sympathetic Nervous System (SNS) and Hypothalamic-Pituitary Adrenal Axis (HPA) respectively.

Stress led to stronger inhibition of return during activation of the SNS and an increased flanker effect during activation of the HPA. Additionally, for females only, stress increased the efficiency of location conflict processing during activation of the HPA. Stress did not impact on WM performance.

The results suggest executive control and orienting of attention are affected by exposure to stress but WM maintenance is not. Importantly, the specific effects on attention processing are dependent on time-dependant physiological activity. The results help explain differences in previously reported studies.

Self-relevant cues preferentially enhance contrast perception for attended stimuli

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Previous work has demonstrated that orienting a participants' transient covert attention to a specific region of the visual scene leads to increased contrast sensitivity at that location. There is also evidence that self-related stimuli are given greater priority and are more effective at attracting visual attention. Here we report on two experiments where shape-cues of varying degrees of self-relevance are used to orient a participant's transient covert attention to one of two Gabor patches. In experiment one the participants were asked to associate geometric shapes used as spatial cues with themselves, their best friend and a stranger. In experiment two the shape-cues were associated with self-generated identities that were either irrelevant to the participant, or were of high- or low- importance. In both experiments the cued Gabor patches were universally perceived as having higher contrasts. However, the magnitude of this effect was mediated by the self-relevance of the preceding shape-cue, with cues of high self-relevance leading to higher perceived contrast enhancement. The results provide evidence for the role of self-relevance on transient shifts of attention.

Statistical averaging and deviant detection in heterogeneous arrays

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Numerous scene properties are associated with rapid gist perception, including set statistics and presence of outlier elements (pop-out). Gist perception is associated with global attention and higher-level cortical processes, in contrast to slower processing of scene details requiring focused attention perhaps with lower-level neural elements. There is long-lasting interest in rapid parallel feature search compared to slower serial conjunction search. In addition, there is recent growing interest in set summary statistics, including analysis of the relative precision of mean perception. We now ask if there is a relationship between these rapid scene gist percepts: set mean discrimination and deviant detection. While most pop-out studies used homogeneous backgrounds, we join the few using heterogeneous backgrounds

to relate pop-out and set mean perception. We tested observers in mean orientation discrimination and pop-out detection using the same psychophysical paradigm, presenting two fields of bars with heterogeneous orientations, where one field either had a mean orientation rotated clockwise or contained a pop-out deviant. Variable parameters were field variance and left-right field mean or field-deviant orientation difference. We found that pop-out detection and mean orientation discrimination have similar dependences on background variance. In both cases, detection is reduced by 20% when variance is increased fourfold. To conclude, detection of a pop-out deviant is inherently related to set statistics perception. Only by knowing the mean and variance of a set can one know if an outlier is indeed a deviant, or just the cusp of the set.

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Pupil dilation reveals the timecourse of voluntary temporal attention

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The timing of visual events is often predictable, allowing observers to voluntarily attend to relevant points in time. Voluntary temporal attention increases perceptual sensitivity, but the dynamic processes underlying this increase are unclear. Here we asked whether and how pupil dynamics correlate with voluntary temporal attention. Pupil size has been shown to index cognitive processes including spatial and feature-based attention and provides a continuous neurophysiological readout during a visual task. On each trial of the temporal attention task, two oriented grating targets (T1 and T2) were presented 250 ms apart in the same spatial location. A precue tone 1000 ms before T1 indicated which target was likely to be probed. A postcue tone 500 ms after T2 indicated which target's orientation to report. In valid trials (60%), the precue and postcue matched, in invalid trials (20%), they did not match, and in neutral trials (20%), the precue was uninformative and the targets were equally likely to be probed. We used a general linear model of the pupil size timeseries to recover the amplitude and latency of pupil dilations related to the trial events. We found that pupil dilation anticipated the onset of T1, and the latency of this pupil dilation depended on the attention condition, with the earliest pupil dilation for valid, then neutral, then invalid trials, specifically for correct trials. The amplitude of pupil dilation also predicted performance accuracy. We conclude that voluntary temporal attention advances the timing of processes relevant for the perception of upcoming stimuli.

The effect of target salience and size in visual search within naturalistic scenes under degraded vision

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We address two questions concerning eye guidance during visual search in naturalistic scenes. First, search has been described as a task in which visual salience is unimportant. Here, we revisit this question by using a letter-in-scene search task that minimizes any confounding effects that may arise from scene guidance. Second, we investigate how important the different regions of the visual field are for different sub-processes of search (target localisation, verification). In Experiment 1, we manipulated both the salience (low vs. high) and the size (small vs. large) of the target letter, and we implemented a foveal scotoma (radius: 1°) in half of the trials. In Experiment 2, observers searched for high- and low-salience targets either with full vision, or with a central or peripheral scotoma (radius: 2.5°). In both experiments, we found main effects of salience with better performance for high-salience targets. In Experiment 1, search was faster for large than for small targets and high salience helped more for small targets. When searching with a foveal scotoma, performance was relatively unimpaired regardless of the target's salience and size. In Experiment 2, both visual-field manipulations led to search time costs, but the peripheral scotoma was much more detrimental than the central scotoma. Peripheral vision proved to be important for target localisation, and central vision for target verification. Salience affected eye movement guidance to the target in both central and peripheral vision. Collectively, the results lend support for search models in which salience is combined with target knowledge.

A saliency based scan path prediction model in free-viewing condition

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Recent studies have indicated that the visual scan paths are effective to evaluate the users' regions of interest on the media, such as web contents or TV commercials. Since collecting eye movement data needs time and costs, gaze predictions by saliency based models are starting to be used instead of using actual data. However, predicted scan paths by these models repeatedly point at some particular areas because they do not consider the history of gaze positions. Yamasaki & Kohama (2013, In Japanese) proposed a model to reproduce gaze shifts for searching targets by using conditional probability considering the history of gazed areas. Despite the fact that the location information and visual features are processed in different areas of visual brain, this model processes them in an integrated manner. In this study, we proposed a new model which is able to predict scan paths in free-viewing condition and evaluated the validity of the model. The proposed model calculates the probability map from the saliency distribution of input image. Visual features are separately processed from the location information of gazed positions and integrate them into the probability map. Simulation results show that the prediction accuracy of the proposed model, which is defined as cross correlation from predicted gaze positions and measured data, was higher than the other models. This suggests that our model can predict the gaze positions of human subjects in the free-viewing condition.

Local item density modulates adaptation of learned contextual cues

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In everyday scenes, searched-for targets do not appear in isolation, but are embedded within configurations of non-target or distractor items. If the position of the target relative to the distractors is invariant, such spatial contingencies are implicitly learned and come to guide visual scanning ("contextual cueing"). However, the effectiveness of contextual cueing depends heavily on the consistency between bottom-up perceptual input and context memory: following configural learning, re-locating targets to an unexpected location within an unchanged distractor context completely abolishes contextual cueing, and gains deriving from the invariant context recover only very slowly with increasing exposure to the changed displays. The current study induces variations of the local target context, i.e., item density, to investigate the relation between this factor and contextual adaptation. The results showed that learned contextual cues can be adapted quickly if the target is re-positioned to a sparse local distractor context (consisting of 1 neighbouring non-target item), as compared to no adaptation with a dense context (with 3 surrounding non-targets). This suggests that contextual adaptation is modulated by spatial factors and is not per se limited by order effects in the learning process.

Not FLEXible enough: Exploring the temporal dynamics of attentional reallocations with the multiple object tracking paradigm

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The dynamic environment of human observers requires continuous reallocations of visual attention in order to compensate for location changes of the attended objects. Particularly, situations with reduced spatial distance between targets and other objects in the display are crucial for keeping track of the target objects. In the present experiments, we explored how the temporal dynamics of such moments of reduced spacing affects the reallocation of visual attention. We asked participants to track four targets among indistinguishable distractors. Hereby, we manipulated whether target and distractor objects moved at a constant speed or whether their actual speed followed a sine wave profile. The variable speed oscillated around the constant speed thus maintaining average speed as well as travelled distance and average spatial proximity. We observed inferior tracking performance with variable speed profiles relative to constant speed profiles (Experiments 1a and 1b). When we increased the number of pairs of targets and distractors moving with a variable speed profile (Experiment 2), performance declined continuously. Remarkably, tracking performance also declined when only distractors moved at variable speeds, suggesting that the dynamic changes in inter-object spacing rather than the variable speed impairs tracking (Experiment 3). In sum, our results provide evidence for a flexible allocation of the attentional resource toward targets suffering spatial interference by demonstrating the temporal constraints of the reallocation process.

Preparing for selection: The neural dynamics of temporal prediction (and its violation) in visual search

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Attentional templates are visual working memory (VWM) representations that guide attention during visual search. Importantly, memory needed for search is not static: the strength of a template representation waxes and wanes as a function of its current relevance. Here, we tested the hypothesis that when the moment of search becomes predictable, the VWM system will use this information to activate the template around the expected time of its task relevance. Human participants performed a task in which they remembered one category-specific object and, after a certain delay, searched for it in a 6-object array. In one block, the delay was always 5 seconds, allowing for the formation of a reliable prediction of when to search. A generalization-across-time decoding analysis on EEG data revealed a U-shaped curve in which classifier accuracy first dropped to chance level, followed by a reactivation pattern towards the expected moment of search. In a second block, the delay was 1.5 seconds in almost all trials, but could unexpectedly turn into a longer 5 second delay. During these long delays a temporal prediction error should occur around the time the search task was expected. Indeed, in these trials we found a midfrontal theta-band (4-8 Hz) power, right after the anticipated moment of search had passed. Importantly, this effect was directly followed by a transient increase in decoding accuracy, which again reappeared prior to the eventual moment of search. Together, these results provide evidence for a flexible temporal orienting mechanism within VWM.

Interacting with objects affects the allocation of attention in multiple-object tracking

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We investigated the effects of different degrees of involvement in complex object behaviours, specifically bounces, using a Pong-like multiple-object tracking (MOT) task. Our first group of participants was instructed to track and bounce target objects as often as possible with a paddle that they could actively move. A second group of participants viewed recordings of trials performed by the first group and was instructed to track targets and press a button whenever a target was about to hit the paddle. A third group of participants also viewed recordings from the first group, tracked the targets and tallied the bounces, but additionally had to identify whether a target approached the paddle from the left or from the right. During each trial, probes could appear just before a target hit the paddle, either at a future location of the target (bounce-probes), or at a location along a linear extrapolation of the target's current path (through-probes). Probe detection rates were recorded for each participant. We found that the group that actively moved the paddle detected bounce-probes more often than through-probes. For the two groups that tallied the bounces made by the first group, probe detection was affected differentially. That is, when merely tallying bounces, through-probes have the advantage, but when

a target's movement direction is relevant for the task, probe detection rates resemble those of the first group. We show that attention can 'bounce' when object directionality is a relevant feature for the task at hand.

Factor analysis of individual differences in the spectral sensitivities of M/L cone pigments in bioengineered mice

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Wild-type mice express a single M cone pigment. A version of an opsin-gene knock-in mouse additionally expresses a human L cone pigment (Jacobs et al. 2007). Following earlier modeling approaches (Webster & MacLeod, 1988; Peterzell, 1991), we factor-analyzed individual differences in the spectral sensitivities of these mice to measure independent expression of M and L photopigments. Because the spectral properties of photopigments in these mice are known, and because ERG flicker photometric spectral sensitivity data have small measurement error, our analyses provided a test of the validity and accuracy of factor analysis when it is used to identify processes underlying visual data. Flicker ERG responses from 86 M/L mice (Jacobs et al. 2007) expressing both M and L cone pigments were analyzed. Principal component analyses confirmed that two- and three- factor solutions accounted for 92.6% and 96.0% of individual variability. The first two Varimax-rotated factors were bipolar, consistent with underlying absorption spectra for M and L photopigments with zero-crossings at deuteranopic and tritanopic confusion points (equal M or L responses in test and standard). A third small factor (peak 560 nm) reflected very small variability in the peak wavelengths of the measured spectra (Two additional factor analyses of data from mice having only M [n=17] or L [n=12] pigments each extracted two factors traceable to minor individual variability in peak wavelength). These results confirm that factor analysis can extract factors that coincide with known visual mechanisms. However, some additional tuned factors do not necessarily represent fundamental visual mechanisms.

Can you recognize two words at once?

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Background:

How much information can the visual system process simultaneously? In some instances, it may process multiple stimuli in parallel with no cost. At the other extreme, the system may process just one stimulus at a time, due to a severe capacity limit. Such serial processing has rarely been observed in visual tasks. Here we compared parallel vs. serial models of the perception of written words in order to understand the attentional constraints on reading.

Methods:

Words appeared briefly and simultaneously to the left and right of fixation. Observers either detected semantic targets (nouns belonging to a category such as "animals") or color targets (words colored slightly red). For both types of judgments we compared a dual-task condition (e.g., detect animal nouns on both sides) with a single-task condition (e.g., detect animal nouns on only one side). In several experiments, we controlled task difficulty by embedding the targets in rapid RSVP streams or by post-masking them.

Results:

In all experiments, the difference between dual- and single-task accuracy for the semantic judgment was so large that it supported a serial processing model. This serial model was also supported by a negative trial-by-trial correlation in the accuracy of dual-task responses. In contrast, color detection performance with identical stimuli was consistent with unlimited-capacity, parallel processing. Thus, the severe capacity limits are due to the requirements of semantic categorization and not the mere presence of words. We will interpret our results in light of ongoing controversies in the study of reading.

The extreme retinal periphery: Experimental evidence of specific function suggested by A. Yarbus for blind retina

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According to the idea of Yarbus, a narrow retinal ring running along the ora serrata could be considered as a blind retina having certain specific functions. The photoreceptors of this ring aren't designed for formation of local images being only stimulated by diffuse light scattered inside the eye. Their responses are used for estimation of average illumination characteristics aimed at general normalization of the perceived scene. One prediction of this hypothesis is that selective light stimulation of the blind retina should cause darkening of the perceived visual images and changes in color. To test the validity of Yarbus's hypothesis, we used two methods providing diascleral stimulation of the retina. The subject had to describe the changes in visibility of the observed visual scene in the following conditions: (1) he/she fixated the test stimulus positioned 30-40º temporally or nasally while a small spot of light was projected onto the sclera near the limbus and moved to the corner of the eye and back; (2) he/she observed a peripheral part of the visual field left visible after occlusion of the pupil while the thin light rings of various diameters and brightness were projected onto the sclera around the iris. By both methods it was possible to find the conditions of paradoxical darkening of the visual field due to illumination of certain area presumably covering the blind retina. Stimulation of the adjacent areas produced quite different effects. Supported by RFBR grant 16-04-01421a.

Control of spatial attention in bright and dark environments

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Two experiments were conducted to compare the characteristics of allocation of attention in real 3D space between bright and dark environments. Under bright condition, the participant could understand the configuration through a trial. A fixation point was located at 58.5 cm from the participant. Four cubes with LED were used and there were two stimuli configuration conditions: horizontal and depth directions. Therefore, cubes were arranged nearer and further than a fixation point under depth direction condition and were arranged to the left and right of fixation point under horizontal condition. The cueing paradigm (Posner et al., 1980) was used to clarify how well attention distribution could be controlled in real 3D space. The information about the direction of a target relative to the fixation point (near/far or right/left) was used by means of colors. The duration of cue presentation was 300 ms. After disappearance of cue, one target was presented. The participant in the attentional task was required to detect the target depending on pre-cues. Furthermore, simple reaction times to detect a target were measured to compare attentional tasks. The results revealed that only the main effect of pre-cue validity in the attentional task and that of the stimuli configuration in a simple reaction task were significant. These findings indicate that internal representation based on pre-cues plays a crucial role in attentional tasks.

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Individual differences in simultaneous contrast for color and brightness: Preliminary small-sample factor analyses reveal separate processes for short and long flashes, different hues and luminance polarities

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In classic studies of color/brightness contrast, a central disc that normally appears gray shifts toward the opposite brightness and/or the complementary color of its surround. In five experiments, Kaneko and Murikami (2012) showed that induction strength was much higher for brief than long flashes (10 - 80 vs. 160 - 640 msec). This result held for surrounds of (1) four different equiluminant hues, including red, green (complementary along the L-M axis), purple and lime (complementary along the S–[L+M] axis), and (2) four different achromatic brightness levels, including two increments and two decrements relative to the 33 cd/m2 central disc. Although the original study analyzed mean differences in induction strength, our reanalysis used correlations and factor analyses (Varimax-rotated principal components) to examine processes in 3 small-sample data sets (n=6 or 7 observers). For each colored surround condition, two factors were found to account for results from either brief or long flashes. Similar but separate brief/long factor pairs emerged for each hue, with no factors common across hues. For achromatic surround conditions, similar but separate brief/long factors emerged for increments and decrements. In all three analyses, factors explained >96% of the total variance in induction strength. Although these results involve preliminary small samples, some details of processes underlying chromatic and brightness induction emerged. Separate processes mediate induction strength for brief and long flashes, consistent with previous conclusions. But separate sets of slow- and fast-responding processes exist for different hues and brightness levels.

Top-down modulation of gaze following in social contexts

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Predictive processing is crucial for social cognition. It allows understanding of others' behavior and mental states. Social signals, like gaze direction, provide valuable information to generate expectations of unfolding events. However, the link between prediction and gaze following in relatively complex social situations remains unraveled. We investigated how high-level expectations concerning others' action goals and predictions regarding their successive action steps influence gaze following. Our novel design embedded a typical gaze-cueing procedure in an action sequence composed of naturalistic photographs. We examined how attention is guided by two factors: the observed gaze direction, and the background expectations regarding the action context. Behavioral results (all Exps) showed (a) faster reaction times in target discrimination at validly cued, relative to invalidly cued, target locations; and (b) modulation of the gaze-cueing effect by action expectation: an enhanced gaze-cueing effect when the actor gazed at congruent, rather than incongruent or neutral objects, with respect to the action context. Monitoring eye movements (Exp 2) showed that this pattern of effects was due to covert, rather than overt, attentional orienting. Finally, EEG/ERPs (Exp 3) showed that gaze validity and participants' expectations modulated the target-locked N1 component. We also found that an ERP component in the range of N330, locked to gaze shift, was more positive when gaze was congruent with the action sequence, relative to incongruent and neutral conditions, presumably reflecting update of expectations. Collectively, our findings suggest that expectations regarding others' behavior modulated attentional orienting in response to others' gaze direction.

Impact of strabismic and anisometropic amblyopia in colour vision and contrast sensitivity of different levels of complexity

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Amblyopia is a cortical neural disfunction caused by abnormal visual experience during critic period of visual development. Recent studies have shown that beyond deficits of vision already known as visual acuity of resolution many others perceptual visual functions (Local and global) are affected. The objective of this work is analise déficits on visual processment on amblyopia caused by strabismus, anisometropia and strabismus-anisometropia compared to control subjects. We analised colour vision by measuring chromaticity threshold for axis protan, deutan e tritan; spatial constrast sensibility of luminance of second order for frequencies 0,4;1,6;3,2 and 6,4 cpd; radial spatial contrast for frequencies 0,4;1,6; 3,2; 6,4 and 12,8 cpd and measures of contrast threshold for ON and OFF systems in frequency 0,5 cpd.

Our results show decrease of sensibility of second order contrast to frequency 3,2 cpd (F=7,00 p<0,001); decrease of sensibility to radial contrast in frequency of 12,8 cpd (F=13,96 p <0,001) in amblyopic eyes; increase of contrast threshold for OFF system in amblyopic eyes of group strabismic-anisometrope (F=4,18 p=0,012). There was no alterations on colour discrimination in amblyopes. We concluded that there is different visual functional impacts between different types of amblyopia in visual contrast processment. There was no impact in colour vision in amblyopia of any group when analised with stimulus without spatial aspects.

Neuropsychological assessment of visual-cognitive processing capabilities with the virtual reality device HTC Vive

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The assessment of visual-cognitive capabilities strongly depends on testing conditions such as viewing distance, stimuli, and lighting. Valid comparisons across assessments can only be drawn in standardized conditions. To ensure optimal standardization, we suggest using the increasingly available virtual reality head-mounted displays (HMDs). These HMDs cover the entire visual field, thereby warranting the same visual stimulation across testing situations, whether in a laboratory or in a patient's room. A fundamental prerequisite for using such devices for neuropsychological assessment is sufficient reliability. Recently, we verified that the HMD "Oculus Rift" provides similar test-retest reliabilities of basic visual-cognitive processing components as a CRT screen, the standard for lab-based measurements (Foerster et al., 2016). Assessment of components relied on a whole report paradigm grounding on the theory of visual attention (TVA, Bundesen, 1990). This paradigm measures processing speed, threshold of conscious perception, and working memory capacity. Here, we compare the test-retest reliabilities of these components measured with the HMD "HTC Vive", and with a standard CRT. In addition, we used the combiTVA paradigm (Vangkilde, Bundesen, & Coull, 2011) which adds the important attentional component of top-down selectivity. Results revealed that the reliability was comparable between Vive and CRT. Thus, not only the Oculus Rift, but also the HTC Vive is applicable for a reliable assessment and diagnosis of elementary visual-cognitive functions. The inherent visual standardization of HMDs provides the opportunity to compare visual components between individuals and institutions relatively independently of environmental testing conditions and will allow to establish statistical norm distributions.

Bright paint makes interior space surfaces appear farther away

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Previous studies have reported that bright ceilings appear higher than dark ceilings, irrespective of wall and floor luminance. These studies focused on effects of achromatic color. Here, we extend these findings in two directions. Firstly, we report effects of surface luminance on perceived depth and width (Experiment 1). Secondly, we report effects of chromatic ceiling colors (Experiment 2). In both experiments, we presented stereoscopic room simulations on a head-mounted display (Oculus Rift DK2). In Experiment 1, we varied the luminance of the rear wall, side walls, and ceiling. We found that rooms with a bright rear wall appeared deeper than rooms with a dark rear wall, and that rooms with bright side walls appeared wider than rooms with dark side walls. In Experiment 2, we varied the hue (red, green, blue), saturation (low, high), and luminance (bright, dark) of the ceiling. We found the previously reported ceiling luminance effect to apply also to chromatic colors: subjects judged bright ceilings to be higher than dark ceilings, irrespective of hue and saturation. The remaining color dimensions only had a small effect (hue) or virtually no effect (saturation) on perceived height. In sum, our results confirm that the perceived extent of a given spatial dimension is affected by the absolute luminance of the room's bounding surfaces, but is less affected by hue and saturation or by the luminance contrast to the other surfaces.

Detailed changes in global functional connectivity during attentional tracking

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The challenge for any comprehensive analysis of the functional correlations accompanying sustained attention is the overwhelming amount of information at voxel level. To reduce this complexity, previous studies have resorted to spatial averaging or have restricted themselves to correlation densities (FCD). We have developed a novel approach and have reduced, in an information-preserving manner, the high-resolution correlation matrix of voxels to an intermediate resolution matrix of 758 'functional clusters'. We subdivided the anatomically-defined AAL regions, into 758 'functional clusters' averaging 212 voxels each, on the basis of functional connectivity in the resting state. This parcellation, which we call 'MD758', combines voxels with similar local correlation profiles such as to remove correlational redundancy without losing correlational information. We applied this method in an Attention experiment with tree conditions: Resting State, Passive Viewing and Attentive Tracking. The 'attention contrast' (comparing Attentive Tracking with Passive Viewing) shows a preponderance of decorrelation mainly in occipital cortex, as well as parietal, in addition to strong recorrelation within other ares in parietal cortex. The 'stimulus contrast' (comparing Passive Viewing with Resting State) shows decorrelation within and between occipital and lingual cortex, as well as recorrelation between occipital cortex and cingulum, insula, and frontal inferior and orbital cortex. The most dramatic effect, however, is a massive recorrelation between thalamus, caudate, and putamen, on the one hand, and calcarine, insula, occipital, cuneus, and fusiform cortex.

Are colours enough to make a painting beautiful?

Anke Marit Albers[1], Sérgio M. C. Nascimento[2] & Karl R. Gegenfurtner[1]

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Colour is an important aspect of paintings: many great works of art would probably not be as impressive in grey scales. But is the beauty of colours anchored to the spatial composition of an image or is it preserved even with random spatial arrangements? To address this question, we asked participants to select, using pairwise comparisons, the more beautiful of colour-manipulated versions of the same painting. The colour volume was rotated rigidly around the L* axis in CIELAB space, preserving lightness and saturation but changing hue. To test the influence of the spatial structure, the images of the paintings were presented in three formats: (1) the original painting, (2) a spatially scrambled version that preserved the colour composition, and (3) a version with both colour and spatial scrambling. In general, the preferred colour configuration was close to the original (within 20º of the angle of the colour gamut in the original paintings), reiterating the notion that artists select colour compositions that match what is perceived as beautiful (Nascimento et al, 2017, Vision Research, 130, 76-84). More importantly, our participants preferred the same colour distributions for spatially scrambled paintings as for the original paintings: the difference in preferred gamut angle followed a normal distribution that peaked near zero degrees. This suggests that the perceived beauty of colours is not anchored to particular spatial compositions but is partly preserved even when the spatial composition is destroyed. Paintings thus seem to contain a beauty component that is exclusively related to colour.

Subtle eye movements reveal the temporal dynamics of preparing for visual search

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The search template is a visual working memory (VWM) representation that facilitates search by guiding attention towards matching features when they appear in view. Earlier studies suggest that template activation occurs prior to search during the delay period, but the temporal dynamics of such pre-activation remain unclear. In two experiments we tested if both general and template-specific preparatory effects can be inferred from the subtle involuntary eye movements (mostly microsaccades) that participants typically make while maintaining fixation. Participants memorized a target color (i.e. the template) for an upcoming search task. During the delay, we presented an irrelevant Rapid Serial Visual Presentation (RSVP) of lateralized colored disks; the length of the delay was manipulated in blocks of long (4650 ms) and short (2790 ms) trials. Crucially, at different time points into the delay, the template color was inserted in the RSVP, allowing us to measure specific attentional biases towards this template location as a function of time. Results revealed a general suppression of saccade production in preparation to search: the closer in time to the task, the fewer saccades the participants made. Strikingly, this suppression was stronger when a template-matching disk was present compared to when absent. Moreover, in the time points where a template-matching disk was presented, relatively more and larger saccades went to the matching disk than to an irrelevant color, an effect that became stronger near the end of the delay. We conclude that subtle eye movements track the dynamics of preparing for selection in search.

Detection of smallest changes in complex images comparing self-organizing map and expert performance

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This study uses a Self-Organized-Mapping (SOM) technique for biologically inspired computational analysis of MRI images, previously described in http://dx.doi.org/10.1016/j.imu.2017.03.001.The whole image instead of a region of interest (ROI) is analyzed under the assumption that this approach helps overcome some of the limitations imposed by image segmentation. New results show that quantization errors (QE) in the SOM output increase with increasing natural and artificially added (Possion noise) lesion contents in the images. The diagnostic potential of the QE is further assessed in the light of expert ability to detect very small local differences in pairs of random-dot images using 'same-different' procedures. The QE of output from SOM run on the random-dot images increases progressively with progressive increases in size of a single dot. In expert detection, these increases in local dot size produce consistently increasing correct positive rates, however, well below the 75% detection threshold, indicating that they are technically undetectable even by experts. The novel method of analysis investigated here is reliable and fast, and could be employed as an assistive computational tool for image-based decision making by experts in the medical and other domains.

Temporal integration and spatial attention

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Recently, we found that sustained spatial attention increases temporal integration using the feature fusion paradigm. In the current study, we examined the effect of transient spatial attention on temporal integration using a modified version of the Ternus display. In a typical Ternus display horizontally aligned disks are shifted by one position across alternating frames that are separated by a varying inter-frame interval. This display can induce two different motion percepts: three disks moving together (group motion), or two central static disks and an outer disk that jumps across them (element motion). Several studies suggested that spatial and temporal integration underlie these two motion percepts. According to this notion, element motion reflects temporal integration while group motion reflects spatial integration. We used a modified Ternus display, composed of oriented Gabor

patches as elements and no inter-frame interval. Temporal integration was manipulated by varying orientation similarity across frames. The patches' orientation varied between the two frames by 0° to 45°. Attention was manipulated via peripheral cues. Observers reported which of the two motion percepts was perceived. As expected, the percentage of element motion report increased as the orientation difference between the frames decreased, supporting the hypothesis that element motion is mediated by temporal integration. Critically, we found a higher percentage of element motion report in the attended condition, suggesting that transient attention, like sustained attention, enhances temporal integration. We are currently also varying the intra-frame orientation difference to examine the effect of transient spatial attention on both spatial and temporal integration.

From understanding human visual development to improving CNNs

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With the availability of large-scale image databases and advancements in graphics processing units (GPUs), deep Convolutional Neural Networks (CNNs) have received increased attention within the Machine Vision community over the last few years. In order to develop these CNNs as models of human visual processes, we need to examine how their performance compares with human data across various settings. To this end, we explored how a CNN performs on multiple ecologically significant perturbations of face images that the human visual system is widely known to be robustly invariant against. Our simulations reveal that introducing stimulus manipulations along various dimensions, including resolution, scale or chromatic information, leads to performance drops that are significantly stronger than in humans, as indicated by behavioral experiments conducted within and outside of our research group. Such significant discrepancies are not only instructively pointing to the domains in which neural networks require further improvement; they may also provide inspiration for how to implement these improvements. Along those lines, we find that we can increase the ability of a CNN to generalize across image transformations by developing a training regimen that transitions from more to less extreme values of the transformation. This, interestingly, captures some salient aspects of human visual development. Overall, we argue that establishing benchmark paradigms for Machine Vision systems across various datasets and creating more plausible computational models of human vision will not only result in better computational recognition but also superior models for testing new hypotheses about the human visual system.

How well do the Munsell and the natural colour systems describe the colours of natural scenes?

Ruben C. Pastilha, João M. M. Linhares, Ana I. C. Rodrigues & Sérgio M. C. Nascimento

University of Minho

There are several colour ordered systems based on printed samples designed to represent the colours available in natural world. Examples of such systems are the Munsell Colour System (MCS) and the Natural Colour System (NCS). Their chromatic gamut is confined by the colour reproduction limitations of printing process. The purpose of this work was to assess how accurately the MCS and the NSC represent the chromatic diversity of natural environments. The reflectance spectra of 1269 MCS colour ships and 1950 NCS colour samples was obtained and compared with reflectance spectra retrieved from 50 hyperspectral images of natural scenes. The MCS reflectance spectra were obtained from the University of Joensuu, Finland, and the NCS reflectance spectra were measured with a contact spectrophotometer (CM-2600D, Konica Minolta, Japan). The natural reflectance spectra were retrieved from a public database of hyperspectral images of natural scenes. All reflectance spectra were converted into the CIELAB assuming the CIE 1931 2º standard observer and the CIE D65 illuminant. The CIELAB volume occupied by each set of colours was assumed to be the correspondent colour gamut and compared among data sets. It was found that the MCS colour gamut corresponds to 71% of the NCS colour gamut and that this represents only 21% of the natural scenes colour gamut. Therefore a considerable portion of the natural colours are not accounted for either of the systems. These results seem to indicate that these two systems have important limitations in describing the overall chromatic content of the natural scenes.

Computing optic flow: A biologically inspired model

Linda Bowns

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When humans (or robots) move through a scene, the scene can be represented as an optic flow field that contains vectors representing all of the movement within the scene. The movement may be caused by the agent moving through the scene, or it may be caused by independent objects moving within the scene. The resulting vectors carry an enormous amount of information. For example, relative depth of objects, the shape of objects, biological motion, and information about a moving object. Extracting this flow field automatically under any condition is therefore extremely valuable. Previous attempts have been described but are either biologically implausible, or they are not sufficiently explicit to be implemented and/or tested. Here, the author presents an approach that is biologically plausible, mathematically explicit, simulated in MATLAB and tested using a variety of both artificial and natural movies. Results for artificially created translating patterns range between 90% to 100% correct. The patterns include both narrow and broad band spatial frequencies. The model is also able to interpret the motion of objects moving in different directions, in both artificial and natural scenes. This is facilitated by partitioning the movie into smaller parts, and applying the same model to each partition separately. The model mimics a number of human errors, and provides insight into a number of known phenomena, for example, how static information might effect motion, and the motion after effect.

Colour naming in natural images by colour-vision-deficient Observers

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Colour-vision-deficient individuals (CVDs) have been shown to name isolated colour samples in relatively high agreement with normal trichromatic individuals (NTs) (e.g. Bonnardel 2006; Lillo et al. 2014), despite poorer performance on colour discrimination tasks, suggesting a dissociation between CVDs' linguistic and perceptual colour categories. Do CVDs show the same concordance with NTs in naming object colours in real-world images? NTs (23) and CVDs (7 anomalous trichromats; 6 dichromats) (mean age 22.13 years) performed three naming tests. Stimuli were images (60; 30 x 40 degrees) selected from the McGill Calibrated Image Database for heterochromatic content or isolated colour patches (18; 5 x 5 degrees) including high-NT-agreement colours for each basic colour term (BCT), presented centrally against a neutral background on a calibrated 10-bit display. Participants had 1 minute to name the colour of all distinct objects in each image by clicking on one of 13 terms in a pop-up menu (11 BCTs plus "peach" and "turquoise"). Results: CVDs and NTs did not differ in their individual proportional use of each BCT, with "green" being highest frequency for both. CVDs named significantly fewer colours per image than did NTs, and were significantly slower in naming colours than NTs but only for the isolated patch colours. In a separate recognition task, CVDs used significantly more colour terms than NTs to describe the first object they identified in images. Conclusions: Contextual cues aid the speed of colour naming by CVDs and may contribute to learning of lexical colour categories.

Fixational eye-movements: An analysis of perturbation using frequency-tagged visual motion

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The functional role of fixational eye-movements in visual perception is well established, but is variable across individuals (Cherici et al, 2012; Martinez-Conde, 2006; Martinez-Conde, 2004). Here, we develop a paradigm to test the sensitivity of fixational eye-movements to peripheral moving stimuli. To that aim, we employed frequency-tagged visual motion of random dot kinematograms (RDKs) presented in different locations of the visual field. Healthy subjects (N=8) were told to maintain fixation at the center of a loosely defined fixation circle in the presence of RDKs whose dots oscillate on the horizontal and vertical axis at combinations of temporal frequencies (0.5- 1, 1-1.5, 1.5- 2 Hz). The RDKs were presented in restricted regions of the visual field (rings; bowtie quadrants) and at different contrasts. Applying spectral signal analyses onto the recorded (EyeLink II, 500 Hz) eye-movements, we found a sustained power in the range of the tagged-frequencies, indicating that eye-fixation is perturbed by RDK motion and oscillate at the tagged-frequencies. The power of these oscillations is greater for vertical as compared to horizontal eye-movements, depends on stimulus locations, but less on contrast. These preliminary results indicate that fixational eye-movements are perturbed by peripheral motions. As patients with neuropathies (RP, Glaucoma, AMD) are not sensitive to stimuli moving in their scotoma, it is planned to use perturbation of fixational eye-movements as an objective measure to assess their visual loss.

The "Camouflage Machine" Part II: Optimising both colours and textures for camouflage and visibility

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To remain unseen, an effective strategy is to maximise crypsis: matching both the textures and colours of the background. Camouflage is important in both natural and human-made environments, such as in a prey-predator arms race or concealing urban infrastructure. While camouflage focuses on reducing visibility and, for animals, is obviously advantageous in enhancing survival, highly visible warning or sexual signals can also provide a significant evolutionary advantage. Furthermore, much modern infrastructure is economically important, but is often not aesthetically pleasing and creates visual clutter. Although highlighting the problem is straightforward, finding a solution for any given environment is not trivial given the vast range of possible colours and textures. Previously we have presented a framework that provides an efficient method to find optimal colours for concealment or conspicuity in two realistic environments. Here we extend the framework to include both texture and colour. A texture-space with more than 4000 naturalistic textures was produced using Gray-Scott reaction-diffusion equations. We presented human participants with patterns in monochromatic, dichromatic and trichromatic contexts, using three-layer experimental stimuli (foreground-target-background) created using chroma key replacement, and measured their reaction time to detect a single target. Bayesian optimisation was used in order to sample efficiently the most (in)conspicuous patterns and colours based on detection times for previous trials. Deep neural networks were then built to provide interpolation of reaction times across the full texture and colour gamut. Our framework provides an effective and efficient method to derive optimally camouflaged or conspicuous patterns.

Looking behaviour and central preference indicate a "centre stage" heuristic

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The spatial location of an item influences its evaluation: objects in central locations are often preferred and elicit more positive evaluations. One explanation is the gaze-cascade theory, proposing that gaze combines with increased exposure to create a positive feedback loop as people view items. This automatically favours central items as they are often looked at first. Two studies tested this theory. In the first study participants were shown three artworks in a row (left, centre, and right location) and their eye movements were recorded as they selected their preferred artwork. Triplets depicted slightly different images, or were

identical images. In the latter case items could be of positive or negative emotional valence. Triplets of identical positive or negative artworks elicited a centre preference, but not neutral items. Regression analyses indicated that for positive (identical) artworks the participants' last fixation predicted preference for the central art-work, whereas the fixation duration predicted preference if the images were different. In a second experiment participants viewed triplets of consumer items that were slightly different but from the same category (e.g., three different tennis rackets) and asked which one they preferred. In one condition, participants were told to "Think carefully" about their choices, and in a second condition to "Use your gut feeling". Only the latter condition resulted in a significant behavioural centre preference, but in both conditions eye movements indicated a centre effect. These results are incompatible with the bottom-up gaze explanation and demonstrate that top-down factors influence centre preference.

A spatial frequency spectral peakedness model predicts discrimination performance of regularity in dot patterns

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Subjective assessments of spatial regularity are common, for example in developmental biology, and are consistent across diverse stimuli (Protonotarios et al., 2014). For jittered square lattices of dots, humans can distinguish up to 16.5 jnd levels of regularity between total disorder (Poisson) and perfect regularity (Protonotarios et al., 2016). Ouhnana et al. (2013) demonstrated that regularity is an adaptable visual dimension and hypothesized that it is coded via the peakedness of the distribution of energy responses across receptive field size. We tested that hypothesis using judgments of relative regularity of pairs of jittered square-lattice dot patterns. 31 levels of jitter were used. Observers made all pairwise comparisons twice for ten sets of pattern presentation parameters. Presentation parameters controlled dot diameter (0.6-1.2 cm), dot number (80-245), and overall radius (3.8-8.4 cm). Perceived "order" values were estimated using Thurstonian scaling. We take the number of jnds from the most to least ordered pattern as a measure of discriminability of regularity. Discriminability varied with presentation parameters between 12.9 and 17.8 jnds. Using a filter-rectify-filter model, we determined energy responses across scale. There were two peaks: One corresponded to average inter-dot distance (from a regular lattice) and one to a peak that results from a disordered, Poisson pattern. We define peakedness as the relative heights of these two peaks. Across presentation parameters, peakedness is highly correlated with discriminability (r=0.83).

Blink detection based on noise in pupillometry data

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Pupillometry (or measurement of pupil size) is commonly used to index both parasympathetic and sympathetic activations of the Autonomic Nervous System. Several methodological issues should be addressed when processing and analyzing pupillometry data, such as the brightness, contrast and the position of the stimuli. Other challenges are related to pupillometry data processing: converting the data to comparable units, removing blinks and outlier samples, and averaging across trials and conditions. There are several methods to detect and remove blinks from the data. The most common method is replacing missing samples using linear interpolation. This method is not optimal and may lead to misleading findings. Here we suggest a simple but useful algorithm to detect blinks based on the fluctuations that characterize pupil data. These fluctuations ("noise") result from changes in nervous system activity, but also from noise produced by the eye-tracker device. Our algorithm finds the onset and offset of the blinks based on this fluctuation pattern. This method was proven to be highly accurate and thus provides a more optimal solution for researchers who analyze pupillometry data

Saccadic peak velocity reveals attention holding for direct-gaze faces

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It is known that task-irrelevant pictorial faces displaying direct gaze shown at fixation can increase manual response times to peripherally presented targets. This result is generally interpreted as evidence that direct-gaze faces can hold attention. Here, we conducted three experiments to explore whether this attention-holding effect is also detectable in saccadic response times. Participants performed rightwards and leftwards saccades towards a symbolic target, while an irrelevant face with open vs. closed eyes appeared at fixation. Surprisingly, saccadic response times did not show any consistent result as a function of open- vs. closed-eye faces. In contrast, saccadic peak velocities were significantly lower in the presence of faces with open rather than closed eyes (Experiment 1), an effect that emerged even in the presence of non-human primate faces (Experiment 2), and that disappeared when faces were presented inverted rather than upright (Experiment 3). These findings suggest that establishing eye contact with another individual can modulate saccadic dynamics.

Multiple saccades enhance spatial specificity of resource allocation in visual short-term memory

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The visual system has limited resources to maintain stable representations in visual short-term memory (VSTM). We recently showed that saccades bias resource allocation in VSTM in favor of stimuli whose former location becomes the target of a subsequent saccade (Ohl & Rolfs, 2017). Here, we examine whether this spatial bias varies as a function of the number of saccades. 400 ms after the disappearance of a memory array consisting of six oriented Gabors, we cued

observers to generate a sequence of saccades. In the one-target condition, participants made a saccade to the cued target; in the two-target condition, participants made a first saccade to the cued target and a second one to the next location counterclockwise of the first target. Finally, participants made a saccade back to the center of the screen. After a total of 1800 ms after the offset of the memory array, a response cue appeared at a random one of the previous stimulus locations and participants reported its orientation from memory. Although saccades were uninformative about the memory task, memory performance was higher for stimuli that coincided with the saccade target location (congruent trials) than for stimuli at incongruent locations. Critically, performance also depended on the number of saccades: Whereas performance was similar across all congruent conditions, it was worse at incongruent locations in the two than in the one-target condition. Thus, multiple saccades enhance performance at additional congruent locations at the expense of incongruent ones, increasing spatial specificity of resource allocation in VSTM.

Not all short-latency saccades are express

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The initiation of short-latency visually-guided eye movements has been extensively studied and modeled using different types of graphical representations such as frequency histograms and reciprobit plots. In recent years, some authors have suggested a distinction between early and express saccades. According to the Threshold Interval Modulation with Early Release-Rate of rIse Deviation with Early Release (TIMER-RIDER) model, early and express saccades may be different movements in psychophysical and physiological nature. Here we present findings in monkeys and humans showing evidence for a segregation between the two types of movements. Saccades were recorded in monkeys in variable gap visually-guided tasks. Healthy humans underwent eighteen saccadic tasks, cued or non-cued. The optimal conditions to obtain either early or express or both saccades are described. We also show pathological conditions in humans where the two movements are observed. These results advocate for a clear distinction between early and express with potential theoretical and clinical impacts.

Integrating motion predictive information across different time scales: An eye-movement and transcranial random noise stimulation (tRNS) study

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Predictive information about target motion can strongly bias tracking eye movements. Previous evidence suggests that eye movements can be efficiently adjusted to predictive information integrated either over a short (single-trial) or long time-scale (trial-sequence), and that two key areas (parietal and frontal) play a direct role in these tasks. We ask whether different sources of predictive information are combined across different time-scales to control tracking eye movements. Second, we probed the role of key cortical areas in controlling predictive eye movements, by applying tRNS over the frontal, parietal, and occipital cortex as a control, in separate sessions. We recorded eye-movements from eight participants during a smooth pursuit task, where the probability of motion was either uniform across directions, or biased in favor of one direction. In half the trials (blank) the moving target was transiently occluded for 800ms. As expected, (a) robust anticipatory pursuit was observed before motion onset in the biased condition and (b) pursuit velocity was reduced during the target blank. In the direction-biased condition, sustained predictive pursuit during blank was stronger in the more likely direction, suggesting that information integrated over a long trial-sequence can be combined with the within-trial visuomotor memory. Interestingly, tRNS over parietal cortex facilitated the occurrence of predictive saccades during blank, while tRNS over the frontal cortex facilitated trial-sequence effects, as measured by the variability in predictive pursuit as a function of the direction of previous trials. Mean predictive pursuit velocity wasn't modulated by tRNS either during blanking or during anticipation.

Modulatory effect of melanopsin activation on contrast sensitivity and pupil response

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Melanopsin is a photopigment expressed in a small group of retinal ganglion cells called ipRGCs. This photopigment mediates non-image forming functions as circadian rhythms and pupillary responses. Involvement of melanopsin activation in human vision was reported, however, its function is not clear. In this study, we assessed melanopsin activation as a modulator of visual and pupillary responses. A Five-primary photostimulator, which allowed us to selectively stimulate each photoreceptor (Cao et al, J. Vis, 2015), produced temporal sinusoidal cone stimulation (L-, M- and S-cone excitations in phase, while keeping rods and melanopsin activation constant) at 1000 photopic td. We obtained cone contrast sensitivity (CS) from 1 to 16Hz using a staircase procedure and flicker pupillary responses (PR) at 1Hz and 3Hz (contrast = 9%) for two melanopsin activation background levels: Mel-Low (356.4 melanopic td) and Mel-High (447.5 melanopic td). Significant differences were found for CS at 3Hz with Mel-High producing higher CS than Mel-Low ($p < 0.05$). Pupillary responses for condition Mel-Low were delayed by 21ms from condition Mel-High this phase difference was only found at 3Hz ($p < 0.05$). Our results showed the modulatory effect of melanopsin activation on contrast sensitivity and pupil responses. An increment in melanopsin activation produced better visual sensitivity and faster pupil response at one specific temporal frequency. These findings suggest that melanopsin activation could modulate contrast detection and adaptation mechanisms, depending on the dynamics of the stimulation.

Ocular tracking of occluded ballistic trajectories: Effects of visual context and of targets' law of motion

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When tracking a moving target, the visual context may provide cues to interpret the causal nature of the target motion and extract features to which the visual system may be weakly sensitive, such as the acceleration imposed by gravity. This information could be particularly critical if vision of the target is temporarily impeded, requiring predictive neural mechanisms to extrapolate the target motion. To gain further insight, we investigated how visual context influenced ocular tracking of motion either congruent or not with natural gravity. To this end, 12 subjects pursued computer-simulated ballistic trajectories that, in the descending segment, were either perturbed with altered gravity effects (0g | 2g) or retained natural-like motion (1g). Shortly thereafter, targets disappeared for either 450 or 650 ms and became again visible until landing. Target motion occurred in two different scenarios, with either realistic pictorial cues or neutral grey background, presented in counterbalanced order across subjects. We analyzed saccadic and smooth pursuit movements after the target motion perturbation (0g and 2g motion) and for corresponding time intervals of unperturbed 1g trajectories. We found that saccade frequency, post-saccadic errors and smooth pursuit parameters differed significantly between scenarios. With neutral background, eye movements did not depend on target kinematics, whereas with pictorial background they depended significantly on the ball law of motion, denoting better ocular tracking of accelerated motion. These findings may imply tuning of oculomotor control processes to realistic visual environments.

Predictive remapping of visual features beyond saccadic targets

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Predictive remapping refers to the phenomenon that visually responsive neurons predictively increase their activity to stimuli that will be brought into their receptive fields by an upcoming eye movement. Recent studies are conflicting regarding the issue whether feature information is transmitted around the time of an eye movement, with a number of studies claiming that orientation and motion features are remapped (Ezzati, Golzar, & Afraz, 2008; Melcher, 2007), while others found no evidence of feature remapping (Lescroart, Kanwisher, & Golomb, 2016). In the current study, using the tilt aftereffect (Melcher, 2007) we investigated whether orientation feature remapping: 1) occurs only at the location of future visual input, or also at the location where the adaptor is remapped to; 2) occurs selectively for to-be-foveated saccade targets, or also for stimuli that are not saccade targets. Results show pre-saccadic remapping specifically at the location of future input, but not at the remapped adaptor location – consistent with Melcher (2007). Furthermore, preliminary results suggest pre-saccadic remapping also occurs for items that are positioned 4 visual degrees above the saccade target. Together, our results suggest that predictive remapping of orientation is robustly present for future visual input, irrespective of whether it is a saccade goal. This may aid visual stability across eye movements.

Markers of surprise measured by the involuntary oculomotor response to auditory and visual stimuli

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Involuntary eye movements occur constantly but are known to be inhibited momentarily in response to external stimuli (oculmotor inhibition, OMI), with a time-course and magnitude that depend on stimulus saliency, attention and expectations. Here we asked whether the OMI markers of surprise are specific to violation of local repetition, or can provide quantitative measures of prediction errors in general settings, including non-local auditory (experiment 1) and visual surprise (experiment 2). In experiment 1, observers (N=11) listened passively to repeated (0.5Hz) rapid sequences of 6 pure tones that either contained a deviant tone (local surprise), or varied in the probability of the deviant (global surprise over several seconds). To insure fixation, an image was transiently presented between 200ms after sound onset until end of trial. The results showed altered microsaccade rate modulation in response to the local deviant tone, demonstrating a local surprise effect. Further, when the deviant tone rarely appeared, the rate modulation was further altered, demonstrating a global surprise effect. In experiment 2, observers (N=10) followed a transiently (1Hz) ascending figure on a 4-stairs staircase pattern, which jumped to the starting point every cycle, but frequently fell back unexpectedly. The results showed a gradual shortening of the OMI effect within a cycle demonstrating the buildup of a statistical expectation and surprise. Taken together, these results show that the effect of oculomotor-inhibition provides markers of surprise not specific to local violations of repetition and can be used to investigate the mechanisms of perceptual surprise.

Cross-cultural biases in categorising emotions expressed in British and Egyptian faces

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Menoufia university

It is widely assumed that basic emotions are universally recognized in faces. More recent findings suggest however that cross-cultural differences in emotion categorization depends to some extent on the methodology used. Here we investigate whether sensitivity to cultural variation enhances when the number of possible response options (emotional labels) is increased in a standard facial expression categorization task. UK nationals (n=95) and Egyptian nationals (n=133) were presented with British and Egyptian faces expressing four emotions: Angry, fear, sadness and happiness. For each image, participants selected one of eighteen emotional labels. The results showed that the addition of more response options resulted in substantial variation in selected responses for all participants, particularly for angry and fearful faces. Moreover, an 'own-culture bias' was found for angry and sad expression, reflected in a more frequent selection of the intended expression for own-country angry and

sad faces. These findings supports the notion that emotion recognition is characterized by cultural differences. The underlying social and cognitive mechanisms are currently under investigation.

Positive ERP components in the "go/no go" saccadic paradigm

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Lomonosov Moscow State University

In 17 healthy right-handed subjects P1 and P2 ERP components have been studied in GO/NO GO saccadic paradigm. Parameters and topography of these potentials depended on the saccade latency (LP). The subjects were divided into two groups: "slow" subjects (LP=287 ± 13 ms) and "fast" subjects (LP=193 ± 10 ms). In "fast" group Go P2 was corresponded to the spike potential and was excluded from analysis. In "slow" group Go P2 were enhanced compare to P1 and was not differ from Go P1 in "fast" group. These potentials emerged in the time period 50 - 100 ms prior to saccade onset, and we suppose that they are a marker of saccade programming decision making stage. In all subjects No go P2 was enhanced compare to the No go P1. We also assume that No go P2 ERP reflects decision making process that does not depend on the stimuli significance. The nature of decision making (Go or No go) may be reflected in the opposite direction of P2 foci spreading along the fronto-parietal networks of saccadic control: «top-down» in the «Go» conditions and «bottom-up» in the «No go» conditions, as EEG mapping have been shown. In "slow" group the No go P1 was reduced compare to Go P1. Its peak was mostly located over the centro -parietal- areas of the right hemisphere that may suggest the reflection of inhibition influence on the early stages of sensory stimulus evaluation.

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Color assimilation by eye shadows occurs only on the face

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This study confirmed whether the perceptual assimilation effect by eye shadows was peculiar to the faces and how the phenomenon extended. Experiment 1 measured the point of subjective equalities of five eye shadows, red, orange, yellow, green, and blue. The color of face applied eye shadows was yellowish. There were three types of comparative stimuli: entire face, only eye part, and only cheek part. Each type of the comparative stimuli had nine steps which colors varied from redder to paler. Twenty female participants selected a comparative color stimulus subjectively equal to the face with a certain eye shadow. The subjective color of the face without eye shadow was also measured. The results of the entire face were similar to those of the eye part; the red eye shadow and the orange one made the face look significantly redder and the yellow and green eye shadows made the face look significantly paler. However, in the cheek part stimuli, there was no eye shadow significantly changing the perceptual face color. Experiment 2 measured the similar perceptual color change, using geometric figures. The standard stimuli were rectangles with certain colored line and color gradation. These colors were the same five colors used in the experiment 1. The comparative stimuli were flesh-colored rectangles. As a result, there was no color that perceptually changed the rectangle's color. We concluded that the perceptual changes of complexion by eye shadows only occurred in face stimuli, although the phenomenon was limited within an area near to eyes.

Number magnitude influences saccade parameters: Evidence from foveal and peripheral processing

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Numbers are represented as mental magnitudes, placed on a mental number line from left to right in Western cultures. A Theory of Magnitude (ATOM by Walsh, 2003, Trends Cogn Sci, 7(11), 483-8) proposes that numbers, space and time share a common system of magnitude predicting that a change of magnitude in one perceptive domain will change the perceived magnitude in another one (more A implies more B), observable on motor output. Most of the studies have investigated manual response times but rarely other parameters of the action. Here we investigated the effect of number magnitude on saccadic parameters. A foveal fixation stimulus and peripheral saccade target (two possible positions, 5 and 10°, to the right) were off after a 600 ms delay. Then the participant had to make the saccade to the memorized target location, independently of the number magnitude. Finally, they had to make a categorization task (higher or lower than 5) on the number (1, 3, 7 or 9) that had been previously presented either in fovea (fixation stimulus) or in periphery (saccade target). Non numerical stimuli were interleaved as control trials. Preliminary analyses on temporal and spatial saccade parameters show different congruency effects between numerical magnitude and target eccentricity in foveal and peripheral conditions. Theoretical implications of our results will be discussed in the framework of ATOM model (Walsh, 2003).

Worth a look? Exploring the reward values of different face categories in children and adults.

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Links between individuals' motivation to engage with social stimuli and their processing abilities for them are rarely investigated directly, particularly in typical development. Here we used an economic key-pressing paradigm to infer and contrast the relative reward value of different face categories (varying in age, expression, attractiveness) for young children (6 – 8years, n=101), older children (9 – 12 years, n=122) and adults (>16, n=157). Results confirmed that all three age-groups were willing to 'work' (complete effortful key presses) to increase time spent viewing happy faces (relative to angry

and neutral faces) and attractive faces (relative to unattractive faces): consistent with these stimuli holding high reward values for participants across groups. We also observed a strong motivation to view own-age faces in young children, which diminished in older children and was absent in adults. When testing directly the relationship between all children's viewing behaviour in this paradigm and their face expertise (accuracy, Cambridge Face Memory Test - Children) we observed a somewhat counterintuitive association. Specifically, a tendency toward shorter face viewing times in the children with the strongest abilities compared to the weakest. This difference was significant for the child faces (p=.04) and a similar trend was observed for adult faces (p=0.23). At first glance this profile of attenuated reward-related responses in these most expert face processors seems to challenge links between social motivation and face processing expertise, unless – as we propose – the association between these variables is more complex in these paradigms than traditionally assumed.

Trait anxiety is correlated with the correct categorization of faces, but not reaction times, in a spatial attention task

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University of Tartu

Individual differences in personality traits and common genetic variability are known to have an effect on basic visual perceptual skills such as those required for target discrimination in visual masking or RSVP. We extended this line of research by examining how trait anxiety relates to socially relevant target perception in two well-known paradigms – metacontrast masking (SOA = 70 ms) and exogeneous spatial-attentional precueing. Brief images of female and male faces with neutral or angry expression were used as targets. The two-alternative task required to categorize faces as male or female. Observers' trait anxiety level (measured by STAI) did not predict reaction time to targets neither in the peripheral pre-cueing task ($p = 0.501$) nor in the metacontrast task ($p = 0.273$). However, target correct categorization level decreased with increase in trait anxiety in the spatial attention task ($p = 0.005$). Target gender and expression significantly interacted ($p < 0.001$): in both paradigms, face gender categorization correctness was at a comparable level for male and female targets with neutral faces, but showed a relative decrease in correctness of female face categorization with angry faces.

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Behavioural and neural correlates of distraction by faces

Markus Neumann, Charles Viska, Sascha Van Huis & Romina Palermo

In everyday life we constantly experience distractions during an ongoing task. Distractions could potentially put us in great risk, for instance when they occur while we are driving. The present study explores behavioural and event-related potential (ERP) correlates of distraction by faces, as compared to non-face objects (cars), given that faces are often found to be very efficient in attracting attention. We employed the irrelevant-distractor paradigm, in which participants performed a letter search task, under either high and low load, while peripheral distractors (either faces or cars) infrequently appeared. In the low load task, face and car distractors both slowed responses relative to distractor absent trials. Consistent with previous research, no distraction occurred in the high load task for either distractor type. However, ERPs revealed evidence for face-specific distractor processing independent of load. First, while N170 was generally reduced by the presence of a distractor, it was larger in response to faces as compared to cars, indicating face-specific distractor processing, under both load conditions. Second, we also found that contralateral biases of face-selective processing in the N170 were unaffected by load. In conclusion, we found that (i) faces were not more distracting than cars when performing a letter-search task, and (ii) even though faces did not affect letter search performance under high load, ERPs indicated face-specific processing was present. One interpretation of these findings is that face-specific and letter-search processes may not compete for the same attentional resources.

Leaders need to look trustworthy in times of peace but strong and devious in times of war

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Facial attributions can be distilled into two main dimensions: looking competent (powerful) or trustworthy (having a positive emotional expression). Appearance has a powerful influence on leadership choice. In the West, candidates with the most 'competent' facial appearance are preferred, particularly in the context of external conflict (war). The role of a trustworthy appearance on leadership is less well defined. We therefore compared the impact of apparent strength and trustworthiness in leader selection in war and peacetime contexts. 3D facial surfaces were scanned for 50 male Caucasians (age 19-31). The face surfaces were subjected to: Procrustes alignment, delineation of 49 feature landmarks, resampling, and cropping to discard hair and neck. Each face shape was rendered with the average facial colour creating 50 male faces differing only in shape. 60 participants rated these for apparent strength and trustworthiness. Face shapes with high and low ratings in strength and trustworthiness were used to create continua varying in apparent strength and trust. 100 new participants adjusted the appearance of male faces along these continua to make them look most leader-like in time of external conflict and war or to resolve internal conflicts peacefully. In the context of external conflict participants increased the apparent strength of faces and decreased facial trustworthiness. In the context of internal conflict, participants increased facial trustworthiness but not strength. Our research indicates a complex influence of appearance on leader selection. A trustworthy appearance is preferred in peacetime but the opposite, an 'untrustworthy' look, is preferred in war!

The influence of other people on facial attractiveness judgments

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Human faces are a special object category. An information which we easily and rapidly extract from faces and process is their attractiveness. However, this cue is usually embedded in a context of experiences, as we are confronted with a lot of faces in daily life - which we could use as reference for attractiveness judgments. In this study we aimed to answer the question how the attractiveness judgment of a specific person is influenced by preceding and simultaneously perceived faces. Depending on attractiveness differences between faces we expected that assimilation and contrast effects would occur. To test this we used isolated female and male faces and combined those to have various attractiveness differences between two paired faces respectively between preceding and subsequent faces. In different blocks men and women had to judge facial attractiveness of the same faces, either presented in a sequence or in pairs. Between them a filler task was implemented where participants had to judge artworks. We also collected perceiver information like relationship status to be able to test if and which perceiver variables modulate the effect. For some faces we found assimilation and for others contrast effects. These were influenced by perceiver variables. Our results indicate that judging facial attractiveness is not objective, but is influenced by amongst others our (recent) past experiences.

The effect of image size and face inversion on the uncanny valley

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The uncanny valley is a well-known phenomenon, but it has not been scientifically examined. The purposes of this study were to identify the uncanny valley experimentally and to test the effect of size and inversion of face images on uncanny valley. The stimuli were face images of human-like agent. Three types of image size were used; small, medium, and large. The images were presented in upright or inverted orientation. The task of participants was to rate the horribleness of face images. Results showed that as predicted by uncanny valley, face-image in particular range which was similar to the real human were rated horrible. The larger sizes of images were presented, the stronger horribleness was induced. The uncanny valley patterns appeared in both inverted and upright condition. These results suggest that similarity with an actual figure in size could be a key factor for the uncanny valley effect.

Does our brain need awareness to "recognize" familiar faces?

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Faces are a special type of stimulus which provide rich social information to us. It is easy for human beings to recognize their friends, relatives, famous persons and themselves by faces. But can our brain see the difference between familiar and unfamiliar faces without awareness? We used a continuous flash suppression (CFS) paradigm (Tsuchiya and Koch 2005), in which a series of different Mondrian patterns is flashed to one eye at a steady rate, suppressing awareness of the image presented to the other eye. CFS has been proven to be a valuable tool in the investigation of visual processing outside of conscious awareness. Faces were seperated into four groups depending on their familiarity: famous faces, faces of the subjects' classmates, self-face and strange faces. In experiment 1, we used a break-through CFS paradigm and analyzed the latency of the break-through. We found that unfamiliar faces broke through the CFS faster than familiar faces, but there was no difference between the three groups of familiar faces. In experiment 2, we recorded the event-related potentials (ERPs) during the experiment. We focused our analysis on the N250 component which is known to index face familiarity (Schweinberger, Pickering et al. 2002; Schweinberger, Huddy et al. 2004). When subjects "saw" the stimuli, the classmate faces induced smaller amplitudes than other faces. And when subjects "did not see" the stimuli, there was no significant difference between unfamiliar and familiar faces. We conclude that the familiarity effect of faces does depend on awareness under CFS conditions.

Specific patterns of dissociations between metacognitive awareness and visual emotion perception in individuals with schizophrenia.

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Several studies suggest the relevance of emotion perception deficits to clinical symptoms in schizophrenia population. Indeed, several empirical paradigms on facial emotion recognition show that schizophrenic patients exhibit deficits to accurate identifying negative facial expressions. Recent studies also indicate that schizophrenic patients may be predisposed to false perceptions (e.g. visual hallucinations) because of their reduced metacognitive awareness. The present research investigated empirically relationships between metacognitive awareness and emotion perception in individuals with schizophrenia spectrum disorders and healthy controls. Participants performed a backward masking task with subliminally presented fearful faces (33ms) and then expressed subjective certainty in perceptual responses on the confidence rating scale. Our data analysis with the signal detection measures showed that patients exhibited deficits in emotion perception. Interestingly, there was no difference in metacognition awareness between both groups. These results are consistent with studies showing that no all of aspects of cognitive processing in schizophrenia are impaired and supports the hypothesis that schizophrenia is associated with a specific pattern of dissociations between

awareness and emotion perception. Fundings: This research has been supported by the National Science Center (Poland), and funded under the award number 2014/15/B/HS6/03834

Saccades toward faces are not only faster but also larger

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Recent studies showed that we are able to initiate reliable saccades toward an image of a human face in just 100-120 ms (Crouzet et al., 2010, Guyader et al., 2017). In this study, we used the same saccadic choice task but we were interested in the amplitude of the saccade as a function of their accuracy. Pairs of colored photographs of natural scenes were simultaneously presented left and right of fixation. One image contained a human face and the other a vehicle. 12 participants were asked to saccade toward the image containing a pre-defined target. They performed two experimental sessions, one with faces as target and one with vehicles as target. As before we observe very fast saccades toward faces compared to saccades toward vehicles. More interestingly, whereas images are always displayed at the same position 8° eccentricity, the amplitude of saccades are on average larger for correct saccades (6.5°) than error saccades (5.2°) for both vehicle and face targets. Moreover, correct saccades are larger for face target (6.8°) than vehicle target (6°). Results are discussed regarding a possible on-line correction of saccade trajectory contrary to the classical view that saccade parameters are determined before its onset.

Tracking spatial frequency integration in EEG

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UCLouvain

According to the coarse-to-fine account of face perception, the global information about a face, largely carried by low spatial frequencies (LSF), is processed earlier and faster than the more detailed information contained in higher spatial frequencies (HSF). To elucidate the relative contribution of high and low spatial frequencies over the course of full spectrum image-processing, we used EEG source reconstruction and multivariate classification techniques. Participants were presented with images of human faces, monkey faces and their scrambled versions. Images were filtered to selectively contain either LSF, HSF or a combination of both (Broad band, BB). We then trained support vector machines to classify between sensor space EEG responses to human vs monkey images as well as intact vs scrambled images using narrow shifting time windows. Classification was not only generalizable across spatial frequency conditions (e.g. train on LSF and test on HSF) but also generalized across time. To restrict our analysis to occipital and ventral temporal visual cortex, we reconstructed the source time-series of two regions of interest (early visual cortex and high level ventral temporal cortex respectively). We are currently investigating how effective connectivity between those regions changes with image content. We expect to find enhanced top-down connectivity for LSF, compared to HSF images, which we would interpret as evidence for coarse-to-fine processing.

Deafness amplifies visual information sampling during face recognition

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Vision is the primary sensory input for the human being. However, it remains unclear how visual sampling is modulated and shaped by non-visual information. A particular fate of nature might be helpful to achieve this feat: the occurrence of deafness. Research has shown that early profound hearing loss enhances the sensitivity and efficiency of the visual channel in deaf individuals, resulting in a larger peripheral visual attention compared to the hearing population. However, whether such perceptual bias extends to visual sampling strategies deployed during the biologically-relevant face recognition task remains to be clarified. To this aim, we recorded the eye movements of deaf and hearing observers while they performed a delayed matching task with upright and inverted faces. Deaf observers showed a preferential central fixation pattern compared to hearing controls, with the spatial fixation density peaking just below the eyes. Interestingly, the deaf observers were not impaired by the face inversion and did not change their sampling strategy. To assess the visual information intake, the same participants performed the identical experiment with a gaze-contingent design parametrically and dynamically modulating the quantity of information available at each fixation (Expanding Spotlight). Retinal filter reconstruction revealed an enlarged visual field in deafness. Unlike hearing participants, deaf observers used larger information intake from all the fixations. This visual sampling strategy was robust and as effective for inverted face recognition. Altogether, our data show that the face system is flexible and might tune to distinct strategies as a function of visual and social experience.

Reliability of portable stereo device for testing hollow-face illusion in schizophrenia patients and controls

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Introduction: Viewers perceive a 3-D hollow face as a normal convex face under certain condition; this is known as the hollow-face illusion (HFI); it is the best known example of a class of depth-inversion illusions. It has been observed that schizophrenia patients do not perceive the HFI as strongly as do controls. Elaborate desk-top stereoscopes are too expensive and bulky to be portable. Methods: In an effort to administer this test more conveniently to a wider group of Ps, we developed a portable stereo system that can be brought to each P's environment. We examined the reliability of this system by comparing it to a desk stereoscope on 13 Ps. We used 12 individual face stimuli, some of which were convex (X), flat (F) or concave (V). Ps' task was to report which type (X, F, V) they perceived. We used an ABAB design regarding which platform was used first, in a counterbalanced fashion; this enabled comparison within (AA, BB), as well as across (AB, BA) platforms. We ran a Monte-Carlo simulation to get an estimate of the expected error rates. Results: Results are

consistent across platforms for convex (errors 5%) and flat (11%), especially as they compare to within platform performance (convex: errors 4%; flat: 11%)). They also compare favorably to the Monte-Carlo simulation figures. Conclusions: The new portable stereo device compares well with desktop devices and increases patient accessibility by bringing the test to patients' environment, rather than requiring patients to be tested in the laboratory.

Why are we better at recognising moving faces? An eye-tracking study

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People are more accurate at recognising familiar faces when they are viewed as moving rather than static images, especially when the faces are degraded. However, it is unclear whether this is due to a general effect of motion attracting attention (i.e., people look more at moving images in general); or whether motion attracts attention to specific regions of the face that facilitate identification, such as the internal facial features. In this study, participants (N=31) were asked to identify 60 famous faces, presented as moving or static images. Identification was significantly better for moving than static faces. A subset of participants (N=20) had their eye movements recorded during the task. Participants spent a significantly higher proportion of time and directed more fixations to internal features of faces (eyes, nose, mouth) when they were presented as moving rather than static images; conversely, the proportion of time and fixations to non-feature areas of the face (e.g., cheeks, forehead, chin) was significantly reduced for moving compared to static images. The effect of movement was consistent across internal facial features: movement did not significantly alter the ratio of time spent viewing different features. These results suggest that the movement advantage for familiar faces may be driven by increased attention to internal facial features, perhaps because they also carry socially salient movement cues (e.g., expression, eye gaze, speech movements), or because characteristic patterns of movement information that can be used as supplementary cues to identity are more prevalent in these areas.

Is human face processing a feature- or pattern-based task? Evidence using a unified computational method driven by eye movements

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Research on human face processing using eye movements has provided evidence that we recognize face images successfully focusing our visual attention on a few inner facial regions, mainly on the eyes, nose and mouth. To understand how we accomplish this process of coding high-dimensional faces so efficiently, this paper proposes and implements a multivariate extraction method that combines face images variance with human spatial attention maps modeled as feature- and pattern-based information sources. It is based on a unified computational representation of the well-known face-space concept. The spatial attention maps are summary statistics of the eye-tracking fixations of a number of participants and trials to frontal and well-framed face images during separate gender and facial expression recognition tasks. Our experimental results carried out on publicly available face databases have indicated that we might emulate the face perception processing as a pattern-based coding scheme rather than a feature-based one to properly explain the proficiency of the human visual system in recognizing face information.

Redundancy gains in face perception

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KU Leuven

Early theories on face perception posit that invariant (identity) and changeable (expression) facial aspects are processed separately. However, many researchers have countered the hypothesis of parallel processes with findings of interactions between identity and emotion perception, and shared neural visual representations. The majority of tasks measuring interactions between identity and emotion employ a selective attention design, in which participants are instructed to attend to one dimension (e.g., identity) while the other dimension varies orthogonally (e.g., emotion), but is task-irrelevant. Recently, a divided attention design (the redundancy gain paradigm) in which both identity and emotion are task-relevant was employed to assess the interaction between identity and emotion. A redundancy gain is calculated by a drop in reaction time in trials in which a target from both dimensions is present in the stimulus-face (e.g., 'sad person A'), compared to trials with only a single target present (e.g., 'sad' or 'person A'). Redundancy gains are hypothesized to point to an interactive activation of both dimensions, and as such, could complement designs adopting a selective attention task. The initial aim of the current study was to reproduce the earlier findings with this paradigm on identity and emotion perception (Yankouskaya, Booth, & Humphreys, 2012), but our study failed to replicate the results. In a series of subtasks, multiple aspects of the design were manipulated separately in our goal to shed light on the factors that influence the redundancy gain effect, and limitations of the paradigm to assess face processing are discussed.

The order of transfer of different spatial frequency information to the short-term memory

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An order of information transferring from a perception level to the short-term memory (STM) is a question being discussed. A recent study (Gao, Bentin, J ExpPsychol, 37, 2011) found that the faster the information is processed at the perception level, the faster it is transmitted to STM. That is, low spatial frequencies (SFs) have priority. However, middle SFs

are more important for face recognition. Some methodological features of the mentioned research prompted us to conduct our investigation. Our purpose was to determine the order of transfer of different SFs to STM. Unfamiliar faces were adopted as stimuli. Each face was preliminary filtered to create 6 copies with different bandpasses. Each trial began with the presentation of a filtered face (test image). The test stimulus duration was limited by a mask and varied from 26.6 to 133 ms with step of 26.6 ms. After that 4 unfiltered (initial) faces were simultaneously presented (comparison images). The observer had to match one of the comparison faces with test stimulus. SF of the test image changed randomly from trial to trial. The dependencies of accuracy of comparison on test stimulus duration were determined for each SF. We found that the performance improved most rapidly for SFs 2 and 4 cpd. Efficiency gaining was slower for 1 and 8 cpd. The worst results were obtained for 0.5 and 16 cpd. Since the comparison images were compared with the information stored in STM, we suggest that middle SFs enter STM first. Supported by MESRF project 3336.

Segmentation of image cues for perceived gloss of grapes in painted still lifes

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Understanding which variables are involved in gloss judgment is a widely-investigated topic in the field of material perception. Although several mechanisms have been suggested, there is still considerable disagreement about the identity and the complex interaction of the elements playing a role. Here, we proposed a new approach to analyse low-level image features, namely highlights' contrast and sharpness, contributing to gloss perception. Psychophysical experiments were conducted using as stimuli 81 digital images of 17th century paintings, depicting grapes. A group of 10 observers was asked to rate the perceived glossiness of the grapes. The task of another group of 7 observers was to segment, from the same set of images, the cues they considered to be responsible for gloss perception. All participants regarded the highlights as the most salient cue. Thereafter, highlights' contrast and sharpness were calculated for each segmented grape, via computation of Michelson's contrast and steepness, from their intensity profiles. A strong linear correlation was found between perceived gloss and highlights' contrast ($\rho=0.65$, $p<0.01$), whereas sharpness showed a slightly lower correlation ($\rho=0.39$, $p<0.01$). One advantage of our method was that observers were able to freely assess gloss cues, which could then be directly measured from the images. Moreover, the choice of paintings as stimuli demonstrated that the study of perceived gloss is not restricted to controlled computer-rendered images. Our findings validated the proposed role of highlights' contrast and sharpness, as part of the aspects to take into account when computing gloss perception.

Facial identification and feature integration under memory load

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We studied working memory precision for facial identities and the integration of facial features with and without memory load. Our stimuli consisted of face images of 60 identities from the Radboud and FACES databases. We formed 20 continuous, circular identity spaces by morphing subsets of the faces from one identity to another. On each trial, participants adjusted a probe face to match a target identity either while viewing the original target stimulus (perception) or after a 1.5 s retention period while keeping in mind 1-4 identities (memory). Under memory load, the target face was indicated with a spatial cue after the retention period. We measured adjustment-error distributions for eye region only, mouth region only, and the whole face. We estimated the precision of perception/memory from von Mises distributions fit to these data. As expected, precision was higher in the perception than in the memory condition and also for the whole face compared to mouth or eyes alone. From the single-feature conditions (eyes and mouth), we estimated the noise in the coding of individual features and the additional noise due to the memory load. We then predicted the whole-face precision assuming optimal integration of independent features. The data closely followed the model predictions. We conclude that memory precision declines with increasing memory load similarly for individual features and for the whole face. The near-optimal precision for the whole face suggests that the decline is mainly due to memory noise, not due to disruption of feature integration in memory.

Exponential filtering of the Hermann grid illusion and its variants

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White gridlines placed over a black background induce the perception of grey smudges at their intersections, known as the Hermann Grid illusion. This illusion was originally explained by lateral inhibition invoked by retinal ganglion cells, where the neural activity of centre-surround cells is lower at gridline intersections compared to non-intersections (Baumgartner, 1960). This explanation proved inadequate when variations of the illusion reduced or obliterated the illusory percept (Schiller and Carvey, 2005).

We successfully demonstrate that an exponential filter model is able to account for the majority of Hermann illusion variants and their diminished illusory effect. This model demonstrates performance on par with the best filtering models in predicting a large variety of lightness illusions, while reducing the required model parameter set, restoring spatial frequency characteristics found in natural images and demonstrating consistency with theories based on spatial frequency restoration (Zeman et al., 2015). Interestingly, exponential filters provide a good approximation for the oblique effect, where responses to stimuli aligned with cardinal axes are higher than those along obliques. Our model removes

the need for orientation selective filters and their associated weighting schemes. We show results for filters varying in size and shape, and we investigate the role of normalisation (using contrast gain control) in estimating perceptual responses to Hermann grid variants. Overall, we present a parsimonious, unifying account towards modelling lightness illusions, extending on the model's success in predicting a range of contrast and assimilation effects with evidence of its ability to handle oriented illusions.

Facial identity learning in the occipital face area

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In two TMS experiments, we have investigated the claim, supported by growing evidence, that the occipital face area (OFA), originally thought to be involved only in the construction of a low-level representation of the physical features of a face, is also necessary for the correct encoding of facial identity. First, we tested if the OFA is causally involved in the learning of novel face identities, using a sequential sorting – face matching paradigm, and found impaired identity acquisition when the activity of the rOFA was disturbed during learning. Second, in an old-new decision task, we contrasted the pictorial and the image-independent face representations to investigate to what extent the OFA is involved in these processes. We found that novel photographs of a previously seen identity were more often rated as old, when compared to previously seen images that were not of the identity, when the OFA was stimulated during the acquisition phase. Our results support the hypotheses that the role of the rOFA is not limited to the processing of low-level physical features, but has a significant causal role in face identity encoding and in the formation of identity-specific memory-traces. Further investigations are needed to describe the mechanisms underlying these processes.

Contrast, assimilation, and image segmentation in a cortical model of lightness and color computation

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University of Washington

Previous work has demonstrated that achromatic color perception in simple displays can be modeled by a process that spatially sums separate lightness and darkness induction signals generated by edges and gradients (Shapley & Reid, 1985; Rudd & Zemach, 2004; Galmonte et al., 2015). I have proposed a computational model of this process involving processing stages within the ventral stream of visual cortex (Rudd, 2014). Here, I extend this model to account for novel contrast and assimilation effects in more complex lightness and color displays. I first discuss a "found" color display – the 2016 U.S. Election Battleground Map – in which the yellow color of narrow hatched lines drawn within the border of the U.S. State of Nebraska appear to bleed into the surrounding red regions within the Nebraska borders. This phenomenon is an example of a larger category of color assimilation phenomena in which a comparatively large region surrounded by narrow borders tends to take on the color of the border. I argue here that such phenomena can be explained by the same principle of spatial summation of contrast induction signals that accounts for lightness in simple achromatic displays. I will then discuss some novel achromatic displays that I created by modifying White's Effect, which demonstrate that such assimilation effects are confined to regions that are first perceptually segmented by the visual system. I propose that this image segmentation occurs in cortical area V2, followed by a spatial integration of edge signals to compute lightness and color in area V4.

Do you see what I see? Inferring target trajectory from another's tracking movements

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UNSW Sydney

The human visual system contains specialized mechanisms for extracting the geometric focus of others' gaze. This capability is critical to typical development and social behavior, subserving visual orienting to salient aspects of the environment, the coordination of attention and behaviour between individuals, and our understanding of others' intentions and mental states. The sensory encoding of others' gaze entails neural mechanisms sensitive to eye deviation, binocular vergence, and head position, which together specify the depth and direction in which another individual is fixating. It is unknown, however, whether the brain exploits this type of social information to inform low-level visual perception. Here we show that the perceived depth and movement of physical objects in our environment are influenced by others' tracking behaviour. This effect occurred even in the presence of conflicting size cues to object location, and generalized to the context of apparent motion displays (i.e., inferences about the continuity of visual objects over successive images) and judgments about the causal interactions between moving objects. Perceived object trajectory was modulated primarily by coupling between the motion of the target object and the gross motion of the tracking agent (e.g., head rotation), with less pronounced effects of eye motion and local background motion. These results demonstrate that social information can have a fundamental effect on our vision, such that the visual reality constructed in each brain is determined in part by what others see.

Contrast based lexical decision in the parafovea

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While during natural sentence reading most words are being fixated at least once, some words are skipped completely and therefore must be processed solely based on parafoveal visual information obtained during fixations of nearby words. It is known that reducing visual stimulus qualities like letter-to-background contrast affects reading speed, but it is unclear whether or how this reduction can affect higher level processes like lexical identification. As we are specifically interested in parafoveal processing, we used a lexical decision task to investigate the psychometric function of letter contrast affecting the decision accuracy for a word or a word-like

nonword displayed to the right of a three letter x-string presented at the center of fixation, without imposing any time constraints for the task. Using a gaze contingent boundary paradigm, we ensured, that the stimulus was only visible parafoveally and was replaced with an x-string after the eyes first crossed a boundary located after the last letter of the fixated string. The decision accuracy increased as a function of contrast, suggesting that lexical processing of words in the parafovea is dependent on visual stimulus quality. We further explore interactions with word frequency, word length and decision speed.

Alexithymic, but not autistic, traits are associated with emotion adaptation

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Nanyang Technological University

Exposure to socially relevant emotion signals in the visual and auditory domains can alter our perception of subsequently presented facial emotion, the emotion aftereffect. What are the factors associated with this aftereffect in emotion processing? Here we tested whether levels of autistic or alexithymic traits were associated with such adaptation aftereffects in a neurotypical sample. Participants were adapted to either angry face or prosody before judging the emotion of fearful to angry morph continua test faces. They also completed alexithymia and autism quotient questionnaires. We found that increasing levels of alexithymia, but not autism, were associated with a heightened sensitivity for detecting fear in the test faces during a no adaptation baseline condition. In the auditory alone and cross-modal adaptation conditions, a multiple linear regression showed that alexithymic, but not autistic, traits were a significant predictor for increasingly smaller or negative adaptation aftereffects. However, neither trait was associated with visual emotion adaptation. These findings suggest that levels of alexithymia, but not autism, are linked to alterations in both emotion adaptation and identification. Alexithymic traits must affect high-level emotion processing but not necessarily low-level facial feature perception. The recently proposed alexithymia hypothesis for emotion processing seems to fit best with our data.

Inhibitory surrounds of motion mechanisms revealed by continuous tracking

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IRCCS Fondazione Stella Maris

There exists strong psychophysical and electrophysiological evidence for surround inhibition of motion mechanisms (Tadin et al, Nature 2003; Pack et al,J Neurophysiol 2011). The strength of the inhibition decreases with decreasing contrast, giving way to summation at low contrast, making it difficult to study with traditional contrast sensitivity techniques. Here we study surround inhibition with a new and efficient technique introduced by Bonnen et al (JOV 2015), where subjects track continuously the position of a stimulus on the screen, and their tracking accuracy calculated by correlating tracking and stimulus trajectories. We asked subjects to track the motion of a thin vertical grating (1x6°) drifting leftward or rightward (2 deg/sec) at random every 16 sec. The target was flanked above and below with vertical gratings of variable contrast, which drifted according to an independent random direction sequence. The cross-correlograms with target motion varied with the properties of the target stimulus, becoming broader and increasing latency at lower contrasts and higher spatial frequencies. When the response was correlated with the surround motion sequence (which subjects were asked to ignore), the correlation was as strong as with the target, but negative, implying surround inhibition. The inhibitory effect was maximal at high contrasts of target and surround, consistent with of Tadin et al's results. We conclude that the tracking technique has high potential for studying function and dysfunction of basic psychophysical functions.

Familiarity mediates face detection in natural scenes and can facilitate feature-based processing.

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University of Stirling

Face detection is pivotal to social interaction, yet factors mediating this process have received little attention in literature and remain poorly understood. Researchers to date have investigated the roles of viewpoint and colour on face detection, showing that frontal views of naturally coloured faces are most beneficial for detection in natural scenes. Another possible candidate for such a mediating factor is face familiarity. Specifically, familiar faces are recognised quickly and efficiently, but it is unclear whether familiarity plays a role in face detection in natural scenes and in non-face visual search arrays. This study examined the hypothesis that familiar faces "pop out" faster than unfamiliar ones which, in turn, may contribute to more efficient recognition. Across three experiments, we observed that viewers detect familiar faces with fewer errors and somewhat faster, but the speed of detection is not always independent of face orientation. Pertinently, the familiarity advantage was also present when faces were displayed upside down. Given that face inversion disrupts configural or holistic processing, this suggests that it is the featural aspects of a familiar face that enhance its detectability. Implications and future directions of this research are discussed.

Cognitive styles and visual signal detection task performance

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The high level of perceptual uncertainty is inherent to sensory tasks in psychophysical studies. Under these circumstances observer is enforced to overcome or compensate the deficit of sensory information in order to solve the task successfully. Thus, the solution of psychophysical tasks necessarily highlights individual differences in sensory performance. We suggest that cognitive styles (CS) regulate the way of task performance through the selection of appropriate tools and strategies. To analyse this issue we employed an experiment, where subjects performed a set of CS tests (measuring such CS as leveling-sharpening, equivalence range, augmenting-reducing, constricted-flexible control and focusing-scanning) as well as 'yes-no' visual signal

detection task. The experiment consisted of two series depending on the duration of stimulus presentation (90 and 60 ms), representing two difficulty levels of signal detection and hence the level of sensory uncertainty. We analysed sensory sensitivity and decision making criterion indices, RT and response confidence. Results revealed individual differences in sensory performance predicted by CS. Moreover, the contribution of CS differed according to task's difficulty level. We believe that changes in the level of stimuli uncertainty lead to the transformation of functional organ, or perceiving functional system (according to A. Leontiev, A. Ukhtomsky), including subject's available resources or strategies preferred, and relevant to conditions and demands of the particular task.

A model of configural processing for face detection

Carmine Gnolo, Mario Senden, Alessandro Grillini, Rainer Goebel

Brain Innovation

In the study of higher level vision it is most common to use experimental designs in which the stimuli are described with qualitative categories instead of formalized features. This limits the capability to describe the processes underlying specific high level visual tasks. How the face processing network works is still object of extensive research, and it would benefit from this novel investigation approach. With this study we wanted to model the features that the brain extracts from a stimulus in order to perform face detection. We decided to focus on the formalization of first order configural processing because the relative information is the only one that stays coherent in stimuli causing pareidolia. We designed our stimuli as a collection of 4 stylized face parts, simplified to rectangles. This limits the information represented to configural only. The position and alignment of all of the parts is univocally described by a 4x3 matrix. We defined a face prototype based on reciprocal properties between the face parts, instead of on a specific image (i.e. an average face). We then modeled a series of features measuring the intensity of different ways in which a specific configuration deviates from the prototype. Those features are directly computed from the matrix representing the stimulus using analytical geometry and trigonometry. This model achieves the objective to describe the configural properties with a mathematical model and shows several properties typical of face detection, among which invariance: to position, to size and to second order configural properties.

Metacognitive approach to deficits in suppression mechanisms of unwanted thoughts or memories

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There is still an ongoing debate on effectiveness of cognitive strategies to deal with unwanted intrusions and threatening information from our memories. In the context of processing unwanted thoughts or memories, the main goal of individual is to suppress undesired contents by keeping them out of consciousness. During the talk a metacognitive approach to suppression mechanism and its deficits will be presented. According to the metacognitive view of suppression, top-down control processes that manage memory and attention are needed to reduce the availability of unwanted contents to consciousness. The model also assumes that monitoring processes to handle with unwanted contents operate automatically in a bottom-up direction to maintain access to emotional-cognitive components. When the inhibitory mechanisms of top-down control are weakened, there is increase of monitoring to the undesirable level leading to more frequent experiences of intrusive thoughts or memories. The presentation will provide supportive evidence from empirical research and clinical studies that effective suppression depends on concordant co-operation of both metacognitive control and monitoring mechanisms in regulating behavior.

Best-worst scaling as an alternative to Likert ratings in face perception

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In face perception research, Likert scales are often used to measure participants' subjective impressions of stimuli. However, Likert scales have many well-documented issues, including inconsistent scale use between participants and across cultures, difficulty separating items and difficulty obtaining reliable ratings for special populations such as young children and people with intellectual disabilities. Here we investigate an alternative method of ranking stimuli, Best-Worst Scaling, for applicability to face perception research. In this method, participants are presented with subsets of stimuli from the set to be ranked and select the "best" and "worst" items from that subset. Stimuli appear in multiple sets, and responses across the sets are used to rank items relative to one another. This method has many benefits over Likert ratings: the forced choice nature of the task allows good separation of items, scores are relative and so can be compared cross-culturally, and the task is simple and intuitive. Here we present results from several large online samples comparing Likert ratings and best-worst scaling of several different facial attributes, suggesting that Best-Worst Scaling may be a useful alternative to Likert ratings in face perception research. This method may also be of use in other areas of perception research where participants are required to judge stimuli, particularly in large numbers.

Analysing the contents of visual short-term memory by classification images

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We used a new psychophysical reverse-correlation based approach to study what stimulus information is maintained in visual working memory (VWM), and investigate the mechanisms of the memory decay.

A signal-detection variant of a same-different change detection task was used. The stimulus consisted of circular (radius 2.5 or 5) array composed of 64 oriented Gabor elements. A probe stimulus where element orientations were random

was shown to the observer (n=18). After a blank retention interval (500, 1000 or 5000 milliseconds) a test stimulus was displayed, where either large (σ=9) or small (σ=46) Gaussian jitter was added to the probe orientations. The task was to indicate whether the orientations in the test stimulus were slightly or very different from the probe stimulus. A double-pass design where identical stimuli were shown twice in randomized order was used. Two stimulus densities were tested.

The memory performance decreased with retention time. Next, we estimated which parts of the stimulus are available in VWM as a function of retention time, by reverse-correlating the orientation jitter on each trial with the corresponding observer decision. These memory classification images show that VWM representation is limited, and item-based: only the 4-6 most central stimulus elements were weighted for decisions, irrespective of the physical stimulus size. Element weights decreased gradually over time, but the distribution of weights across the elements remained constant. Estimated internal-to-external noise ratio increased. These findings support the idea that memory decay is caused by accumulating random internal noise in the memory representations.

Effects of facial femininity/masculinity on the experience of beauty of male and female faces

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In the present sudy we evaluated the Evolutionary hypothesis which holds that the intensity of facial femininity/masculinity determines the experience of facial beauty. More specifically, this hypothesis predicts that the enlargement of eyes and mouth and diminishing of nose and chin will induce the beauty ratings of female faces, whereas the enlargement of chin will induce the beauty ratings of male faces. Stimulus set included the images of 6 male and 6 female original faces and their versions made by enlarging and diminishing the four face parts: eyes, nose, mouth and chin. Twelve participants of both genders rated the stimuli on six dimensions: Amazing, Arousing, Cute, Erotic, Clear and Elegant beauty. The results of the analysis of variance are in line with the Evolutionary hypothesis regarding the female faces: diminishing of the nose increased the ratings on all six dimensions, enlargment of the eyes increased the ratings on Arousing, Cute, Erotic and Elegant beauty, and enlargement of the mouth increased the ratings on Arousing beauty. Analyses failed to confirm the expectations regarding the male faces: diminishing of the chin increased the ratings on Cute, Erotic, Clear and Elegant beauty, diminishing of the nose increased the ratings on Arousing beauty and enlargment of the mouth increased the ratings on Clear beauty. These findings suggest the need for the reformulation of the Evolutionary hypothesis: the increase of femininity induces the increase of female facial beauty (as expected), but the increase of masculinity reduces the male facial beauty (as not expected).

Eye moves when memorizing overlapping scenes

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People are able to accurately memorize large number of scenes (Konkle et al.,2010). In our experiment, we studied how the memory accuracy and eye movements differ when we present repeatedly identical or overlapping stimuli. Our preselected images were divided into three segments and we present either two overlapping 66%-parts or an identical 66%-part twice. We presented 220 images for 3 s each and we measured eye movements using Eyelink II. After each 5 trials, we asked about an image patch (43% x 43%). The patches were selected either from unseen third of the presented image, from the seen image, or from the new image. We also tested the recognition in the end of the experiment. Behavioral results showed that participants were able to accurately recognize patches of seen images (percentage correct: 78%) or identify new patches (false alarm, FA: 17%), while they showed high FA rate for unseen patches (41%). The fixation durations in the second presentation were longer for identical images (273 vs 281 ms; $p < 0.001$), but not in the overlapping images ($p = 0.083$). In the later test trials, the duration of fixations was highest for the new patches (322 ms) followed by patches from the seen parts (308 ms) and unseen parts (298 ms). Our results suggest that although people are able to memorize large number of photographs, they show higher false alarm rate when queried about patches beyond the boundaries of the original image. Also, they fixate the novel patches longer.

Individual perception style determines not explicit but implicit memory effect.

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Not only explicit but also implicit memory has considerable influences to our daily life. However, it is still unclear whether or not implicit memory performance is sensitive to individual difference. Here, we investigated how individual perception style (global or local) correlates with implicit or explicit memory performance. In our study, participants viewed 17 movies of scenery from a car window (the average of movie length was 31 sec) and took an implicit or an explicit memory test. In the implicit memory test, participants were asked to tell about an associable word to 60 given words (e.g. "coffee" to <beverage>). In the explicit memory test, participants were asked whether or not they recognized the words as the objects presented in the movies. Also, all participants did Navon task (Navon, 1977) for checking each individual perception style, global- or local-style. As a result, we found that the performance of the implicit memory test in the local perception style people were higher than that in the global perception style people. On the other hand, there was no difference on the explicit memory test. This finding suggests that we can predict foresee some individual behaviors based on implicit memory, such as physical task and decision making, by knowing individual perception style.

Mona Lisa's happiness is by 35% in the eye of the beholder

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We investigated the influence of immediate and long-term memory on the perception of Mona Lisa's emotional face expression (high-level ambiguity) and of geometric Necker lattice stimuli (low-level ambiguity). We utilized the "perceptual hysteresis effect", which allows a quantification of memory influences. In Experiment 1 we created a series of nine Mona Lisa variants by a stepwise manipulation of the mouth curvature. In Experiment 2 we presented nine lattice variants differing in the back-layer's luminance. Each experiment consisted of two conditions with opposite orders of stimulus presentation. In a third condition stimuli were presented in a random sequence. Participants indicated happy or sad face percepts and alternative 3D lattice percepts by key presses. For both stimulus types and all conditions perception followed sigmoidal function. The sigmoid positions on the abscissa depended strongly on the presentation orders (hysteresis effect). In Experiment 1 (Mona Lisa) the sigmoid of the random condition was located in between the two ordered conditions. In Experiment 2 (Necker lattice) the sigmoid of the random condition was superimposed on one ordered condition. The sign of the hysteresis effects differed between stimulus types. Our results indicate both similarities and differences between high and low-level ambiguity. Perception of both Mona Lisa and the lattice stimuli can depend by up to 35% on perceptual memory. The direction of memory influence, however, was stimulus-driven (repulsion/adaptation for Mona Lisa and attraction/priming for the lattices), which may be explained by either the duration of stimulus presentation or by stimulus complexity.

Design of a novel audio game to study spatial memory in visually impaired children

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Spatial memory relies on the capability to encode, store and retrieve knowledge about localizations of objects in the environment. In sighted individuals it is mainly based on the visual experience. In case of blindness the tactile and audio spatial memory is essential. However, to date, most of spatial memory tests and games are not useful for blind people. In collaboration with rehabilitators, we implemented an audio memory test, in the form of a game, to study and improve spatial memory skills in both sighted and visually impaired children. blind and sighted teenagers (9-16 years) were involved in the study. The task was to find pairs among sounds displaced on a surface composed of 25 loudspeakers covered by tactile sensors. Sound stimuli had a semantic meaning (animal sounds). To test the ability to remember stimuli positions, we varied the number of sound sources. 4 and 12 sound pairs were presented in first and second set respectively. After each correct response, selected speakers were covered with cardboards. To evaluate subjects' performance, three parameters were analyzed: time employed to complete the test, score and number of attempts. While both groups performed equally well in the 4-pairs task, in the 12-pairs task, blind participants tended to perform worse. They finished the task in longer time with more attempts, reaching a lower score. These results support the hypothesis that lack of early visual experience influences the ability to construct complex spatial representations and to chart all locations into a unified cognitive map.

Biological motion cues aid identification of self-motion from optic flow but not heading detection

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When we move through the world, a pattern of expanding optic flow is generated on the retina. In completely rigid environments, this pattern signals one's direction of heading and is thus an important source of information for navigation. When we walk towards an oncoming person, however, the optic environment is not rigid, as the motion vectors generated by the other person represent an ambiguous composite of that person's movement, his or her limb motion and the observer's self-motion. Though this biological motion obfuscates the optic flow pattern, it also provides cues about the movement of other actors in the environment. It may be the case that the visual system takes advantage of these cues to simplify the decomposition of optic flow in the presence of other moving people. The current study sought to probe this possibility. In two experiments self-motion was simulated through an environment that was empty except for a single walking point-light biological motion stimulus. We found that by using biological motion cues, observers were able to identify the presence of self-motion despite the lack of stable scene information. Heading estimates, on the other hand, reflected an approximate combination of self-motion and the motion direction of the oncoming walker. These results suggest that though biological motion can be used to disentangle self-motion in ambiguous situations, optic flow analysis does not use this information to derive heading estimates.

The dynamic coding of visual relative-frequency

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People distort probability or relative-frequency in a variety of tasks in a stereotyped pattern: small probability overestimated and large probability underestimated. Here we used a visual relative-frequency judgment task to investigate whether the distortion reflects a coding mechanism that adapts to the environmental statistics. Methods. The task was to report the relative-frequency of black (or white) dots in a display of black and white dots, for 693 trials. The objective relative-frequencies were sampled from four possible distributions (16 subjects per condition): uniform between 0.01 and 0.99, higher density for low (below 0.11) relative-frequencies, higher density for high (above 0.89) relative-frequencies, and higher density for both low and high

relative-frequencies. For the reported relative-frequency, we quantified its deviation from the objective relative-frequency and compared the resulting distortion of relative-frequency across the four distribution conditions. We also modeled how the pattern of distortion might vary from trial to trial. Results. (1) In all conditions, subjects overestimated small and underestimated large relative-frequencies, as typically found. (2) The pattern of distortion changed with the distribution of relative-frequencies, but in the reverse direction as Bayesian inference would predict: a greater overestimation of small relative-frequencies for a higher density of small relative-frequencies, and a greater underestimation of large relative-frequencies for a higher density of large relative-frequencies. (3) These effects could be accounted by a non-linear dependency of the current trial on the recent history of stimuli and responses. Conclusion. The coding of relative-frequency adapts to the environmental statistics trial by trial via non-linear inter-trial interactions.

Does the discrimination of speed depend on dedicated 'comparator units'?

Marina Danilova & John Mollon

How well can visual stimuli be compared when they fall at different, widely separated, positions in the visual field? What could be the neural basis for such comparisons? These theoretically interesting questions are seldom asked.

In the present experiments, we measured thresholds for comparing speed in two concurrently presented patches of random moving dots that were juxtaposed or were spatially separated by up to 10 degrees (while remaining at constant eccentricity). Presentations were too brief to allow eye movements. The discrimination of speed was measured by a two-alternative forced choice: one of the patches, chosen randomly, consisted of red dots and the other of green dots of equal luminance; and the observer indicated which dots moved faster.

There was rather little variation in thresholds with spatial separation. This was the case whether the motion was in the same direction in the two patches, was in opposite directions or was in orthogonal directions. An absolute judgement control showed that observers were actively comparing the two patches.

Since there is little deterioration of discrimination at large separations (as we have previously found for discrimination of spatial frequency), it is implausible that performance depends on dedicated 'comparator neurons', i.e. higher-order cells which would draw inputs from pairs of lower-order cells that signaled speed in local retinal regions: such model would require an unlikely bulk of neurons and white matter. We postulate a 'cerebral bus' that carries abstract representations of separated stimuli.

Deficit in the delayed visuospatial memory in ADHD children

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Ural Federal University

Objective: the goal of this research was to examine the hypothesis that children with ADHD have a deficit in the delayed visuospatial memory. Participants and Methods: the experimental group included 24 children with ADHD at the age 6–7. The control group included 24 typically developing children. The children from experimental and control group were matched for IQ, sex and age. Children from both groups were assessed with the Rey-Osterieth Complex Figure in Copy, Immediate and Delayed Recall conditions. Results: two-way ANOVA was used to reveal group differences in reproducing the Rey-Osterieth Complex Figure in different conditions. We have not revealed significant differences ($p<.05$) between children from experimental and control group in reproducing the Rey-Osterieth Complex Figure in Copy and Immediate conditions. However, children with ADHD had weakness in the accurate reproduction and placement of specific design elements of Rey-Osterieth Complex Figure in Delayed Recall condition. Conclusion: in view of the obtained results, it can be assumed that children with ADHD have specific deficit in the delayed visuospatial memory. Funding: The research was supported by Act 211 Government of the Russian Federation, agreement 02.A03.21.0006

Investigation of high-frequency transcranial random noise stimulation (hf-tRNS) mechanism on visual motion perception: A stochastic resonance approach.

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High-frequency transcranial random noise stimulation (hf-tRNS) is a neuromodulatory technique consisting of the application of an alternating current at random frequencies ranging between 101 and 640 Hz.

Stochastic resonance is a nonlinear phenomenon whereby the addition of a random interference "noise" can enhance the detection or discrimination of a weak signal. An optimal amount of noise result in performance enhancement, whereas further noise increments impair the signal detection or discrimination.

hf-tRNS induces random activity in the system (i.e., hf-tRNS-induced noise) that may serve as a pedestal to boost the sensitivity of neurons to weak inputs, thus increasing the signal-to-noise ratio. On the contrary, either a lower or higher current intensity than the optimal level may produce no modulation or even impair the performance.

In this study observers performed a two-interval forced choice motion direction discrimination task in which they had to report whether two moving patches presented in two intervals had the same or different motion directions. The aim of the study was to assess the effects of different hf-tRNS intensities (No-stimulation, 0.5, 0.75, 1.0, 1.5 and 2.25 mA) administered in separate sessions.

The results show a significant improvement in performance for 1mA (M=64.5% [SEM=1.73%]) and 1.5 mA (M=64.1%

[SEM=1.18%]) with respect to the No-stimulation condition (M=60.3% [SEM=0.26%]) and a significant impairment of the performance for 2.25 mA (M=56.8% [SEM=1.35%]).

These results suggest that hf-tRNS-induced noise might modulate the signal-to-noise ratio in a way compatible with the stochastic resonance phenomenon

Expertise and recognition memory for aerial photographs

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Aerial photographs depict objects from an overhead position, which gives them some unusual visual characteristics that are challenging for viewers to perceive and memorize. However, even for untrained viewers, aerial photographs are still meaningful and rich with contextual information. Such properties of the visual stimulus are considered appropriate and necessary when testing for expertise effects in visual recognition memory. The experiment investigated memory recognition of expert image analysts and untrained viewers using two types of aerial photographs: vertical photographs and oblique photographs, which established a baseline reference. Experts were better than untrained viewers at recognizing images from their domain. The difference in performance between the subject groups in favor of the experts was more pronounced when a detailed visual memory going beyond remembering the gist of an image was required. In comparison, the intergroup difference was not larger for vertical photographs than for oblique photographs. The present study provides rich data on how expertise may facilitate memory performance.

A sparse coding model of MST can account for human heading perception in the presence of eye movements

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Humans use visual cues from the relative movement between observer and the environment ("optic flow") to judge their direction of self-movement ("heading") during navigation. In particular, human and nonhuman primates can discriminate heading angles as small as 1° away from straight-ahead. However, discrimination thresholds rise precipitously in the presence of eye movements, or when subjects judge small variations in heading with respect to an eccentric heading reference. The neural basis of these findings is thought to involve the dorsal superior medial temporal area (MSTd), where neurons are tuned to complex patterns of optic flow that result from observer translations and rotations in a 3D world. Here we present a computational model of MSTd that can account for these findings. The model is based on the hypothesis that neurons in MSTd efficiently encode the continuum of optic flow patterns encountered during self-movement on the basis of inputs received from neurons in the middle temporal area (MT). We show that the model can predict behavioral thresholds of heading discrimination and heading perception during eye movements using a sparse, distributed code. In addition, the model can account for several essential response properties of neurons in macaque MSTd, ranging from single-unit activity (e.g., 3D translation and rotation selectivity) to population statistics (e.g., an over-representation of lateral headings). Our findings support the notion that MSTd might form the neural basis of heading perception by encoding multiple self-motion related variables (e.g., heading and eye rotation velocity) without relying on specialized subpopulations.

Can cognitive brain function be quantitatively evaluated by event-related fNIRS measurement?

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The objective of this study is to establish a quantitative evaluation method of cognitive brain functions by fNIRS measurement based on the event-related design experiments to reduce artifacts of skin blood flow due to body movements. For the sake of measuring brain function, fMRI or PET has been usually used. This kind of equipment needs a higher cost and a large amount of space so it is difficult to install in rural area's facility. On the other hand, functional near-infrared spectroscopy (fNIRS) is a potential candidate for use as a noninvasive and relatively inexpensive brain function measurement instrument. However, since the spatial resolution of fNIRS is lower than fMRI, and there are fundamental disadvantages such as artifacts of fluctuation of skin blood flow, improvement of experimental methods and analysis methods for using fNIRS is needed. We measured fNIRS signals while subjects were completing Posner type tasks to control their attention foci, and analyzed event-related activations which relate to attention allocation. The results show that activations occurred around the temporal parietal junction when undergoing interrupt processing to detect the targets presented at unpredicted places. They are consistent with a result of conventional fMRI study (Corbetta et al., 2000). At the same time, the effects of interrupt reduced under the condition in which the cue has multiple meanings. These results suggest that the higher-order brain functions, such as attention, are able to be evaluated from the fNIRS signal based on the event-related design experiments.

Evaluation of a distortion induced motion aftereffect - psychophysics and modelling

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Problem. Spatial geometrical distortions are often induced as artefacts in optical utilities, such as spectacles. Image skew is the prominent among those distortions. It shifts the motion direction of a moving stimulus towards the skewing direction. During habituation to spectacles, wearers report vanishing of disturbing distortions. We hypothesize that neural adaptation to distortion induced alterations of motion contributes to the habituation process. We report psychophysical and modelling results about the mechanisms underlying this adaptation effect. Method. A MAE was

tested with a constant stimulus procedure in nine observers. After adaptation to skewed natural image sequences, observers identified if random dots were moving diagonally upward or downward. The point of subjective equality (random dot motion direction that is perceived as horizontal) was shifted to the adapted skew direction. Inspired by a previously proposed neural model of cortical motion processing (Bayerl & Neumann, 2004), we suggest a dynamic mechanism which might constitute the observed distortion induced MAE. Motion direction processing in areas V1 and MT was modeled together with a population response readout decision layer. We suggest a dynamic short-term synaptic plasticity mechanism within feedforward and feedback pathways between V1 and MT units to realize motion direction adaptation. Results and Conclusion. Visual adjustments in motion perception partake in the process of habituation to geometrical distortions. The experimental results demonstrate that this effect varies parametrically with the direction of the skew adaptation stimulus. Our model qualitatively predicts visual adjustments in the processing of random dot motion after the natural stimuli induced motion adaptation.

Memory for past decision variables biases current perceptual choice

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Perceptual decision-making is biased by previous events, including the history of preceding choices: Observers tend to repeat (or alternate) their choices more often than expected by chance. We present results indicating that such sequential choice biases result from active memory for action-independent, internal decision variables. Human observers performed different variants of a visual motion discrimination task around psychophysical threshold. First, we decoupled perceptual choices and motor responses on a trial-by-trial basis, to disentangle their relative contributions to sequential biases. The impact of previous choices outweighed the impact of previous motor responses. Second, observers performed the task in both random and biased environments (containing systematic tendencies towards either repetition or alternation of motion directions) and in the absence of external feedback about the correctness of their choices. Observers adapted their sequential choice biases to the biased environmental statistics, in a way that indicated active memory for previous choices and predicted their overall performance. We further found that this adaptation was reduced by the uncertainty about previous choices, consistent with the idea that decision variables driving choice encode both the categorical choice, as well as the graded uncertainty associated with it. Taken together, our results are consistent with the idea that high-level decision variables, dissociable from sensory input and motor output, are accumulated across choices towards biases for upcoming choices.

Effects of velocity- and position-based cues on horizontal vergence using different forms of motion in depth

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The perception of motion-in-depth (MID) can be elicited by two types of binocular stimuli (changes of disparity over time (CD) or inter-ocular velocity differences (IOVD)) both of which could, potentially, generate directed vergence eye movements. Here, we describe experiments designed to dissociate the contributions of CD and IOVD to eye vergence by varying the availability of velocity information using step and ramp motion and the cue type (IOVD, CD or 'FULL cue') present in random dot stereograms (RDS) displayed on a passive 3D display. Vergence eye movements were recorded using an Eyelink II in response to four types of MID cue: anticorrelated 'aIOVD' (in which dots are paired binocularly but have opposite polarity), decorrelated 'dIOVD' (in which dots are unpaired between eyes), CD stimuli (using dynamic RDS to eliminate IOVD cues) or stimuli that contained both cue types (FULL). We found that CD stimuli generated reliable and veridical vergence responses in both the 'step' and 'ramp' conditions: the percentage of correct vergence response direction was always close to 100% for CD and FULL. In comparison, vergence response direction was at chance for all dIOVD stimuli and was also at chance for 'ramped' aIOVD stimuli. Finally, we found that aIOVD 'step' motion generated a non-random vergence response that was less reliable than those generated by CD or FULL. We hypothesise that under our conditions IOVD has very little input to vergence mechanisms and that the weak vergence responses generated by aIOVD stimuli are due to residual disparity cues.

Intermittent overt choice alters the temporal weighting of sensory evidence in a continuous visual estimation task

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Perceptual inference does not only depend on sensory evidence, but also on top-down factors. One of these is categorical perceptual choice, which might alter subsequent inference in a top-down fashion. Here, we tested the impact of overt perceptual choices on the integration of subsequent sensory evidence into continuous estimation reports. Observers made a continuous estimation of the average motion direction across two intervals of random dot motion. In addition, an unpredictable auditory cue at the offset of the first interval prompted the observers for a response (button press) halfway through the stream: a fine discrimination judgment based on the first interval of dot motion ('choice-trials'), or an evidence-independent response ('no-choice trials').

We observed larger pupil dilations in choice trials over no-choice trials after the intermittent response, in line with phasic release of neuromodulators at the time of choice (de Gee et al, eLife, 2017). Choice trials showed a greater influence of first interval ('primacy') while no-choice trials showed a greater influence of second interval ('recency') on the final estimations. With roughly equal total weight awarded to the evidence stream, overt intermittent choice biased subjects towards primacy by reducing the sensitivity to subsequent evidence.

Consistent with recent findings from a higher-level numerical estimation task (Bronfman et al, Proc R Soc B Biol Sci, 2015),

our results suggest that overt categorical choices render perceptual inference less sensitive to additional evidence. This is in line with a low-level form of confirmation bias in perceptual decision-making.

Multisensory integration of object sonification and self-motion cues for navigation in darkness

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University of Bath

In the absence of visual input, sensory substitution devices can be used to replace this modality; however, the efficiency of their integration with self-motion is unknown, thus limiting our understanding of how efficient these devices are in replacing vision during everyday navigation tasks. We examined whether 24 blindfolded sighted individuals could use the new vision-to-sound information provided by the vOICe in three different conditions when learning the location of three objects. In the vOICe alone condition participants only scanned the environment, in the self-motion alone condition they were guided to the object positions, and in the combined condition they could use both cues. After the learning participants walked to the position of a target object in darkness either using an egocentric representation (relatively to their position), or an allocentric representation (relatively to another object) for a total of 60 navigation trials. 3D motion data from participants were collected to determine measures of navigation accuracy and precision. Participants were more accurate and precise in egocentric navigation and performance with the vOICe was as good as that for self-motion. An increase in precision for the combined condition was observed in the allocentric task. Participants' accuracy increased with trial number for the vOICe condition, but not the self-motion condition, in both tasks. Our findings suggest the vOICe is effective in replacing vision in spatial navigation tasks after a short training and that its information may be integrated with self-motion in real life navigation, with clear implications for the visually impaired.

How do we discriminate the speed of looming?

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Extensive research has investigated speed discrimination performance. It is difficult to rule out the role of distance and duration cues in speed discrimination: previous designs have typically used partial randomisation of distance/duration and careful analysis of the subsequent pattern of performance to do this. Here, we explore speed discrimination of looming, where objects undergo constant speed in the three-dimensional world, and compare conditions where observers cannot use duration or distance information with those where they can. In the first condition, observers identified which of two intervals contained a change in speed. The distance and duration of the looming stimuli were kept constant here. In the second condition participants completed a standard 2IFC speed discrimination task with either distance fixed or duration fixed, so that either duration or distance could be used to perform the task. Observers were instructed to pick which stimulus moved faster. "Catch" trials were included to help identify which cues observers used to perform the task. We found that thresholds for the speed change task were much higher than those for the fixed distance and fixed duration speed discrimination tasks (18.9cm/s in depth, 10.2cm/s in depth and 11.1cm/s in depth respectively). Furthermore, the catch trials indicated that some participants were not using speed for the discrimination tasks. We will discuss the extent to which observers may be using distance, duration, or speed cues to perform the speed discrimination task.

Functional tuning for auditory motion direction in hMT+/v5 of sighted and blind individuals

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The middle temporal visual area (hMT+/V5) is a region of extrastriate occipital cortex that contains neurons coding for visual motion direction. Even if this region has been traditionally considered as purely visual, recent studies have suggested that part of the hMT+/V5 complex could also selectively respond to auditory motion in blind and even sighted people. In our study, we characterized the brain activity of sighted and blind individuals listening to left, right, up and down moving and static sounds. To create a vivid and ecological sensation of sound location/motion in external space, we relied on individual in-ear stereo recordings that were re-played to the participants when they were inside fMRI. Whole-brain univariate results revealed that in addition to a dorsal fronto-temporo-parietal network, selectivity for auditory motion was observed in both blind and sighted in the anterior portion of the middle temporal gyrus. In contrast, more posterior middle temporal regions showed stronger auditory motion selectivity in the blind group, overlapping with regions selective for visual motion as independently localized in the sighted. Importantly, we were able to decode auditory motion direction in visually defined hMT+/V5 in both groups, but significantly more in blinds. Moreover, early blinds showed higher correlation between decoding accuracy in this region and the behavioral ability to discriminate auditory motion direction. All together, those results demonstrate that hMT+/V5 participate in processing auditory motion direction in both sighed and blind groups, but that functional tuning extends more posteriorly in case of early visual deprivation.

A mechanism for integration of visual speed

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The estimation of the speed and the visual tracking of moving prey or threatening dangers is essential for the survival of many animal species. In primates, speed is believed to be represented by a set of channels sensitive to different spatial and temporal characteristics of the optic flow. It is not yet clearly understood how motion signals detected through different spatiotemporal frequency channels are integrated together to estimate speed.

Using psychophysical and computational methods, we show that speed integration, at the level of the global percept, involves a complex interaction between different speeds and scales. When presented with a complex stimulus that simultaneously activates multiple spatiotemporal channels, the activity in a given channel is both enhanced and reduced following a systematic pattern over neighboring channels. This pattern of interaction can be decomposed into two parts. One over speed, consistent with a slow-speed prior, and the other over scale, which accounts for sharpening of similar features. Interestingly, the interaction over scale involves lateral inhibition, a canonical principle commonly found in early sensory interactions. Our results from psychophysics and ocular following responses suggest that such a normalization mechanism may reflect the natural tendency of the visual system to integrate diverging stimuli into one coherent percept with interaction parameters having some task dependence.

Tactile enumeration and brain plasticity in acalculia

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The ability to enumerate is one of the building blocks of arithmetic and fingers are used in the early steps of this process. We explored tactile enumeration with fingers as the input surface, and voxel-based morphometry (VBM) to study gray matter (GM) changes of an acalculic participant—NO, a 22-year-old female with acalculia following a stroke to the left intraparietal sulcus (IPS). NO and neurologically healthy controls reported how many fingers were stimulated. NO was tested four times: one month after the infarct (acute phase), two months, six months and eighteen months later. For the sensory intact hand, the RT slope of enumerating up to four stimuli was significantly steeper than that of controls but this difference gradually diminished over time. NO performed poorer than controls when enumerating stimuli applied to neighboring fingers in the acute phase. VBM analysis of the acute phase and six months later showed larger GM volume for NO relative to controls in the right inferior occipital cortex. Importantly, for NO, the concentration of GM significantly increased from the acute phase to six months later. NO's tactile performance provides a first glance of tactile enumeration during acalculia. Deficit in tactile enumeration and the subsequent recovery suggests subitizing (and not counting) is the basic tactile enumeration process using one hand. Moreover, GM increase in the inferior occipital cortex, which is a multisensory object recognition and visual magnitude area, suggests that NO's recovery is based on plasticity changes that involve the primitive "sense of magnitude" system.

Attention restoration theory in motion: Is gait impacted differently by visual exposure to natural and urban environments?

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Exposure to urban environments as opposed to nature has been proposed to negatively impact attention restoration due to higher demands on directed attention in built environments, an effect that can even be observed when simply looking at photographs (Berman et al., 2009). Here we tested whether images of natural and urban environments impact differentially on gait, as gait tends to slow with increasing cognitive load (Amboni et al., 2013), and if they do, whether their image statistics (Fourier transforms) and related visual discomfort ratings contribute towards this effect. Gait parameters of twenty participants were measured with 3D-motion capture while participants repeatedly walked down a 15m long laboratory, viewing and rating for discomfort images projected to the back wall. Each participant did 105 walks with images presented one per walk in randomised order (50 urban, 50 natural and 5 neutral/medium-grey). Viewing urban images was associated with a significant decrease in average step length and reduced velocity as compared to natural and neutral images. While images statistics (as deviation from 1 over f) correlated significantly with subjective (dis)comfort, image statistics did not predict changes in step length. However, an increased subjective visual (dis)comfort score was predictive of decreased average step length for the corresponding image. This study suggests that, indeed, viewing different environments directly affects walking style. However, it remains unclear whether this effect is caused by visual characteristics, semantic associations related to different image types, or the discomfort rating task used.

Where am I? Pointing to myself and body parts in virtual reality

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Where do people experience themselves and their body parts to be? It seems obvious that we are located where our bodies are. However, it is not a given, whether we associate our location with specific part(s) of our body. In one study where they were asked to directly point at themselves, people most frequently stopped a physical pointer at upper face and upper torso (Alsmith and Longo, 2014). This suggests, they experienced themselves not homogeneously spread out over their bodies, nor in a single bodily location, but rather in these two distinct regions. To investigate the robustness of these findings, we asked participants to point directly at themselves and nine different body parts, in two

virtual reality (VR) setups (VR headset and large immersive screen). Investigating in VR provides strong experimental control, specifically the possibility to manipulate visual and body-based cues about the body separately. For pointing at self, we found frequent pointing at all body regions above mid-torso, as well as above the head. For many of their body parts people were pointing remarkably accurately. However, when pointing at knees, feet and top of the head, participants were not very exact, especially in the VR headset (without visual access to the body). However, when normalizing pointing to self by indicators of how participants may perceive their body part locations in VR, the pattern found for pointing at self interestingly changes, such that it resembles more the pointing to self in the physical setup (mainly face and upper torso).

Effects of perceptual grouping on apparent sliding motion

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It has been accepted that the apparent sliding motion perceived in an array of square-shaped checks made up of black and white L-shaped parts, must be caused by the difference in the orientation of implicit diagonals of the L-shaped parts in the central area and in the surround (Pinna and Spillman, 2005). However, the differences in magnitude of apparent sliding motion are difficult to be proved by the implicit diagonals alone. Takahashi and Yukumatsu (2016) showed that even when the implicit diagonals were the same, stronger apparent sliding motion was perceived to depend on the angle between two sides of L-shaped part, the distance and the configuration, between L-shaped parts. In order to investigate these results, we studied the role of the perceptual grouping in the central area. We manipulated the frame which demarcated the central area, the ratio of noise elements, and the spatial arrangement of the noise. The results of magnitude of apparent sliding motion showed that stronger sliding motion was perceived when the central area was surrounded by the frame (closure) and, also when noise elements were absent (common fate). These suggest that the perceptual grouping on the basis of figure-ground segregation enhances the perception of apparent sliding motion. Besides, the negative effect of noise was found to depend on the spatial arrangement. From this, it is presumed that the local motion signals on the border of the central area integrate the whole central area based on the motion capture inside the border.

Cross-modal size-contrast illusion: Hearing sounds of increasing intensity leads to underestimation of object size by touch

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Changes in the size of objects in the visual field are a crucial cue to the observer's motion in the environment: Increases in size indicate their forward motion whereas decreases indicate their backward motion. In this study, a series of six images each comprising a pair of pine-tree figures were translated into auditory dimension using the vOICe, a software developed to assist the blind by converting visual scenes to sounds. Resulting auditory stimuli were either presented in an ascending sequence (i.e. increasing in intensity and bandwidth conveying a pair of pine trees becoming larger in the visual field), descending sequence (i.e. decreasing in intensity and bandwidth conveying a pair of pine trees becoming smaller in the visual field), or in a scrambled order. During the presentation of the auditory stimuli, blindfolded participants were asked to estimate the lengths of wooden sticks by tactile exploration. Results showed that those who listened to the auditory stimuli compatible with their forward motion underestimated the lengths of the sticks. The constant underestimation observed here may share some aspects with the dynamic Ebbinghaus illusion (Mruczek et al. 2015) where an object surrounded by others increasing in size is perceived to be smaller than that surrounded by others of a constant size. In contrast, participants in the other two conditions did not show such consistent error in size estimation. This is consistent with the "adaptive perceptual bias (Neuhoff 1998)" for acoustic increases in intensity and eccentricity as their sources can potentially be threatening.

Vection perception across different display types: Wider, higher, stronger?

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We tested whether the perception of illusory self-motion, known as vection, is modulated by the display type used to present the vection-inducing stimuli. Alternating black and white moving bars were presented on four different display types in randomized order: (1) large field of view dome projection, (2) combination of three computer screens, (3) single computer screen, (4) large field of view flat projection screen. In addition, the individual level of field dependence was measured, indicating the person's tendency to rely on external spatial cues. Thirty healthy adults (age range 18-45 years) participated in the study. Participants rated the level of perceived vection with respect to intensity, onset time, and duration; each participant was exposed to every display type. All four display types successfully generated vection, with strongest vection (i.e., shortest onset time, longest duration, and strongest intensity) obtained for the dome projection. However, the combination of three screens induced vection that was comparable to the dome projection. The other two display types resulted in significantly lower vection ratings. Additionally, field dependency modulated vection: For the dome projection, vection ratings were stronger in field dependent participants. In contrast, no group differences were obtained in the other three display types. Our findings suggest that vection can be effectively induced using rather simple display settings such as a combination of three screens. Furthermore, our results also indicate that personal trait factors can affect vection perception. We showed that field dependence is a promising area for future research.

The effect of visual content cues on auditory N1 and P2 ERPs

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Studies have shown that the N1 and P2 auditory event-related potentials (ERPs) that occur to a speech sound when the talker can be seen (i.e., Auditory-Visual speech) occur early and are reduced in amplitude compared to when the talker cannot be seen (auditory-only speech). An explanation for why seeing the talker changes the brain's response to sound is that visual speech provides information about the upcoming auditory speech event. This information reduces uncertainty about when the sound will occur (resulting in a smaller N1, a neural marker associated with event onset) and about what the event will be (resulting in a smaller P2, a marker associated with stimulus classification). It has yet to be determined whether form information alone can influence the amplitude or timing of P2. We tested this by contrasting ERPs to auditory speech preceded by print cues presenting reliable information about their content (written "ba" or "da" shown before these spoken syllables), or to control cues (meaningless printed symbols). No difference in the amplitude or timing of P2 (or N1) ERPs to the reliable print versus the control cues was found. A follow-up experiment confirmed that the presentation of visual speech produced the expected effect. We interpret the null effect of print cues in terms of the importance of the temporal relationship between visual and auditory events.

Suprathreshold contrast summation of motion direction signals

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Previous research has found that summation of luminance contrast over area for motion detection and discrimination is diminished, or lost, at high contrast. Meese and Summers (2007) introduced a technique allowing suprathreshold summation to be measured when the target size does not co-vary with pedestal size and showed strong summation of luminance contrast for static grating patterns at suprathreshold. The limited summation in previous studies was suggested to be a result of suppression from gain-control mechanisms which increases as pedestal size increases. This study used a similar technique to determine whether motion summation can also be demonstrated at suprathreshold contrast levels. Target contrast increments were applied to either the entire pedestal (20% contrast), or in the configuration of a checkerboard pattern (Battenberg stimuli) in which the target increment was applied to every alternate region. The sizes of the checks making up the fixed-size pattern were varied to measure summation behavior. Sensitivity to the full pedestal increment, measured using an adaptive staircase in a 2IFC procedure, was significantly higher than that for Battenbergs, indicating areal summation. Two observers showed strong summation across all check sizes (0.71°-3.33°), and for two other observers the summation ratio dropped to levels consistent with probability summation once check size reached 2.00°. Therefore, areal summation with moving targets does operate at high contrast, and is subserved by relatively large receptive fields covering a square area of at least 2.00° x 2.00°, but this can extend up to at least 3.33° x 3.33° for some observers.

The facilitation and inhibition of vection by wind of hot and normal temperature

Kayoko Murata & Takeharu Seno

When a person inside a stationary train observes a train on an adjacent track beginning to move, she or he could perceive that it is their own train that is moving in the opposite direction. This phenomenon is known as the 'train illusion'. This is a kind of vection (self-motion perception). Multiple sensory modalities, such as vision, audition and vestibule, contribute to the perception of self-motion (Gibson, 1966). Murata et al. (2014) found a new type of self-motion elicited by cutaneous sensation which accompanied vestibular inputs. Visually induced self-motion could be enhanced by a consistent wind to the faces of the observers (Seno et al., 2011). The present study examined whether a cutaneous cue suggesting forward self-motion facilitated or inhibited vection. Optic flow stimuli were created by positioning 16000 dots at random inside a simulated cube (side length 20 m), and moving the observer's viewpoint to simulate forward self-motion of 16 m/s. We provided an air flow to subjects' faces by using a bladeless fan. Wind speed was 5m/s. There were two conditions in wind temperature, i.e. hot and normal temperatures (37□ and 24□). Normal temperature was room temperature. And No wind condition was adopted as control condition. Onset latency, accumulative duration and rating of subjective strength (0-100) were measured. One-way ANOVA revealed significant differences in all indexes. Vection strength was increased by the air flow of normal temperature but it was inhibited when the wind was hot.

When vision is more emotionally loaded than music – the impact of visual-acoustic congruencies in films on emotional assessments

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Pavlović and Marković (2011) investigated how the emotional evaluation of visual information (film scenes) can be influenced by auditory information (music). In a pre-study, participants had to choose one of eight emotions (joy-sadness, anticipation-surprise, fear-anger, acceptance-disgust) and according to their matching results, film and music excerpts were chosen for the main study. Four film-music combinations were congruent (e.g., fearful film, fearful music), four incongruent (e.g., fearful film, angry music). Results showed that visual information had a greater impact on emotional ratings than auditory information for all emotions except for fear. There were also modulation effects dependent on the emotional quality (e.g., joyful music reduces sadness of sad film). Since in the original study, emotions were only validly matched for joy-sadness and fear-anger stimuli, the present study focused only on these emotional pairs. Participants had to choose quality and respective intensity of each emotion in the pre-study (for selecting strong emotional stimuli) as well as the main study. 40 participants perceived sad films combined with sad music as being sadder than sad films combined with joyful music. The least sad combination was joyful films combined with sad music (similar results for fear-anger). Therefore - with regard to the used material -, the visual channel seems to be dominant for

emotional perception (regardless of the emotional quality), although auditory information and congruency play an important role.

Memorable pictures are more recognizable in ultra-fast RSVP

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Memory performance for some natural scenes is consistently better than for others, irrespective of the observer (Isola, Xiao, Parikh, Torralba, & Oliva, 2014). Previous work has largely examined which features (e.g., indoor scenes, people) are most predictive of a picture's long-term memorability (e.g., Khosla et al, 2015). It is currently unknown whether pictures that differ in how well they can be remembered also differ in how well they can be perceived. To this end, we compared recognition and short-term memory performance between images that had been classified as memorable or non-memorable in a previous study (Isola et al, 2014). Participants viewed memorable and non-memorable pictures they had never seen before that were presented for 13 to 360 ms per picture in rapid serial visual presentation (RSVP) sequences. In half the trials, one of the pictures was a memorable or a non-memorable picture and perception of this picture was probed by a visual recognition test at the end of the sequence. Recognition for memorable pictures was higher than for non-memorable pictures and this difference increased with increasing duration. Recognition performance for non-memorable pictures was low for short durations, did not increase until 120 ms, and never caught up with recognition performance for memorable pictures. These findings suggest that long-term memorability of an image may be associated with initial perceptibility: a picture that is hard to grasp quickly is hard to remember later.

The effect of consistency of wind speed and transfer speed on cutaneous vection

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When observing a train on a next track beginning to move from a stationary train, one could feel that it is her or his own train that is moving in the opposite direction. This phenomenon is known as the 'train illusion'. This is a kind of vection (self-motion perception). Perceived self-motion has been mainly investigated in vision. But, multiple sensory modalities contribute to the perception of self-motion (Gibson, 1966). Murata et al. (2014) reported the wind for cutaneous sensation with vibration for vestibule also occurred perceived self-motion. They referred to as "cutaneous vection". The authors of this study have compared perceived self-motion on cutaneous vection with actual body transfer. In this study, we prepared two conditions that were the wind speed (0.5m/s or 5.5m/s) and the transfer speed (0.8mm/s or 4.0mm/s). The consistent condition was that wind speed and transfer speed were both fast or wind speed and transfer speed was both slow, and the inconsistent condition was that wind speed was fast but transfer speed was slow or wind speed was slow but transfer speed was fast. We used a bladeless fan for cutaneous stimulus to the participant face. The floor of the participant could move to and fro. Onset latency, accumulative duration and rating of subjective strength were measured. When the wind speed was consistent with the transfer speed, latency was significantly shorter, duration was significantly longer and the value of rating was significantly higher than other conditions.

Perceiving partly occluded objects: Structure versus knowledge

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Abstract: When objects are partly occluded we may still have an idea about the complete shape of the objects, a phenomenon that has been referred to with the term "amodal completion". Often there is a strong tendency to smoothly continue the contours of the partly occluded objects behind the occluder. In the past decades, the phenomenon of amodal completion has frequently been studied by using simple, geometrical shapes. In the present study we aimed to contrast this type of structure-based completion with our knowledge of objects. We used stimuli of Hazenberg and van Lier (2016) that were designed such that structure-based and knowledge-based completions could reveal the same or different objects. By means of the so-called primed matching paradigm we then tested the strength of a given completion, structure-based versus knowledge-based, for different prime durations. The results suggest that both types of completions have different temporal properties. Effects of structure-based completions appear most prevalent for the shortest prime duration (100 ms), while effects of knowledge appear to kick in somewhat later (after 150 ms of prime onset), and dominate for the longest prime duration (after 500 ms). We discuss the findings in the light of the perception-cognition debate.

Audiovisual integration of ON and OFF signals.

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Unisensory information is processed before integration with signals from other senses. Here we investigate how the intensity of visual and auditory stimuli is represented at the integration stage. Specifically, we tested whether information about intensity is preserved, or whether signals are rectified so that only intensity changes are represented (irrespective of the polarity). To do so, we used audiovisual stimuli that consisted either of step increments (ON stimuli) or decrements (OFF stimuli) in intensity over time. ON and OFF stimuli were paired in all possible combinations. In separate conditions, participants performed temporal order and simultaneity judgments. Recently, we developed a model in which multisensory integration relies on elementary units analogous to Reichardt detectors. This model does not rectify the signals, so an increment in intensity in one modality paired with a decrement in the other would produce an inversion of perceived temporal order, reminiscent

of the "reverse phi" effect in motion vision. Psychophysical data showed that subjects could accurately report the temporal order of the two signals, even when the intensity in the two modalities changed in opposite directions. This suggests that before integration unisensory signals are rectified, yielding an estimate of the time of change without regard to sign. A simple model in which unisensory information is processed through biphasic filters in quadrature pair, before feeding into an energy unit, yields behavior consistent with our experimental observations. Without fitting parameters, the same model tightly predicted simultaneity perception for periodic sequences of visual and auditory stimuli with a square-wave profile.

The planispheric optic array

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The "planispheric optic array" is a full-horizon Mercator projection of the optic array. Such pictures of the environment are coming in common use with the availability of cheap full-view cameras of reasonable quality. This introduces the question of whether the public will actually profit from such pictures in terms of an understanding of the layout of the scene. This is doubtful given the apparent "distortion" of wide-angle images. In previous work we could relate such problems with the highly non-veridical external local sign. As stimuli we used full optic array photographs taken with a Ricoh Theta-S consumer camera. Our test images include four persons located at the corners of a square centred at the camera. The persons point at each other in various combinations. The task of participants in the experiment was to judge who is pointing at whom in a number of such photographs. It is found that naive observers are subject to huge systematic errors in these planispheric representations. The bulk of the errors is of a topological nature, people are not immediately aware of the periodic nature of the horizon. Here participants observe pointing out of the picture frame. Another major source of errors concerns the pointing to diametrically opposite targets. Observers interpret this as a pointing out of the picture (not the frame). A minor group of errors is due to the non-veridical external local sign. Observers misjudge the apex of the fan of visual rays.

Upside down: Task demands and stimulus characteristics reverse inverse effectiveness

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The principle of inverse effectiveness (PIE) proposes that multisensory responses are largest, if the unisensory stimulus components presented in isolation only generate a weak response. Moreover, it has been hypothesized that on the neural level multisensory interactions occur automatically and start at very low latencies presumably via direct crosstalk between sensory-specific areas. Using psychophysics combined with electrophysiology in humans we directly tested these hypotheses in two experiments. We presented low and high contrast visual targets; targets were either presented in isolation or paired with an irrelevant sound. Furthermore, the target was surrounded by a white frame (Exp 1) or not (Exp 2). Participants were asked to detect visual target presence. In Experiment 1 (with frame), we observed a behavioral benefit for lower-contrast stimuli if presented with sounds. Concordantly, the earliest ERP-component, P50 (50ms after stimulus-onset), was enhanced for lower-contrast relative to higher-contrast stimuli if presented with sounds, in line with PIE. However, in Experiment 2 (no frame), the P50 was reduced for lower-contrast relative to higher-contrast visual stimuli if presented with sounds, while the behavioral benefit remained largely unchanged. This pattern of results calls into question the relevance of low-latency effects for multisensory integration and the generality of PIE; and strongly suggests that low-latency interactions and inverse effectiveness depend upon task demands and visual stimulus characteristics.

Matching peripheral scene appearance using deep features: Investigating image-specific variance and contributions of spatial attention

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The visual system represents the periphery as a set of summary statistics. Cohen, Dennett and Kanwisher (TICS 2016) recently proposed that this influential idea can explain the discrepancy between experimental demonstrations that we can be insensitive to large peripheral changes and our rich subjective experience of the world. We present a model that summarises the information encoded by a deep neural network trained on object recognition (VGG-19; Simonyan & Zisserman, ICLR 2015) over spatial regions that increase with retinal eccentricity (see also Freeman & Simoncelli, 2011). We synthesise images that approximately match the model response to a target scene, then test whether observers can discriminate model syntheses from original scenes using a temporal oddity task. For some images, model syntheses cannot be told apart from the original despite large structural distortions, but other images were readily discriminable. Can focussed spatial attention overcome the limits imposed by summary statistics? We test this proposal in a pre-registered cueing experiment, finding no evidence that sensitivity is strongly affected by cueing spatial attention to areas of large pixel- or conv5-MSE between the original and synthesised image. Our results suggest that human sensitivity to summary-statistic-invariant scrambling of natural scenes depends more on the image content than on eccentricity or spatial attention. Accounting for this in a feedforward summary statistic model would require that the model also encodes these content-specific dependencies.

Does touch inhibit visual imagery? A case study on acquired blindness

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Does touch inhibit visual imagery? In an fMRI single-case study of acquired blindness, differential brain activation patterns for visual imagery of objects with and without tactile exploration were studied. Comparing mere visual imagery of familiar objects to visual imagery of the same objects with

simultaneous tactile exploration revealed activations in the primary and secondary visual cortex, the left ventromedial prefrontal cortex, and the precuneus. This activation pattern indicates primary visual processes to be more strongly involved in visual imagery related to episodic memory than in visual imagery based on tactile exploration. Paradoxically, simultaneous tactile input might thus not facilitate visual imagery in the visual areas. On the contrary, touch seems to disrupt the creation of visual images, emphasizing the importance of neural inhibition in multisensory processes. This observation raises the question as to whether touch in general suppresses visual imagery in sighted subjects, which is currently addressed in an fMRI-study. According to the findings of our single-case study, we hypothesize a stronger activation in the primary and secondary visual areas, and thus more detailed mental images for imagery without tactile input as compared to imagery of tactilely explored objects. In line with this, we analyze differences in connectivity networks of multisensory and unisensory processes.

Perceiving the shape of transparent objects

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Shape perception has almost exclusively been investigated with opaque objects. However, the shape cues identified for this case can not simply be transferred to light-transmitting objects, because, while some cues remain the same (contour) or exist in modified form (specular reflections), others are no longer available (e.g. shading, texture). On the other hand, there exist potential cues that are specific to transparent objects (e.g. background distortions caused by refraction and colour changes due to internal absorption). To investigate shape perception in the transparent case, we presented subjects with stereoscopic images of randomly shaped transparent objects, either hollow or massive, and asked them to indicate the orientation of the normal at various surface points (gauge figure task). We varied the availability of three potential cues (specular reflections, background distortions, absorption) by altering either scene and material properties or the image generation. Our results show that the shape of transparent objects was judged less accurately than that of opaque ones. For massive objects, both specular reflections and absorption enhanced shape perception, whereas for thin-walled objects of same outer shape, absorption had no and specular reflections even negative effects. The effect of background distortions was, depending on their strength, either absent or negative. Our results suggest that in the transparent case shape perception does not rely on a fixed set of cues. Instead it appears that the kind of information that is usable as a cue depends on a complex interplay between properties of the transparent object and the surrounding scene.

Silent movies evoke auditory sensations more readily when they contain greater low-level motion energy: Results of a large internet survey

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We recently reported that about 20% of randomly-selected participants said they heard sounds when viewing flashes (Fassnidge, Marcotti & Freeman, 2017, Consc. & Cogn. 49). Here we report results of a large internet survey (tinyurl.com/vEARsurvey) probing experiences of this visual-evoked auditory response (vEAR).

>3200 self-selected participants rated a series of short silent movies, in response to the question 'On a scale of 0 to 5, how much auditory sensation do you experience when watching this video?'

Ratings were significantly higher in 20% of respondents who reported experiencing vEAR in everyday life, for example evoked by car indicator lights, people walking or shop displays. Ratings were also significantly higher in younger participants and females, in people reporting vivid musical imagery (e.g. 'earworms'), and those reporting flashes evoked by a sudden noise (e.g. while dozing in the dark). There was also a significant relationship to tinnitus. Ratings were generally higher for movies depicting events that were predictive of sounds (e.g. collisions). However, principle component analysis revealed a further dimension, along which ratings positively correlated with the low-level motion energy in the movies, independently of their predictiveness. This relationship was strongest in the 20% participants with self-identified vEAR.

Our results suggest that vEAR depends on bottom-up inputs to auditory cortex from visual motion-sensitive areas as well as top-down connections, reinforced by frequent association, and that the phenomenon is strongest in those for whom such connections are disinhibited, or where auditory areas are more excitable.

Object recognition with interference in children between 7 and 9 years

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Objective: the goal of this study was to reveal age-related differences in visual recognition of objects with interference in children aged between 7 and 9 years. Participants and Methods: the sample consisted of 54 7-years-olds and 48 9-years-olds. The children were assessed with the ''Visual recognition tasks" from Luria's assessment battery. A first task assesses the ability to recognise 11 overlapping objects. Second task requires children to recognise 12 incomplete visual objects. Results: the results per task were evaluated by two-way ANOVA. The main effect of age was significant ($p<.01$), indicating that there are age-related differences in visual recognition between two age groups. The main effect of type task was also significant ($p<.05$). The amount of correct identified objects in overlapping task was more than in incomplete task. We did not reveal a significant interaction ($p<.01$) between type of task and age. Conclusions: this research demonstrates that there are clear age-related differences in the ability for visual recognition of objects with different kind of interference between two age groups of children. However it can be assumed that the ability to recognise overlapping objects is maturing earlier than the ability to recognise incomplete objects.

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Visual-vestibular congruency does not affect optic flow sensitivity

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Optic flow generated by self-motion relative to the stationary environment is congruent with vestibular self-motion signals. Optic flow that is incongruent with vestibular self-motion signals can be generated by object motion or artificial vestibular stimulation. Since optic flow is most often generated by self-motion, vestibular stimulation may increase sensitivity to congruent relative to incongruent optic flow patterns. Here we test this hypothesis for sensitivity to leftward/rightward and expanding/contracting optic flow during leftward/rightward and fore/aft linear self-motion, respectively.

Sensitivity was assessed by manipulating the motion coherence level in random dot optic flow displays, i.e. the percentage of dots moving in a manner consistent with the global flow pattern. Observers seated on a hexapod motion-platform in front of a screen experienced an out and back movement of the platform. Dot motion was presented during the out movement and the back movement and observers indicated which movement contained the coherent optic flow pattern (2IFC task). Motion coherence was varied trial-to-trial according to a 3-down 1-up staircase procedure to find the coherence yielding 79.4% correct performance.

For expanding/contracting as well as leftward/rightward optic flow, our results surprisingly show no difference in coherence thresholds depending on vestibular congruency. Prior studies investigating sensitivity to expanding/contracting flow under similar conditions have yielded conflicting results. The current results suggest coherence thresholds are not affected by vestibular congruency and raise doubts concerning the generality of prior findings.

Disruptive camouflage: Multiple mechanisms interfere with object recognition

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Disruptive patterning (DP) is a type of camouflage, involving false edges/boundaries that reduce recognition by disguising shape. However, previous research on DP has largely used single-target detection tasks, creating difficulty disentangling effects on recognition from those on detection. In three experiments, screen-based visual search tasks assessed human ability to distinguish a hexagon among groups of octagons (or vice versa), identifying 'the odd shape out' as quickly and accurately as possible. Shapes were plain black or disruptively patterned, and all were easily detectable on grey backgrounds. Disruptive pattern elements were either large or small circles, which either matched or contrasted with background luminance, the latter allowing assessment of whether partial background matching ('differential blending') enhances DP effectiveness. Reaction time data were analysed through comparison of Linear Mixed Models using Akaike's Information Criterion. Experiment 1 found DP significantly increased recognition time over non-patterned shapes, and cross-experimental comparisons suggested edge markings were more effective than internal only. Experiment 2 confirmed the importance of spatial DP characteristics; large pattern elements increasing RT significantly more than small. Experiment 3 tested whether such DP elements act by concealing overall shape or distracting attention from it, finding support for both effects. However, pattern contrast had no significant effect in any experiment, suggesting differential blending may contribute more toward avoiding detection than recognition. These experiments imply that DP may work via multiple mechanisms, and a more comprehensive account of optimal concealment requires a combination of both recognition and detection paradigms.

Crossmodal modulatory effect on the perception of a bistable image: The conveyance of semantic congruency by using tones of voice as modulators

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It has been shown that the perception of a bistable image can be modulated by introducing a crossmodal stimulus, such as auditory stimulation [1] [2] [3]. This type of modulation implies the emergence of crossmodal semantic congruency by associating the information from different sensory modalities so that an integrated unity is assumed [4]. Additionally, there is a way to manipulate the perception of an ambiguous figure by adaptation to unambiguous figures and/or placing the ambiguous figure into a context of unambiguous figures [5]. Thirty-five healthy volunteers participated in this study. The scientific committee of COPELABS (Cognition and People centric Computing Labs) approved the study. The participants had to view the bistable image 'My wife or my mother-in-law' whilst listening to the voice of a woman. Each participant could view the image twice at a viewing distance of 60 cm. The first occasion the participants viewed the image, they were able to listening to a voice of an old woman while they were viewing the image. The second time they viewed the bistable image whilst a voice of a young lady was being heard by them. The bistable image was presented on the monitor of an Eye-Tracker device with a refresh rate of 60 Hz. This study had the aim of establishing the effect of auditory stimulus (the voices) on the perception of the bistable image. The findings showed differences between the reported percept when the congruent auditory stimulus was being heard and the percept incongruous with the voice provided.

What does face pareidolia reveal about visual processing in the primate brain?

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Face pareidolia, or the misperception of faces in inanimate objects, can be considered as an error of the face detection system. Examination of these errors has the potential to reveal new insight into higher level visual processing in the primate visual system. Here we report two related investigations using natural examples of face pareidolia occurring in everyday objects. For each example of an illusory face

in an object, we found a matched stimulus of the same object category with similar visual features, but without a face. First, we demonstrate that face pareidolia is not a uniquely human experience. In a looking preference paradigm, we presented examples of face pareidolia, matched objects, and monkey faces in pairs to five rhesus macaques (Macaca mulatta). All monkeys looked for longer at objects judged to contain illusory faces by human observers than at matched objects or monkey faces. A support vector machine classifier successfully predicted whether a monkey was viewing an object with an illusory face or not based on the fixation density plots. Second, we used fMRI to examine sensitivity to illusory faces in human category-selective cortex. In both face-selective area FFA and object-selective area LOC, but not in V1, a support vector machine classifier could successfully predict whether the subject was viewing an object with an illusory face or a matched stimulus without an illusory face from the patterns of BOLD activation. Together the results demonstrate a strong response to naturally occurring examples of face pareidolia in the primate visual system.

A bias for anisotropy in image classification

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Carpentered (man-made) images generally have anisotropic power spectra with relatively greater Fourier energy near cardinal (vertical & horizontal) compared to inter-cardinal frequencies, whereas the power spectra of natural (non-man-made) images are more isotropic (Switkes et al., 1978). We examined if orientation anisotropy in images influences our ability to classify them. To do this, we created hybrid images by adding together two filtered images ("components") selected randomly from four image categories (natural: animals and flowers; carpentered: houses and vehicles). The two components were filtered such that one retained near-cardinal and the other retained near-inter-cardinal orientations and we varied the log-ratio of their Fourier energy -3.66,-2.20,-1.39,-0.41,-0.20,0,+0.20,+0.41,+1.39,+2.20,+3.66. Ten observers were briefly presented with a hybrid (100ms) followed by a mask (200ms), and had to classify the hybrid into one of the four categories. For each image category we estimated the log-ratio of the point of subjective equality where the hybrids were equally likely to be classified as either one of the components ('bias'). Mean biases were negative for houses (-0.61) and vehicles (-0.28), indicating that classification of the hybrids was biased towards these categories. However, biases were positive for animals (+0.48) and flowers (+0.66). Mean biases across observers correlated with the orientation anisotropy in the unfiltered image categories used to create the hybrid's components ($r(8) = -0.98$, $p<0.001$). We found that carpentered image categories require less Fourier energy for classification in hybrid images, indicating that we may be biased towards anisotropic images.

A neurophysiological response to symmetry is formed through the integration of partial transient information over parieto-occipital regions.

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Processing visual symmetry triggers the activation of a neural network in extra-striate visual areas. This corresponds to an ERP-component known as Sustained Posterior Negativity (SPN). SPN amplitude reflects perceptual coding of regularity in the retinal image. This signal is robust, long-lasting and automatic. Interestingly, the network can also compensate for perspective distortion, but this requires attention to symmetry. In this study, we investigated whether the symmetry-sensitive network can integrate partial information revealed over time. Observers saw abstract unfamiliar shapes with one-axis (either vertical (Exp.1) or horizontal (Exp.2)) reflection symmetry compared to random configurations. A vertical bar occluded half of the shape for 500ms. The bar then shifted to the other side, uncovering the previously occluded half for 1000ms. Only at this point participants could discriminate stimulus regularity (i.e. reflection/random). No symmetry was presented in the image at any point in time. In Experiment 3 there was no occluder and the two halves appeared as independent objects. In all experiments, accuracy was >80% and SPN was recorded from 300ms after presentation of the second half. Thus, representation of symmetry can be computed by dynamic integration of partial information. However, temporal integration only occurs during active symmetry discrimination. No SPN response was recorded when participants did not attend to regularity but reported rare oddball trials (i.e. colour of second half). Hence, the symmetry-network can be engaged in the extraction of symmetry from the visual transients in the image. However, this process is not automatic.

A dorsomedial cortical hemifield representation with functional connections to scene selective cortex in humans

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Humans are remarkably apt at extracting the 'gist' of a scene without analyzing its content locally: they can judge from flashes of only 50 ms whether the scene affords a hiding place or rather allows walking through, without awareness of its specifics like the colors or the shape of particular objects. Such gist-based visual processing is clearly at odds with the properties of conscious foveal vision that humans use to scrutinize objects. Hence, models of gist-based scene perception propose a type of image processing that focuses on the periphery instead, at a cortical locus relatively early in the visual processing hierarchy. However, a visual cortical region that meets these requirements has yet to be identified. Here, using wide-field retinotopic mapping and population receptive field (pRF) modeling, we identified a new visual hemifield representation anterior of area V2d and inferior to area V6, which we propose to call area V2A. The pRF analysis revealed unique properties for V2A: a large and

constant receptive field size (FWHM 26deg) across the entire range of eccentricities tested (5-40deg). A resting-state fMRI connectivity analysis further suggested that V2A is ideally suited to quickly feed the scene-processing network with information that is not biased towards the center of the visual field. These results not only suggest a cortical locus for the initial stages of gist-based visual scene perception, but also a reappraisal of the organization of human dorsomedial occipital cortex with separate hemifield representations anterior to V2 as well as V3.

Adjustable sensitivity to surrounding motion during goal-directed arm movements

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People constantly adjust their ongoing arm movements to the latest information about the target and their arm. They also consider the latest information from the surrounding. A possible reason for considering the surrounding is that the global optic flow provides information about self-motion when the surrounding is static. Knowing whether the surrounding is likely to be static might therefore influence the gain of responses to changes in the surrounding. Such a change in gain could be a relatively slow process, the gain being set at movement onset based on experience during preceding movements. It could alternatively be a fast process, the gain even being adjusted to new evidence about whether the surrounding is static when the arm is already underway. To evaluate the latter possibility, we compared responses to surrounding motion while people tried to intercept moving targets. The relevant surrounding motion either occurred alone, or 100ms after the surrounding had moved in the orthogonal direction. We found a lower gain in the second case, suggesting that motion in the surrounding is considered to provide less reliable information for guiding the arm once it has been established that the surrounding is not static. The lower gain is unlikely to be due to the surrounding motion being masked by the preceding motion in the orthogonal direction, because the eyes followed the surrounding almost as strongly after preceding motion in the orthogonal direction. This study illustrates how elaborately visual information is considered for the fast guidance of ongoing arm movements.

On the road to … somewhere? Change-blindness in event description tasks is informative about the interrelation between visual perception and language planning

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The visual processing of complex event stimuli and the planning of utterances to describe them happen rapidly and partly overlap in time, posing a challenge to researchers on vision and language: How exactly do the processes interact? As a test case we investigate how sudden content-changes in visual scenes affect speakers of different languages. In a novel approach, we elicit event descriptions from naturalistic video stimuli of motion events consisting of two segments (240ms each), each followed by a mask (80ms). Thus, a potential one-shot change-blindness situation is created. By manipulating the presence/absence of the goal of motion we exploit typological differences between French and German regarding the verbal encoding of goal-orientation to investigate the effect of language as a top-down factor on visual processing. Analysis of the linguistic data (content and timing) reveals how subjects accommodate to seemingly unnoticed changes (e.g., distribution of hesitations, temporal onsets of words). We will also discuss the effects of language on the encoding of goal objects and change detection.

Visuomotor and motorvisual priming with different types of set level congruency: Evidence in support of ideomotor theory, and the Planning and Control Model (PCM)

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Perception can prime action (visuomotor priming), and action can prime perception (motorvisual priming). According to ideomotor theory both effects rely on the overlap of mental representations between perception and action. This implies that both effects get more pronounced the more features they share. We tested this hypothesis by employing in a motorvisual (Exp.1) and in a visuomotor (Exp.2) setting, three different pairs of left/right target stimuli (hand pictures, arrows, and words) varying in how strongly they overlap with the pair of left/right responses. For two stimulus pairs (hands and words) the hypothesis was confirmed: Hand pictures share more features with the responses than words, consequently hand pictures produced a stronger visuomotor and a stronger motorvisual priming effect than words. However, arrow stimuli showed a different pattern: The temporal dynamics of both priming effects, as well as the direction of the effect seen in motorvisual priming, were significant but opposite to that of the hand and word stimuli. This suggests that the arrows' representations were not involved in ideomotor processes, and we propose instead that they were represented in a spatial or scalar fashion, outside the representations assumed in ideomotor theory. The results are discussed in the context of ideomotor theory, and the Planning and Control Model (PCM) of motorvisual priming.

Perturbed cortical hierarchies in autism spectrum disorder: The case of high-level vision

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While people with Autism Spectrum Disorder (ASD) show clear impairments in normal day-to-day behavior, they simultaneously outperform their Typically Developing (TD) counterparts on many perceptual tasks. This relative superiority in tasks requiring the processing of separate features rather than the overall configuration has inspired two competing theoretical frameworks: the Weak Central Coherence hypothesis (WCC) and the Enhanced Perceptional Functioning (EPF) theory. While WCC theory explains these results

by the absence of a normal bias towards the global structure in a visual display in people with ASD, EPF theory insists that generally increased attention for local elements in a scene is the cause. Although both theoretical frameworks have been investigated for years, evidence for either line of theory remains mixed and ambiguously interpretable. To address this problem, we argue that the existing evidence on perceptual processing in ASD should be integrated within a unified theoretical framework, the Reverse Hierarchy Theory (RHT). Within this theory, both neurocognitive theories can be regarded as cases of hierarchy perturbations in the visual cortex. More precisely, people with ASD show a less efficient (slower) early-stage and pre-attentive global processing of visual information (in accordance with WCC) and a later-stage advantage in the attention-focused processing of local scene (or object) elements (in accordance with EPF). The empirical foundation of this alternative framework will be discussed on the basis of four recent studies from our own lab on ultra-rapid categorization, change blindness, complex visual search (chase detection) and spatial frequency priming.

Gesture and outcome processing during the recognition of actions among distractors: Evidence from eyetracking

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Sensorimotor and predictive approaches of action understanding make alternative predictions about the timing and importance of gesture and outcome processing during action decoding. Whereas sensorimotor approaches that consider action recognition can be achieved through bottom-up propagation from gesture activation, predictive accounts claim that a prediction about the intended outcome of the actor is first required. In previous priming experiments, we used action photographs containing gesture and/or outcome violations to manipulate the similarity between object-directed actions in terms of gesture or outcome. For short prime durations (66, 120, 220 ms), priming effects were observed for outcome but not for gesture, supporting predictive accounts of action decoding. Using eyetracking, this study aimed at further specifying the early temporal dynamics of gesture and outcome processing during recognition of actions among distractors. Twenty healthy adults had to find the correct action picture among four pictures displayed in the corners of the screen (>13°) while eye movements were recorded. Target actions were correct with regard to the typical use of the object. Distractor actions were incorrect by virtue of gesture violations, outcome violations or both. Thus, distractors could share the same outcome or the same gesture with the target or neither one. Analysis of fixation proportion over time showed a greater probability of fixating distractors with similar action outcomes than dissimilar distractors from the first fixations after picture display. Results suggest that actions with similar outcomes compete for attention very early during target action visual search, in accordance with predictive accounts of action understanding.

Snakes as evolutionarily threat: Interaction between visual features and high level cognition

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Predatory pressure from snakes may have shaped the primate visual systems since primordial eras. We investigated how visual features of snake images modulate the brain's electrophysiological activity. In the first experiment, we compared the electrophysiological responses elicited by snake, rope, gun and bird images, to test the effect of curvilinear shapes on the visual brain. Our results showed that rope images elicited a similar enhanced brain response compared to snake images. In the second experiment, we studied whether the same rope images elicited enhanced electrophysiological responses when snake images are not present in the experiment, to study the possible role of the context of perception on the brain activity for curvilinear shapes. Rope images still evoked the enhanced brain activity compared to the other stimuli, even when snake images were not presented in the same experiment. However, a comparison between the two experiments revealed that rope images elicited a stronger brain response when also snake images were presented in the same experiment. These findings suggest that bottom-up and top-down mechanisms interact to give an attentional priority to potentially threatening stimuli.

Visual mismatch negativity and fMRI signal adaptation correlate in the occipital-temporal cortex

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Several electrophysiological studies found response differences to a given stimulus when it is repeated frequently as compared to when it occurs rarely in oddball sequences. Initially defined in acoustic perception, such difference also exists in the visual modality and is referred to as visual mismatch negativity (vMMN). Additionally, the frequent repetition of a stimulus also leads to the reduction of the blood oxygen-level dependent (BOLD) signal (fMRI adaptation, fMRIa) when compared to more rarely occurring or alternating stimuli in fMRI experiments. Surprisingly, so far, no study compared vMMN to fMRIa within the same paradigm and participants. Here we tested the possible connections between fMRIa and vMMN in a visual oddball paradigm in two separate sessions, acquiring electrophysiological and neuroimaging data for real and false characters from the same participants. We found significant vMMN as well as fMRIa for both character types. Importantly, the magnitude of the vMMN over the CP1 electrode cluster showed a significant correlation with the fMRIa within the letter form area for real characters. This finding suggests that similar neural mechanisms are responsible for the two phenomena.

Does relevance of orientation content influence low-level cardinal attenuation?

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UCLouvain

Natural scene images contain more energy at cardinal orientations, and mostly at horizontal orientation. In such stimuli, human sensitivity to image amplitude manipulations is best in oblique compared to cardinal orientations and is worst in the horizontal range. Hansen and Essock (2006) proposed that orientation encoding mechanisms may have evolved to discount the most prominent, but non-relevant horizontal content of natural scene images. Akin to scenes, face images are dominated by horizontal information; however face horizontal structure is of high relevance to person identification. Here, we investigated whether and how the relevance of horizontal content modulates low-level orientation sensitivity. First, we made isotropic (i.e. all orientations carry equal amplitude) face, inverted face and scene images. Then we increased the relative amplitude of a 45° broadband centered on one of four possible orientations: horizontal (0°), 45°, vertical (90°), and 135°. 12 participants were asked to detect amplitude increments at each orientation. Using an adaptive staircase procedure, we measured increment detection thresholds for each of the four experimental orientation ranges. At the group level, we found higher thresholds for vertical compared to oblique orientations, and for horizontal compared to 135°, but no increased threshold for horizontal compared to vertical orientations, which indicates a general cardinal suppression. Category differences in the relevance of orientation content did not affect this pattern. We are currently running a follow-up experiment to explore the functional link between low-level orientation attenuation and high-level face identification performance at the individual level.

Poor vision is sufficient to establish size constancy in the newly sighted

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We can estimate the veridical size of nearby objects reasonably well irrespective of their viewing distance, despite drastic changes in their projected retinal image. This perceptual capability, termed size constancy, is accomplished by combining information regarding retinal image size together with the viewing distance. But what if you have had very poor vision during the early years of life? We studied 23 Ethiopian children suffering from bilateral early-onset cataract, who were surgically treated only years after birth. Our expectation was that the newly sighted might be impaired in their depth estimation, and show a tendency to underestimate the far object size due to its smaller retinal image. Surprisingly, most children were able to estimate object size irrespective of distance reasonably well. In fact, they usually tended to overestimate the far-object size. Closer examination indicated that although before surgery the patients were diagnosed as having a full, mature bilateral cataract, they nevertheless had some residual form vision, typically limited to very close range. A previous study in a similar group of newly-sighted children reported susceptibility to geometric visual illusions, immediately after surgery, concluding that size constancy was probably innate. We suggest that the immediate ability to judge physical size irrespective of distance in the newly sighted is not an innate mechanism but more likely to result from their previous visual experience (at close range). A blurred retinal image is still inversely scaled with distance, and object size can be confirmed for objects within hand range.

The role of perspective on the greenback illusion

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If a straight line is superimposed on a picture of a 3D rotated banknote such that the line is perpendicular to one of the sides of the banknote, we observe that the physically right angle made by the superimposed line and the side of the banknote does not appear to be a right angle (http://kshiina.web.fc2.com/newfile.html). This recently found angle illusion is called the Greenback Illusion. It was found in a previous study that the illusion magnitude was about 6-14 degrees and that it occurs even if we remove the pattern on the banknote. Therefore there is a possibility that it is a type of geometrical illusion arising from the configuration of the trapezium and the added line. At the same time, it appears that the more the image is interpreted as a 3D image, the stronger is the magnitude of the illusion, as is seen in Osa's Straight-Road-Illusion (2011) in which the scenic information of the picture is essential. In order to check the effect of pictorial information, this study compared magnitudes of the illusion across the Banknote condition and the White surface condition, in which the pattern on the banknote is replaced by a uniform white mask. Results revealed that the illusion occurred in both conditions and the illusion magnitudes are not different across the conditions. The results may strengthen the idea that the Greenback Illusion is not a perspective-related illusion.

Decision confidence and motivation are differently associated with task strategy during perceptual decision-making

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During perceptual decisions, a subject's choice can vary in response to an identical stimulus, presumably reflecting noise or the influence of fluctuating internal states in the brain. Here we measured pupil size to infer internal states of two macaque monkeys performing a visual discrimination task. We found that predictable changes in reward size were reflected in trial-by-trial fluctuations in pupil size, suggesting they reflected the animals' motivation. In addition, we found that pupil size became larger in easy trials than hard trials towards the end of the stimulus presentation as the timing of the reward was imminent. We wondered whether this modulation reflected animals' decision confidence driven by reward expectation based on the learned probability of making a correct choice. We computed a pupil metric representing

this modulation by averaging the pupil size over 250ms prior to the stimulus offset in each trial. We found that this pupil metric showed signatures of decision confidence based on signal detection theory: it increased with the animals' performance accuracy and was systematically associated with stimulus strength on correct and error trials. We then used available reward size and pupil size to examine systematic effects of the animals' motivation and decision confidence on their perceptual strategy using psychophysical reverse correlation. The separation by decision confidence supported an integration-to-bound strategy while changes in reward-driven motivation were consistent with changes in the height of the decision bound. Together, this study supports distinct influences of motivation and decision confidence on task strategy during perceptual decision-making.

Using neural distance to predict reaction time for categorizing animacy, shape, and location

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Previous research has shown that distance to a decision boundary through neural activation space can be used to predict reaction times (RT) on animacy categorization tasks (Ritchie and Carlson, 2016). More specifically, it has been found that this relationship is driven by animate, but not inanimate exemplars. However it has yet to be explored how this relationship is impacted by target visual features, or whether the RT-distance relationship holds for other categorization tasks. Here we tested whether this asymmetry still held when animate and inanimate stimuli were balanced along an orthogonal shape dimension (Bracci and Op de Beeck, 2016). We also tested whether the same RT-distance relationship held when observers performed a shape categorization task, and a location categorization task that crisscrossed the dimensions of animacy and shape.

Using human fMRI (N = 15), and focusing on shape and object category-selective regions of the ventral visual pathway, we correlated neural distance from a classifier decision boundary with observer RTs on the animacy, shape, and location tasks. In line with previous findings we found a negative correlation between RT and distance for the animacy task, but the same relationship was not observed for either the shape or location tasks. This negative finding suggests that the neural coding for these other properties of objects might depend on a different mapping between activation space and categorization behavior.

Decision to feel sense of agency

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Sense of Agency (SoA) refers to the feeling of voluntarily control over our actions and their consequences (Haggard, 2008). 69 participants took part in three experiments, 288 trials each, that were a modification of SoA explicit measure experimental paradigm (Wenke et al., 2010). Participants responded to arrow targets that appeared after prime arrows. Primes were demonstrated for either 17 or 250 msec in blocks or mixed together. Then a circle which color depended on the pressed key and its compatibility with the prime appeared. Participants judged their subjective control over the circle color. We investigated the role of bottom-up and top-down processes in SoA. Bottom-up processes included premotor fluency, created by prime-target compatibility, and objective feedback predictability created by prime duration and time to learn a feedback rule (number of trials in block).Top-down processes included a number of potential agents (1 or 2), free or cued-choice decision and response bias formed in the beginning of the experiment. We were able to replicate previous studies results on differences in cued- and free-choice trials, but could not find prime-target compatibility influence on SoA (Wenke et al., 2010; Chambon & Haggard, 2010). Our results about feedback predictability effect on SoA confirmed comparator model of SoA (Blakemore et al., 2000). The results questioned "prospective aspect" of SoA (Chambon et al., 2014) and demonstrated the key role of subjective belief about potential control over performance.

The functional state and mismatch work of magnocellular and parvocellular pathways in burnout

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The aim of this study was to examine the functional state of magnocellular and parvocellular visual pathways, features of their interaction in a chronic stress condition on model of professional burnout. Fifteen university employees participated in the study. Burnout was assessed with diagnostic methods of the emotional burnout (V.V. Boyko). Contrast sensitivity was measured with the visual contrastometry (Gabor elements with spatial frequencies of 0.4, 3.6 and 17.8 cycles/degree were presented). It was found that relative to participants without burnout, employees with the resistance phase at a formative stage demonstrated reduced contrast sensitivity at low spatial frequencies but increased contrast sensitivity at medium and high spatial frequencies. Participants with symptoms of formed resistance phase had increased contrast sensitivity at low spatial frequencies and reduced contrast sensitivity at medium and high spatial frequencies. Thus we have demonstrated the important role of matched functioning of magnocellular and parvocellular visual pathways in adaptive behavior in burnout as well as a different mismatch functioning of these visual pathways at the stage of forming burnout symptoms and at the stage of manifestation of burnout symptoms.

Modulation of tactile suppression through visual information

Hanna Gertz, Dimitris Voudouris & Katja Fiehler

Tactile signals are suppressed during reaching, possibly to free capacities for processing other sensory signals. We recently showed that tactile suppression is stronger in the presence of reach-relevant somatosensory signals. Here we

examined whether tactile suppression also frees capacities for enhanced processing of visual signals. Brief vibrotactile stimuli were presented on the participants' right index finger either during right-hand reaching to a previously illuminated target LED, or during rest. Participants indicated whether they detected a stimulus. The LED remained off (no-vision), or was briefly illuminated during reaching (vision) thus providing additional target information. If tactile suppression frees capacities for reach-relevant visual information, suppression should be stronger in the vision condition. In a visual-discrimination condition, the LED additionally flashed once or twice during reaching and participants had to also report the number of flashes. If tactile suppression also frees capacities for such reach-irrelevant visual signals, tactile suppression should be even stronger during the visual-discrimination condition. In all conditions, reaching led to tactile suppression as indicated by higher detection thresholds compared to rest. However, suppression was comparable in all conditions. In general, additional visual information increased reach endpoint accuracy and precision. Yet stronger suppression was associated with lower accuracy and precision. We suggest that suppression does not free capacities for enhanced processing of either reach-relevant or reach-irrelevant visual signals, and that suppression may even hinder the benefit of these additional visual signals on movement control.

From faces to lobsters: Generalizing high-level adaptation aftereffects to alternative categories of natural objects

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To recognize a familiar object, incoming perceptual information is matched against object representations in memory. Mounting evidence suggests that these memory representations are not stable, but adapt flexibly to recent perceptual information, resulting in measurable aftereffects (i.e., exposure to one object influences perception of the next). Although adaptation aftereffects have so far been primarily shown for human faces, they were also found in simple geometric shapes and it has been concluded that face aftereffects partially derive from shape adaptation. Purpose of the present study was to test whether adaptation aftereffects generalize to other categories of complex biological objects, and if so, whether they can be explained by shape adaptation. In three experiments, images of crabs and lobsters were presented in two versions: as complex, naturalistic images or reduced to their simplified geometric shape. In Experiment 1, we found robust adaptation effects for the complex versions of the images. Experiment 2 showed adaptation effects for the simplified stimuli, replicating previous findings on geometric shapes. Experiment 3 demonstrated that adaptation to the simplified animal shapes results in aftereffects on the complex stimuli. This indicates that adaptation aftereffects extend to complex biological objects beyond faces. Comparison between experiments revealed that aftereffects were largest in the first experiment, in which the complex stimuli served as adaptors. Together, these experiments show that the magnitude of adaptation aftereffects depends on the complexity of the adaptor, but not the test stimulus, and that shape adaptation plays a role in – but cannot entirely account for – the aftereffects.

Towards improvement of perception of MRI/CT images as 3D geometry

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During certain surgical interventions the doctors have to mentally reconstruct, with high accuracy and in a short period of time, a 3D model from multiple 2D Magnetic Resonance images (MRI) or Computer Tomographic (CT) images in order to have a better perception upon the clinical case. This research focuses on investigating the accuracy of mentally reconstructed 3D geometry from MRI/CT data. A set of ten 3D models were reconstructed from MRI images of the pelvis area using 3D Slicer. During the experiment, the subjects initially visualized the 2D multiple planes MRI images for maxim 30 seconds. Afterwards they were asked to mentally reconstruct the 3D geometry. The subjects had to specify if the model reconstructed in their mind corresponds to the one obtained with 3D Slicer. After analyzing the experimental data, there is observed the reduction of precision in recognizing 3D reconstituted objects. This result can also be influenced by the human reduced short term memory. A method to improve this accuracy is the collocation of 3D model with the 2D images using Augmented Reality technologies. This solution enhances the visual perception and offers a quick recognition of the object with less perceptive ambiguities.

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Neuronal response types to impoverished images in the human inferior and medial occipital lobe

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One important feature in visual perception is the ability to rapidly classify and recognize objects. The underlying neural mechanisms are not yet well understood. Here, we studied neuronal responses to brief (500 ms) presentations of Mooney images (binary black and white, BW) and of corresponding greyscale images (GS). We recorded single unit responses in deep structures of the human brain from epilepsy patients implanted with electrodes for clinical purposes. Subjects had to report by button press whether they recognized the object shown on the image or not. In this study we report the results of 3 patients with electrodes located in the inferior (IOL) or in the medial occipital lobe (MOL). Using spike sorting we were able to isolate 63 units in IOL and 52 in MOL (2 to 4 recording sessions per subject). More than 90% of the units showed clear modulation to stimulus presentation in raster plots and post stimulus time histograms. In the IOL most responses were sharp peaks indicating fast transient excitation. Typically peaks started around 150 ms after stimulus onset and were less than 100 ms wide, with GS responses often about 20 ms later than BW responses. In GS trials often a slower sustained response followed. In the medial occipital lobe mainly fast transient

inhibition was found, starting around 150 ms after stimulus onset and less than 100 ms wide. After this strong inhibition PSTHs showed oscillations of 10 to 20 Hz. Funding: Society for Neuroscience & BMBF-Award for US-German Collaboration in Computational Neuroscience.

Preparatory brain activity in time-based expectations

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Human behavior is guided by expectations that facilitate perception of upcoming events or reaction to them. In natural settings expectations are often implicitly based on time, e.g. when making a phone call one would expect to hear either a person answering (earlier) or a voicemail greeting (later). We investigated how time-based expectations can improve performance in the absence of explicit prior information on the pending stimulus or the associated response. Visual stimuli were presented centrally after a characteristic short or long foreperiod, and a forced-choice categorization using either the left or the right hand was required. The concurrently recorded electroencephalogram revealed lateralized pre-motor potentials which changed polarity after the short foreperiod. Amplitudes of pre-motor potentials co-varied with performance, so that higher amplitudes were associated with slower responses to unexpected targets. In two behavioral follow-up experiments visual stimuli were presented laterally and the foreperiod duration was correlated with the hemifield where the target would occur. Reactions were faster for targets occurring at expected compared to unexpected locations, both in a bimanual forced choice and in a unimanual detection task. Altogether, the results suggest that time-based expectations can entail preparatory motor activity as well as preparatory shifts of spatial attention.

Neural and behavioral benefits driven by facilitative effect of active exploration/passive observation of real 3-D novel objects depend on individual differences in vividness of imagery

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Our object recognition ability can be facilitated by actively exploring the object. It has been reported that the view-generalization of novel paper-clip objects was facilitated by active exploration of task-irrelevant paper-clip objects (Sasaoka et al., 2010). Passive observation of other's active exploration was sufficient to facilitate recognition, however, only for people with a high visuo-spatial ability (Meijer et al., 2010), supporting a relation of vividness of imagery on the effect of active or passive observation. It was hypothesized that active exploration of real 3-D objects would enhance recognition ability accompanied with a certain degree of individual differences in imagery. To exploit the effect with real objects and to reveal neural underpinnings associated with the active exploration in relation to an individual's vividness of imagery, a battery of recognition tasks and functional activation patterns was compared, immediately before and after the active/passive observation of task-irrelevant novel, real paper-clip objects made using a 3-D printer. Object recognition performance was assessed with a view-matching task, where participants performed a discrimination task for two views of the paper-clip objects sequentially presented on a display. Furthermore, neural state changes, before and after the observation, were examined by resting-state fMRI. Behavioral results showed that active exploration affects the view-matching performance and that the high imagers' performances improved even with passive observation when the angular disparity between the two views was large. Neural substrate changes in active and passive observations will be discussed in relation to individual differences in vividness of imagery.

Is there an effect on exercise on human adult ocular dominance plasticity?

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Short-term monocular occlusion in humans leads to a transient change in ocular dominance with the previously patched eye making a stronger contribution to the binocular sum, this reflects ocular dominance plasticity. Two recent studies have come to different conclusions as to the role of exercise in enhancing ocular dominance plasticity. An initial study by Lunghi and Sale (Current Biology, 2015, DOI: 10.1016/j.cub.2015.10.026) suggested exercise enhances this form of visual plasticity, whereas a later study by Zhou et al (Neural Plasticity, 2017, DOI: 10.1155/2017/4780876) found no effect of exercise. However, these studies used different endpoint measures, namely binocular rivalry and fusional balance respectively, making it possible that the different conclusions with respect to the influence of exercise were due entirely to the different methodology used in the two studies.

To test this, we set out to replicate the original study of Lunghi and Sale (2015); a group of 20 young participants were assessed for ocular dominance changes subsequent to short-term monocular patching, both with and without moderate cycling exercise, using a binocular rivalry endpoint. Unlike Lunghi and Sale (2015) we did not find any significant exercise-based enhancement of ocular dominance plasticity subsequent to short-term monocular occlusion. The reason for the unsuccessful replication is not known and being presently explored as there may have been some subtle but important difference between the two studies.

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On the response properties and range-dependence of manual estimation

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Manual estimates are a popular measure of perceived size in the action-perception literature. These estimates are

thought to constitute a form of cross-modal matching between stimulus size and finger opening. However, few investigations have systematically looked at how manual estimates behave in response to different input stimuli. In a series of experiments using open-loop manual estimates, we (a) sought to map out the response function for estimates of visually presented stimuli, (b) tested under which conditions scalar variability as predicted by Weber's Law was present, and (c) tested whether the frequently reported non-veridicality of manual estimates persists over a very large range of object sizes. We found that standard manual estimation responses scaled extremely linearly with object size, up until a point where participants' hand size limited their responses. In contrast, we found pronounced nonlinearity and non-veridicality when participants adjusted the size of a visual object to match a 'passive', induced finger opening, indicating that there may be more to manual estimation than simply matching a felt size to a seen size. As is typically found, Weber's Law was violated for very large objects; however, our data give mixed results regarding predictions of recently proposed motor-constraints accounts. Participants also showed a clear tendency to overestimate small differences when a set of objects differed very little in size, but responded with a slope close to unity when object differences were more pronounced.

Is reading words more effective in improving peripheral reading speed than recognizing letters?

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Yu and colleagues (2010) found that RSVP training (reading words at multiple durations) is more effective than training on recognizing letters at a fixed exposure duration in improving peripheral reading speed when matching the total training time (9000 words vs. 3500 strings). This study aims to assess whether the advantages of RSVP training are due to the use of words instead of letters during training, to the rapid temporal sequencing of stimuli across multiple exposure durations, or to the higher total number of stimulus presentations. There were four training groups: peripheral-letter, peripheral-word, peripheral-sentence, and foveal-word groups. A non-task-based training procedure was adopted (Yu, 2013). Peripheral-letter group viewed three-letter strings. Peripheral- and foveal-word groups viewed words of sentences with one word per trial. Peripheral-sentence group viewed words displayed in rapid temporal sequence with one sentence per trial (RSVP). Exposure duration was 106ms for the letter and word groups, and ranging between 82 and 1318ms for the sentence group. Training involved a total of 7150 stimulus presentations. For the peripheral groups, training occurred at 10° below fixation. Reading speed was measured at 10° above and below fixation before and after training. Reading speed increased significantly for the three peripheral groups, and the improvement did not differ across the groups (89% increase in the trained field). We found that the advantage of word-based over letter-based training in improving peripheral reading speed disappears when we match the number of stimulus presentations during training, regardless of the temporal structure of stimulus presentation.

The role of previous decision confidence in current speed-accuracy tradeoff for perceptual choice

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Humans can provide finely calibrated estimates of the correctness of their perceptual choices, referred to as decision confidence. Decision-makers might use decision confidence to optimize their choice behavior – for example, by optimizing the speed-accuracy tradeoff: When confidence about a choice is low, the decision-maker might require more evidence before committing to a choice on the next trial. The drift diffusion model of perceptual choice describes the decision process as the accumulation of noisy sensory evidence towards one of two bounds. In this framework, the predicted effect of low confidence is an increase in the decision bound, leading to slower but more accurate decisions. To test this prediction, we analyzed data from a perceptual choice task. On each trial, participants judged the average color of eight circles (de Gardelle & Summerfield, 2011), and then additionally rated their confidence in this decision. Indeed, participants slowed down after trials on which they reported low confidence. Fitting the drift diffusion model to the data as a function of previous decision confidence revealed two effects: (i) a decrease of mean drift rate (i.e., the efficiency of sensory evidence accumulation) with low previous confidence; and (ii) an increased decision bound after previous low confidence – specifically on trials on which participants were sure to have made an error. The effect of confidence on drift rate, but not on decision bound, was explained by slow variations in attentional state. We conclude that decision confidence plays an important role in deciding on current decision strategy.

Can organization into a configuration take place in the absence of visual awareness?

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Here we examine whether visual awareness is required for organizing elements into a configuration. Participants were presented with a liminal prime consisted of 'L' elements organized by closure, collinearity and symmetry into a diamond or a square configuration, followed by a clearly visible target. The prime was rendered invisible by CFS (Experiment 1) or by sandwich masking (Experiment 2). Each experiment consisted of a configuration block, in which the target was congruent or incongruent with the configuration of the prime (square or diamond made of disconnected lines), and an element block, in which the target-prime congruency was at the level of the elements (plus or X made of "L" elements). On each trial, participants made speeded discrimination of the target and then rated the visibility of the prime using a scale ranging from 0 ("I saw nothing") to 3 ("I saw clearly"). Unconscious processing of the prime was measured as the priming effect on target discrimination performance on trials in which participants reported not seeing the prime. Significant priming effect of configuration was observed for visibility rating 0 when the prime was rendered invisible by masking, but not by CFS. In both experiments, priming effect of configuration was observed when the prime was reported visible. When masking was used, the priming effect

was larger in the presence of awareness than in its absence. These findings suggest that organization into a configuration occurs without awareness of the stimulus when the stimulus is rendered invisible by masking. Visual awareness, however, improves processing.

The consequences of motor action and the social context determine the representation of peripersonal space

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Space perception is intrinsically linked to the potentiality of objects to suggest motor actions, combined to the anticipation of the effects of actually acting on these objects. According to this approach, peripersonal space (PPS) defines the region where actual interactions with objects, considering the current location of the body, can be anticipated. While the relationship between the representation of the body and the representation of PPS has been widely investigated, the role of objects value has been largely eluded, in particular in the context of social interaction. We tested the effect of the positive-negative feedback provided by a stimulus used as a target for action, on the representation of PPS. The task consisted in selecting 10 out of 32 targets presented at random on a multi-touch table. The selected target could turn red (0 point) or green (1 point), and the likelihood to select a green target to maximise the total of points was 25%, 50% or 75% in the near and far space. Furthermore, the task could be performed either in an isolated (400 trials) or social context entailing a cooperative task in which each participant selected (200) targets. The results show that the representation of PPS, tested through a reachability judgment task performed before and after the target selection task, was modified depending on the distribution of the targets associated with a positive feedback, and extended in the presence of a partner suggesting that objects value but also the outcome of observed actions determine the representation of PPS.

Symmetry perception for patterns defined by colour and/or luminance

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It is argued that symmetry perception makes use of neural mechanisms that are temporally sustained and pool information from relatively large receptive fields. The S-(L+M) cone-opponent mechanism fits this description and could thus contribute to symmetry perception by providing a large-scale integration window for co-localised luminance signals. To test this prediction, we ran a series of psychophysical and event-related potential (ERP) experiments. In the first experiment, pattern contrast was fixed at individual symmetry discrimination threshold for isoluminant, luminance-defined or combined colour and luminance patterns. Participants then judged whether a single presented pattern was symmetric or random. At threshold contrasts, stimuli at isoluminance were associated with the largest bias towards perceiving a pattern as symmetrical. Stimuli that isolated the luminance channel introduced a bias towards perceiving a pattern as asymmetrical. Participants did not show a bias when judging the stimulus which contained a mixture of S-(L+M) and luminance signals. The subsequent ERP experiments were run at high contrasts, set to five times individual threshold. SPN Sustained Posterior Negativity (SPN), a symmetry-sensitive ERP component, was observed in all conditions and showed the expected enhancement for symmetry. However, only minor interactions between symmetry and contrast type were observed. In conclusion, while our findings at threshold support models that propose an important contribution of large-scale information to symmetry perception, at suprathreshold, these low-level contributions are not robust. Therefore, under everyday viewing conditions, symmetry perception probably engages a relatively broad cortical network that is not fully constrained by low-level inputs.

The Trump effect: The effect of visual hand-size on movement behaviour

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Body perception depends on the proprioceptive information coming from our joints, muscles and skin, but is also heavily influenced by the visual information about the size and position of our limbs. This has for instance been shown in the rubber-hand illusion (Botvinick & Cohen, 1998), as well as the finding that manipulating the visual size of the hand affects the two-point discrimination threshold for touch sensations (Kennett et al., 2001). Here we investigated how such visually induced changes in body perception affect subsequent goal-oriented pointing behaviour.

Participants performed a target-pointing task. Before each movement they saw their hand either in normal size or a magnified or minified version of their hand using Fresnel lenses. Next a target was presented on a touch screen (a vertical line extending the height of the screen) and participants were instructed to try and hit the target as accurately as possible. During the movement direct vision of the participant's hand was prevented (open-loop pointing).

Results show that for a minified hand participants increased the range of pointing movements relative to the actual target locations. That is, when the target was presented to the left of straight ahead, participants pointed even more leftward and more rightwards for targets presented to the right. Similarly, for a magnified hand, participants decreased their movement range.

These results indicate that we directly compensate our movement behaviour based on the visual size of our hand: e.g. exaggerating our movement extent to make up for the smaller perceived size of our hand.

Effects of context on the perception of animacy and intentionality

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We explored the effect of different spatiotemporal contexts on the perceptual saliency of animacy and intentionality. Paired-comparisons and ratings were used to compare the impressions of animacy elicited by a small square moving on the screen, either alone or in the context of a second square. The context element was either static or moved showing an animate-like or a physical-like trajectory, and the target object moved either toward it or away from it. The movement of the target could also include animacy cues (caterpillar-like expanding/contracting phases). To determine the effect of different contexts on the emergence of emotions and intentions, we also recorded and analysed the phenomenological reports of participants. The results show that the context significantly influences the perception of animacy, which is stronger in dynamic contexts than in static ones; also, findings show that the perception of animacy is greater when the target is moving away from the context element than when it is approaching it. The free reports reveal different proportions in emotional or intentional attributions in the different conditions: in particular, the "moving away" condition is related to negative emotions, while the "approaching" condition evokes positive emotions. Overall, the results suggest that animacy is a graded concept which can be articulated in more general characteristics, like simple aliveness, and more specific ones, like intentions or emotions, and that the spatiotemporal contingencies of the context play a crucial role in making them evident.

Knowing where one will hit a moving object influences eye-head-hand coordination

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When making goal directed arm movements we move not only our hand but also our eyes and head. The coordination between the three has not been explored when intercepting moving targets. We asked how such coordination depends on the precision with which one can anticipate the interception point. We explored eye-head-hand coordination while subjects attempted to hit targets that followed unpredictable trajectories. Subjects were instructed either to hit the target while it crossed a small white disk that was visible from the beginning of the trial or to hit it while it crossed a large white ring centred at the point at which the target appeared. The targets' trajectories and the times at which they were to be hit that were identical in both cases, but the eye-head-hand coordination was clearly different. When subjects knew where to hit the target from the beginning of the trial, they moved their hand straight to that position and waited close to the disk until the target arrived. Their eyes fixated the position at which the target was going to be hit, and their heads were oriented towards that position early during the movement. When they did not know in advance where they would have to hit the target, subjects moved their hands more slowly and adjusted the movement as the position at which the target would cross the ring became clearer. In that case, the eyes tracked the target's movement and the head orientation changed later.

Investigating the relationship between symmetry and closure using contour integration tasks

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Introduction: Studies have shown that symmetrical shapes are processed faster and preferred more by humans, and this is believed to involve a global processing mechanism. Closure is another perceptual grouping cue that involves global processing, where closed contours (e.g. a shape) are easier to detect than non-closed contours (e.g. a single line). As both symmetry and closure rely on global mechanisms, the two processes may have bidirectional links and influence each other. At present, the impact of closure on symmetry detection remains unknown. Therefore, using two experiments we (1) examined whether the perceptual advantage for symmetry is present for both closed and open contours (2) investigated the effect of closure on symmetry detection. Both experiments were based on contour integration tasks where healthy participants had to detect Gabor elements forming a contour amidst a background of randomly oriented Gabors. We compared contour detection between symmetrical-closed, asymmetrical-closed, symmetrical-open and asymmetrical-open contours. Additionally, we compared symmetry detection between open and closed contours at different levels of symmetry. Results: In experiment 1, we found that the symmetry benefit was present with closed but not open contours. In addition, the closure effect was larger with symmetrical than asymmetrical shapes. In experiment 2, we found that symmetry detection was also better with closed than open contours. Conclusion: Closure and symmetry have bidirectional links and benefit each other, suggesting that altered perception in one might affect the other.

How a visual representation and mechanism complexity influence reaching with a tool

Qinqi Xu, Eli Brenner & Gabriel Baud-Bovy

Operating a complex tool requires an internal model of the kinematic transformation between the hand and the end-effector (EE). While this transformation is simple for some tools, this is not always the case for more technologically advanced tools such as the laparoscope. In this study, we investigated whether seeing the mechanism of planar linkages helps control the EE position. The study investigated the control of five types of 2-DOF planar linkages constructed by revolute and prismatic joints: RR, PR, RP chains (2 links), a RR chain with a RR constraint, and PR chain with a PR constraint (4 links). Each was investigated in three visual conditions: 1) only the EE position was visible, 2) the linkage was visible during a short period before starting the task and 3) the linkage remained visible during the entire task. Participants were asked to move rapidly and accurately to reach as many targets as possible in some allotted time period. Results showed that seeing the mechanism during the movement had a significant effect on the number of targets reached. It greatly improved control of the 2-bar linkages. Seeing the linkage did not improve reaching performance when manipulating four-bar linkages. Only having seen the linkages in advance had little effect. The differences were more marked for naive participants. Practicing controlling similar types of mechanisms improved participants' performance.

Does relevance shape individual differences in local/global perception of ambiguous motion displays?

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Perceptual organization is not merely the result of stimulus characteristics determining perception in an identical fashion across passive observers. It is determined by a complex interaction between individual and stimulus properties. Because of individual differences, basic (e.g. size) and higher-order (e.g. relevance) stimulus properties differentially affect perception. In the current study, we were interested in baseline differences in, and the malleability of so-called local and global percepts of a bistable stimulus in relation to basic visual processing (spatio-temporal contrast sensitivity). In particular, we asked whether a previously observed 'shift-to-global' can be attributed to relevance of the global percept or mere exposure to the stimulus. Observers were presented with a bistable motion stimulus that could either be perceived as separate rotating dot-pairs (local) or as a configuration of two pulsating geometrical figures (global). In a learning phase, relevance of both percepts was manipulated and participants were divided into three conditions: mere exposure, local task training, and global task training. In a pre- and post-learning test, participants reported their percept for different dot distances and transition points between local and global percepts were measured. In addition, spatio-temporal contrast sensitivity was measured. If mere exposure is sufficient for eliciting the 'shift-to-global', we predicted that transition points should not change differentially depending on the learning condition. Alternatively, if stimulus relevance is responsible for the 'shift-to-global', we predicted that transition points should change in function of general relevance or the learned relevant aspect of the stimulus (i.e., local versus global).

Investigating eye and head movement across different surface conditions

Nicholas Thomas & Rebecca Lawson

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Most existing research investigating the connection between vision and walking behaviour (including postural instability) has been limited to smooth, laboratory based environments. Results from such studies may not generalise to inform us about the factors influencing real-world walking in outdoor environments. Furthermore, existing studies which have tracked eye movements during locomotion have rarely also analysed head position. Both measures are needed in order to determine gaze location in the 3D environment, which was what was investigated in the present study. We used a mobile eye tracker and four inertial measurement units (IMUs) to monitor people's gaze, head position and gait parameters whilst they walked over smooth, flat and rough, irregular surfaces in matched indoor and outdoor settings. Preliminary results from the indoor conditions indicate that people walking on irregular surfaces had a slower, more cautious gait and a reduced step length, as well as an increased step width. Combining information about gait parameters with gaze location (by analysing eye movements relative to head pitch) should enable us to gain for a greater understanding of how we adapt our gaze when traversing different surface conditions. The study aims to provide a greater understanding of how surface conditions impact walking behaviour in young, healthy adults in order to inform our overall goal of understanding how visual factors influence stability and propensity to falling in the elderly.

The effect of corrupted feedback on perceptual inference

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Learning becomes challenging when the environment is unpredictable. Previous studies showed that environmental unpredictability induced by corrupted performance-based feedback led to the perception of illusory patterns in noise. A possible explanation for this phenomenon is that under conditions of unpredictability, observers relied less on available sensory data and more on prior expectations. We tested this hypothesis using a detection task in combination with preceding auditory cues. Prior to the feedback manipulation, participants were trained to learn the association between target presence and cue tone frequency (75% contingency). Following this, the impact of corrupted feedback was measured by means of interleaved Test and Intervention blocks. Target-predictive cues were shown only in Test blocks, and corrupted feedback was provided only in Intervention blocks. Test blocks enabled us to measure changes in performance and cue-association resulting from Intervention blocks. Participants also performed a control session, when correct feedback was given in place of corrupted feedback. Our hypotheses were that, in the Test blocks, (1) performance would deteriorate over time, and (2) perceptual inference would increasingly emphasize prior cue-based information over sensory information, leading to an increase of cue-congruent choices across Test runs. In a sample of 34 healthy participants, we found a substantial decrease in performance ($p<0.001$) and an increase ($p = 0.037$) in cue-congruent behaviour for the corrupted feedback sessions relative to the control sessions with correct feedback. These results suggest that corrupted feedback can lead observers to place relatively more weight on prior information.

Predicting Eye and Head Coordination While Looking and Pointing

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The GLANCE Project at the University of Bristol is an interdisciplinary effort with the goal of developing a wearable assistive device that would monitor behavior in tasks and present short video clips to guide behavior in real-time. In particular, we are interested in the relationship between head orientation and eye position. In our proposed system, eye tracking data may not always be available, and we would like to predict eye position from a head orientation sensor. We have recorded eye, head and hand movements while participants

performed a pointing & looking task. Participants stood in front of a board oriented either horizontally or vertically and were asked to either point or look at a series of targets in a predetermined sequence, an anticlockwise radial pattern. On each trial, participants began at a central start point. When a go signal sounded, they had a brief amount of time to either tap or look at the target and then return to the central start point. Trials were blocked using stimuli arranged in a small (up to 15 deg separation), medium (30 deg), or large pattern (60 deg) and timing per target varied as either fast (2s) or slow (3s). We present a variety of descriptions of behavior comparing across conditions (e.g. distribution of eye-in-head position, eye-head latencies, magnitude of head movements) and then discuss using the data set to predict eye position versus using a central bias model, and under what conditions such a model might be useful.

Shape perception generate from first sensory prediction then background inhibition: A MEG study

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Grouping local parts into coherent shapes is a central function in vision. It has been suggested to be a generative process that feedback signals carry predictions and feedforward signals represent prediction errors. Although recent fMRI studies provide evidence supporting the predictive coding hypothesis in illusory shape perception, the neuronal temporal dynamics underlying this generative process remains unknown. To address the issue, we recorded magnetoencephalography (MEG) signals while human subjects were presented with three Pac-Man figures, the combination of which is either or not able to induce an illusory shape perception ('Kanizsa triangle'), corresponding to grouping and ungrouping conditions respectively. Critically, here we employed a temporal response function technique (TRF) combine with randomly modulated the luminance of each Pac-Man to extract neuronal response specific for each Pac-Man figure. First, the TRF responses for grouping condition showed decreased activities compared to the ungrouping condition, consistent with predictive coding account. Second, two time periods, one early and one late, showed the inhibition effects. Specifically, within 100 150 ms, a beta-band (14-20 Hz) decrease was originated in bilateral early visual cortex (V1 and V2) and TPJ regions; within 200-400 ms, a theta-band (4-7 Hz) inhibition was found to arise from right IFG and TPJ regions. We propose that the illusory shape perception consists of two stages: an early one that quickly encodes predictive error in early sensory areas and a late one that performs background inhibition in right parietal and frontal regions after the establishment of illusory shape as foreground.

Multi-modal serial dependence: No effect in audition, but vision survives auditory interference

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Serial dependence refers to a phenomenon whereby a stimulus viewed at the present moment is biased to appear similar to stimuli seen in the recent past (Fischer & Whitney, 2014). Here we ask whether serial dependence can operate across two modalities simultaneously. We tested for visual and auditory serial dependence in a multimodal stimulus: an oriented Gabor grating (0°–180°) and a sound from a continuous vowel space (/u:/–/ɜ:/–/ɑ:/). On each trial, the stimulus was presented with a random orientation and vowel sound, and participants reported their percept of either modality in an adjustment task. In Experiment 1, participants judged either the visual or auditory modality while ignoring the other throughout blocks of the experiment. Our results replicate visual serial dependence, i.e. responses for the current stimulus orientation were systematically attracted to the stimulus orientation in the previous trial. However, we did not find any serial dependence for auditory trials. In Experiment 2, participants judged a randomly selected modality on every trial. Results mirrored those of Experiment 1, showing that there is visual serial dependence even if we simultaneously attend to information from separate modalities, but no effect for auditory responses. Interestingly, visual serial dependence was unperturbed by intervening trials with auditory responses, even though there was visual information present. We continue to observe visual serial dependence even if two visual response trials were separated by several successive auditory response trials. Therefore, visual serial dependence is robust to interference from the auditory modality.

Estimating variability and accuracy in remote mode infant eye tracking

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Max Planck Institute for Human Development

Eye tracking with infants has become a common method to investigate a multitude of phenomena concerning infant cognition. However, fussiness caused by the repetition of calibration stimuli and body movements during testing are frequent constraints on measurement quality. Here, we systematically investigated these constraints with 29 infants (8 - 12 months of age) and 25 adults using EyeLink® 1000 Plus. Both groups performed several tasks that allowed us to compare looking time and dispersion of gaze points elicited by stimuli resembling commonly used calibration animations. The adult group additionally performed a variety of body movements during gaze recording, equivalent to movements that infants spontaneously produce during testing. In our results, infants' preference for a particular calibration target did not predict precision after calibration, but targets with globally distributed complexity or targets that exhibit the strongest contrasts in their centre resulted in the highest recording precision. Our gaze measures from the adult movement tasks were differentially affected by the type and direction of head movement as well as the attended screen location. Specifically, movement towards the screen resulted in lower dispersion during a fixation, but increased measured gaze distance to targets. Following the stimuli

with head turns resulted in low overall precision and reduced accuracy especially at peripheral screen locations. These heterogeneous effects of movement on measures should be taken into account when planning infant eye tracking experiments. Additionally, to improve data quality, infants' commitment to repeated calibrations can be enhanced by alternating between precise calibration targets.

No external focus advantage for novice in a mirror drawing task

Shi-Sheng Chen & Li Jingling

China Medical University

Focus of attention can affect motor learning efficiency. In particular, external focus, i.e. focus on the consequence of actions, was shown to improve learning speed and learning retention. Meanwhile, theory on motor coordination suggests that internal focus, rather than external focus, may critical for novice. The goal of this study was to investigate the effect of attentional focus in a mirror drawing task. The mirror drawing task is rare seen and rely on eye-hand coordination, therefore was selected as the motor learning task for novice. Attentional focus was manipulated through instruction. The external focus group emphasized to follow their drawing behavior from the mirror, while the internal focus group to feel their wrist during drawing. Totally 57 right-handed males were recruited according to Edinburgh Handedness Inventory. Their age was between 20 to 25 years old. Results showed significant improvement of learning, that is, second trial (65.51 second) was faster than the first trial (116.46 second), for both groups. There was a tendency faster completion of drawing for external group (109.32 second) compare to internal group (123.61 second) at the first trial, leading to a smaller improvement for external group (45.68 seconds) than that for internal group (55.61 seconds). Our data did not support for the external focus advantage on mirror drawing novice, suggesting that eye-hand coordination may require internal focus for novice.

On estimating within-word landing positions

Johan Chandra, André Krügel & Ralf Engbert

Universität Potsdam

Despite high-precision measurement technique, inferring the intended landing positions during reading directly from eye movement data is difficult, because the within-word landing positions are noisy. We analyze the reliability (mean absolute estimation error and mean estimation bias) of three different methods: (1) The mean value of all observations (arithmetic mean method), (2) the peak of truncated distributions (i.e., based on a Gaussian fitting method), and (3) the maximum-a-posteriori estimator from Bayesian inference in estimating the mean (

General model of anomalous motion illusions and retinal image shifting factors

Masanori Idesawa

The University of Electro-communications

Anomalous motion observed in still figure (Fraser and Wilcox, 1979 Nature 281 565 - 566) and in slowly moving figure (Ouchi illusion family) are fascinating topic in human vision study. The author reported the model of anomalous motion illusion (Idesawa, 2010 Optical Review, 17, 557-561, 2010, Perception 40, ECVP Abstract Supplement 172). In the model, periodical retinal visual reset (such as periodical zero level renewing) was postulated and quasi-continuous motions were perceived from the repetitions of short range retinal image shift. Retinal image shift were caused by neural filtering (lateral inhibition) and/or delaying characteristics in photoreceptors (dragging tails or rising head). This time, in addition to these factors, response time differences between S, M and L cone cells and the gamma characteristics of them (latency and/or saturation) were taking account. Intensity distribution of the retinal image is seemed to be the summation of detected intensities of S, M and L cone. S cone is fastest, L cone is slowest; the intensity distribution of retinal image lean to blue color intensity at the beginning of the period and shifting to the summation of all color intensities. Gamma property work so that crashing the higher intensity part, then the retinal image intensity distribution seems to be shifting from higher part to lower part. Then almost all of the features can be explained consistently. As for the retinal visual reset, although the mechanism is not yet clear, new functions of retina including muller cells are expected to be found.

Research on translational medicine of binocular visual function evaluation in strabismus

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Objective: Strabismus surgery is used to correct the anatomical eye position clinically, we develop a novel VR binocular vision method to measure and access the changes and recovery condition after operation, viewing from the retina-brain neural system, not only the eye's optical system.

Methods: 107 strabismus cases before surgery and 155 after sugery, aging 4-10, were examined for strabismus angle routinely, and then measured and accessed the binocular visual function using two binocular visual perceptual model, including binocular alignment model and stereopsis model. All the data were analyzed statistically.

Results: There is a positive correlativity between strabismus angle and binocular alignment deviation before surgery, but no correlativity after operation. There is a positive correlativity on binocular horizontal alignment deviation between preoperation and postoperation, but no correlativity on binocular vertical alignment deviation. Most patients (100 patients pre-operation, 140 patients postoperation) showed severely motion parallax stereopsis function impairment.

Although the anatomical eye position is corrected and binocular horizontal alignment deviation is improved, postoperation, binocular vertical alignment deviation and motion parallax stereopsis function is not improved. We can infer that

they are manipulated by the high-level visual information processing pathways and the retina-brain neural system.

Hierarchical processing in tripole glass pattern perception

Yih-Shiuan Lin & Chien-Chung Chen

National Taiwan University

The percept of Glass patterns involves both a local process of connecting dots into dipoles, and a global process of integrating dipoles into global forms. We used fMRI to investigate the hierarchical processing for tripole Glass patterns (tGPs), which composed of randomly distributed tripoles, instead of dipoles. In each tripole, an anchor dot and two context dots formed the vertices of an equilateral triangle with the anchor dot pointing toward the center of the display. Grouping any two of the three dots into dipoles would result in a global percept of a clockwise (CW) spiral while grouping with the other dot, a counterclockwise (CCW) spiral. Grouping the two context dots together would result in a concentric (CC) pattern. Thus, multiple global forms were presented simultaneously and competing with others in one tGP. The probability of favoring either one of the groupings was achieved by manipulating context dot contrasts and orientation. A random dot control patterns (Con) was also used. The contrasts of the context dots were arranged in ways that CW, CCW, and Con patterns shared identical local properties but produced different global percept, while CC pattern was both locally and globally different from the rest. The multi-variate pattern analysis (MVPA) result showed that V1 and LOC successfully differentiated between locally different tGPs (CC and Con patterns), but not globally different ones. Higher-level regions like hV4 and FFA could differentiate between globally different pairs, but not locally different ones. Our findings supported a hierarchical process in form perception.

Looping in the pupil: Endogenous pupil oscillations provide a biomarker of optic neuritis

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We present a novel method where the real-time coupling of pupil size with the luminance of a visual stimulus induces endogenous pupil oscillations (PO) around 1 Hz. In our setting, pupil size is transformed into luminance such that a dilating pupil elicits a luminance increase which in turn evokes a constriction, provoking a luminance decrease, and so on. The period of PO reflects the time taken to: i. process the retinal stimulus, ii. send signals through the optic nerve to pupil circuits (with relays in the PON, the Edinger-Whestphal nucleus and the ciliary ganglion) before iii. the constriction/dilation of the iris sphincter. We hypothesize that damage to the optic nerve (e.g. demyelination of the nerve fibers in Optic Neuritis -ON) should result in a slowing-down of the frequency of pupil oscillations, due to a slowing-down of the propagation speed through the optic nerve. We test this hypothesis by recording (EyeLink, 500 Hz) monocular and binocular pupil modulations during trials (N=24) of 30 seconds with a blue, red, green or white stimulus (20° disk) in 22 patients with unilateral ON, and in 22 healthy controls. The results show that the frequency of PO in the affected-eye of ON patients is lower than in their fellow-eye (and than in binocular recordings). No such difference between the 2 eyes is seen in control subjects. We conclude that the frequency of PO induced by pupil/luminance coupling provides a reliable biomarker of ON, and possibly of other neuropathologies.

Spatial heterogeneity within perception of bistable images

Nonie J. Finlayson, Victorita Neacsu & D. Samuel Schwarzkopf

University College London

Object perception is generally considered to be insensitive to changes in visual field location. However, recent research has found spatial heterogeneity in the perception of object features such as a size and gender. Here we explored if spatial heterogeneity of perception also affects bistable object perception. Afraz, Pashkam, and Cavanagh (2010) proposed that perceptual heterogeneities arise due to sparse neural sampling. We hypothesised that there may be more face- or object-tuned neurons with receptive fields covering particular locations, which would result in biases in a bistable illusion at different locations. We used Rubin's Vase, a bistable object perceived as either a vase or two faces, to test individual differences in object perception across the visual field. The stimulus was briefly presented at one of 18 visual field locations across two eccentricities, and participants (n = 14) were asked to indicate whether they saw a vase or faces. This experiment was repeated over three sessions on separate days, with stimuli presented 54 times in each location per session. As predicted, individual patterns of response varied widely across the visual field for each participant, but these patterns of bias were stable within-participant over time. We then used fMRI and population receptive field mapping to test if face and vase localiser activity of spatially selective voxels correlated with individual biases at each location. However, we found no evidence for this either in early visual cortex nor object-responsive regions. These results suggest that ambiguous perceptual biases might be more related to early basic processing.

Confidence as a diagnostic tool for perceptual aftereffects

Regan Gallagher & Derek Arnold

The University of Queensland

Much of what we know about how our sensory systems operate comes from studying aftereffects. Prolonged and repeated exposure to a constant stimulus (adaptation) can impact responses to subsequent test stimuli, compared to non-adapted (baseline) responses. Researchers often infer, based on changes to response patterns, that sensory encoding has been changed by adaptation. But behavioural methods are limited, and this type of result could equally be explained by changes to decision processes. In some instances, judgements about our sensations might change, but the underlying sensory encoding might not be impacted. In this talk, I will propose a method for detecting whether an aftereffect results—partially or entirely—from changes to decision processes as opposed to sensory coding. I suggest that measures of confidence have diagnostic value in determining the underlying cause of different types of aftereffects.

The effects of Gestalt grouping cues on synchrony perception: A powerful role for grouping by colour

Benay Başkurt & Aaron Clarke

Bilkent University

An animal running through patches of light and shadow generates a flickering pattern of contrast on an observer's retina. The flicker is locally synchronous amongst visual elements projecting from the same animal, but asynchronous between separate visual elements projecting from the animal and its environment. Thus, in the natural environment, elements that are part of a common object may be expected to flicker together, while elements that are parts of separate objects may be expected to flicker out of synch. Given only partial information about flicker, the visual system could fill in the missing information by propagating synchrony information via perceptual grouping cues. Synchrony has indeed been found to be influenced by grouping cues such as good continuation, proximity, similarity, and closure – modulating synchrony percepts by as much as 20°. Here we tested the effects of grouping by colour similarity on synchrony percepts and found the strongest effects reported yet, with perceptual phase shifts as high as 90°. Our simple experiment employed coloured dots on a gray background. On one side of the display, the dots were all the same colour, while on the other side they were split (top-to-bottom) into two separate colour patches. Flickering elements on the solid side were perceived to be much more synchronous than elements on the split side, thus demonstrating the efficacy of colour-based grouping cues on synchrony percepts.

stimBOLD: Towards a complete forward prediction from visual stimulus to BOLD.

Mark Schira[1], Kevin Aquino[2], Michael Breakspear[3] & Peter Robinson[4]

[1]University of Wollongong; [2]University of Nottingham; [3]Queensland Institute of Medical Research; [4]The University of Sydney

Functional magnetic resonance imaging (fMRI) has become a standard tool in vision science, and some properties of visual cortex are fairly well understood and modelled, such as retinotopic organisation, contrast response functions and the spatiotemporal Hemodynamic Response Function (stHRF). Here we combine these individual models into a new framework, integrating existing models. The key components are (i) retinal processing; (ii) accurate retino cortical projection (Schira et al 2010); (iii) neural responses; and a (iv) spatiotemporal hemodynamic modeling (Aquino et al. 2012 PLoS CB), combined to a modular toolbox. We argue that the result is greater than the sum of its parts, allowing the complete simulation of fMRI experiments, from visual input (video) to BOLD responses in space and time on an average cortical surface (FS_average) within a few minutes. This supports a number of novel applications. Firstly, exploring interactions between the models and generating exact predictions for a more realistic testing of each of the integrated models. Secondly, a more precise planning of fMRI experiments by generating concrete hypothesis in the space that is actually measured, such as estimating the effect of spatial and temporal interactions between multiple stimulus components. Thirdly, it provides a novel teaching tool, with approximately 5-10 minutes from stimulus video to simulated BOLD responses on a normal desktop computer.

We call it "DIRTI" (Disgust-RelaTed Images): Development and validation of a novel set of disgust-inducing pictures

Anke Haberkamp, Julia Anna Glombiewski, Filipp Schmidt & Antonia Barke

Philipps-University Marburg

Disgust is a basic emotion elicited by objects (such as rotten food, body excretion) and plays a major role in the development and maintenance of psychological disorders such as obsessive-compulsive disorder or specific phobias. However, no validated picture set exists for disgust - forcing researchers to use unvalidated stimuli from various sources. We developed a standardized picture set consisting of 240 disgust-inducing pictures divided into six categories (food, animals, body products, injuries/infections, death, and hygiene), and included 60 matched neutral pictures (10 per category). Those pictures were rated by 200 participants (18-75 years) on nine-point rating scales measuring disgust, fear, valence, and arousal. Category means for disgust (1 = none and 9 = very strong) were: rotten food 4.7±0.6 (3.4-5.8), animals 3.3±0.6 (2.2-4.6); body products 4.4±1.2, (range 1.6-6.9); injuries/infections 3.7±1.0 (1.8-5.5); death 4.5±0.9 (2.3-6.2); hygiene 3.6±1.0 (1.3-6.4); and neutral 1.1±0.1 (1.0-1.4). Men and women differed with regard to disgust ratings of individual stimuli; age and disgust ratings were unrelated (r=-0.02) For each picture, we supply ratings for men and women. The pictures in each category vary from medium to strong disgust, enabling researchers to choose the appropriate degree of disgust. We also provide a luminance-matched version. We hope that the validated stimulus material will prove useful to the experimental research of disgust and help to improve the comparability between studies. (Download DIRTI picture set: http://dx.doi.org/10.5281/zenodo.167037).

SNARC effect & visual illusions: Do phenomenal magnitudes equate physical magnitudes?

Valter Prpic, Alessandro Soranzo, Carlo Fantoni, Alessandra Galmonte, Mauro Murgia & Tiziano Agostini

De Montfort University

Both numerical and non-numerical magnitudes elicit similar SNARC-like compatibility effects, with small (vs. large) magnitudes associated with left (vs. right) sided responses. Indeed, faster responses are typically obtained when participants are asked to categorise small numbers and physically small figures (e.g., disks) with a left key, while faster responses are obtained when large numbers and figures are responded with a right key. In the present study, we aim at investigating whether the phenomenal size of visual illusions elicits SNARC-like compatibility effects similarly to physical magnitudes. For this purpose, we ran two separate experiments by using two different illusions: the Delboeuf illusion (Exp. 1) and the Kanizsa triangle illusion (Exp. 2). In Experiment 1, participants performed a speed-comparison between the apparent size of two physically identical circles (targets) surrounded by two annuli (inducers) with different diameters, with stimuli presented simultaneously (one on the left and one on the right side of the screen). In Experiment 2, we created a series of illusory triangles and control figures by manipulating the distance and the orientation of the inducers. Participants performed a two-alternative forced choice

(2-AFC) speed-judgement about the spatial orientation of the inducers. A SNARC-like compatibility effect was elicited in both the experiments, only by the physical size of the inducers, not by the phenomenal size of visual illusions. Thus, we suggest that the spatial representation of magnitudes encodes physical but not illusory magnitudes.

Adaptation to hybrid images: "Pitting" amplitude against phase

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Adaptation can strongly bias the perceived amplitude spectra (ex. blur aftereffects) and phase spectra (ex. face aftereffects) of images. We explored interactions between these aftereffects by examining how adaptation alters the appearance of hybrid images, formed by superimposing low- and high-pass filtered versions of two different images (Schyns and Oliva, 1999). Images were portraits of the actors Brad Pitt and George Clooney, filtered by removing contrast above or below 16 c/image, and then combined with varying weights to form graded transitions from one image to the other. Relative weighting was varied in a 2AFC staircase to determine the level at which the alternative images appeared equally salient. Observers made the judgments before or after adapting to the component images or to images with the amplitude and phase spectra swapped. Adaptation to one identity biased perception toward the alternate face, consistent with face aftereffects. These biases were independent of the relative amplitude spectra. That is, the perceived face in a morph from blurred Clooney to sharp Pitt was shifted similarly whether adapting to blurred Clooney or sharp Clooney. Conversely, blur judgments in the hybrid images were instead driven by the blur of the adapting image, regardless of the face carrying the blur. Our results suggest that adaptation can simultaneously and separately adjust to both the amplitude and phase spectra, even when these are "pitted" against each other in the component images and support the proposed function of adaptation in highlighting the salience of novel (unadapted) features of the stimulus.

The eggs illusion: Inducing factors of an illusory shape deformation

Kun Qian & Hiroyuki Mitsudo

Kyushu University

We report a new visual illusion on objects' shape, the eggs illusion, in which circular disks located at the midpoints between adjacent grid intersections are perceived as being deformed to elliptical ones. In psychophysical experiments, we manipulated some stimulus parameters including the grid luminance and disk size, as well as the shape of disks (circular or elliptical). Some of the parameters were demonstrated influential in producing the eggs illusion or changing the magnitude of the illusion. Based on the results, we found several common features between the eggs illusion and other grid illusions (e.g., the scintillating grid illusion), as well as some possible resemblances between the eggs illusion and other known perceptual phenomena (i.e. the apparent size illusion, the shape-contrast effect, and the Orbison illusion). We discussed the important role of orientation processing in producing the eggs illusion, and also suggested that similar mechanisms might underlie the eggs illusion and other grid illusions.

A transcranial magnetic stimulation study of representational momentum and representational gravity: Exploring the role of cortical areas V5/MT and TPJ

Nuno De Sá Teixeira, Gianfranco Bosco, Francesco Lacquaniti & Sergio Delle Monache

University of Rome Tor Vergata

The perceived vanishing location of a moving target is systematically displaced forward, in the direction of motion, and downwards, in the direction of gravity. These phenomena, taken to reflect the functioning of internal models of physical invariants, were coined, respectively, Representational Momentum and Representational Gravity. Despite the wealth of knowledge gained during the last decades concerning the variables that modulate these displacements, little is known about their neurophysiological substrates. The present work attempts to fill this gap. Cortical areas V5/MT (Medio-Temporal) and TPJ (Temporo-Parietal Junction), thought to bear upon Representational Momentum and Representational Gravity respectively, were subjected to Transcranial Magnetic Stimulation (TMS), with an offline theta-burst protocol (following a Baseline-TMS-Recovery design). During each block, observers were shown a target moving smoothly along one of several possible directions and required to indicate its offset location with the aid of a computer mouse. In the course of each trial, gaze position of both eyes was recorded at a 500Hz frequency, as were response times and the horizontal and vertical coordinates of the localization response. Main findings were that stimulation of MT area increased the dispersion of localization responses along the target's motion direction. Conversely, stimulation of TPJ area decreased the dispersion of localisations selectively for descending targets, partially cancelling out the downward anisotropy found in the remaining conditions. These findings sheds light on the neural basis of Representational Momentum and Representational Gravity, bearing directly upon their link to internal models of physical invariants.

SNARC flexibility is explained by the semantic congruity effect

Giulio Baldassi, Mauro Murgia, Tiziano Agostini, Valter Prpic & Carlo Fantoni

University of Trieste

Recently, a growing consensus has emerged regarding the instructional flexibility of the mental format of non-symbolic magnitudes (e.g., quantities of objects' collections, just-learned height, animals' size). Indeed, while it is well-established that symbolic magnitudes are stably organized according to a left-to-right orientation, this organization is less clear regarding non-symbolic magnitudes. Flexibility has been invoked for accounting for patterns of response times generally observed in tasks involving comparative judgements and deviating from the standard SNARC (i.e., faster left-sided responses to small magnitudes vs. faster

right-sided responses to large magnitudes). We reinterpret flexibility in terms of the Semantic Congruity Effect (SCE): a general tendency for extreme, rather than intermediate, magnitudes to be detected more readily amongst a pair of elements belonging to the same semantic category (i.e., small-small/large-large) when the comparison task requires judging greater/lesser. A major prediction of SCE is a reversed SNARC for pairs of magnitudes displayed in incongruent spatial orientation with the left-to-right mental format. Right-sided responses should be faster for small magnitudes, and vice-versa for large magnitudes, when paired with an intermediate magnitude. We re-analysed the data of some previous studies and show that, in line with our results (Fantoni et al., ECVP2017), a reversed SNARC did reliably occur – consistent with SCE. This undermines preceding interpretation of results in the context of comparative judgements based on SNARC flexibility. In this context SCE provides a more general model than SNARC, being SNARC incidental to the spatial properties of a pair.

Estimating accuracy of spatial representations using virtual environments

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Lomonosov MSU

Humans are able to represent object locations using different spatial mechanisms: one encoding self-to-object spatial information, named egocentric spatial representations (ESR) and the second encoding object-to-object spatial information - allocentric spatial representations (ASR). We investigated the accuracy of ESR and ASR systems using the CAVE virtual reality technology. Six unique virtual scenes consisting of 7 objects located in different 3D positions were constructed. 36 observers were tested. The participant's task was to remember object's locations and then to reproduce a memorized scene in a virtual space using one of three imaginary viewer's positions: 1) the ESR front position (as if the participant would view the scene from the experienced view point), 2) the ASR left position (from the imaginary left point) and 3) the ASR above position (from the imaginary above point). To complete the task the participants chose a virtual object from the object's library and placed it in a virtual space. Coordinates of object's locations in virtual environment were recorded. The accuracy assessment of spatial representations was based on the evaluation of perceived metrics, topology and depth for each of three imaginary viewer's positions. Our results revealed that the topological accuracy was much better than the metric and depth accuracy regardless of an imaginary position. The ESR characteristics were more accurate than ASR ones. The developed method may be effective in measuring the features of ESR and ASR mental representations. The study was funded by Russian Scientific Fund project № 17-29-02169.

The effect of the symbolic meaning of speed on time to contact

Giovanna Mioni & Luca Battaglini

University of Padova

Our work examines the effect of moving task-irrelevant objects on time-to-contact (TTC) judgments. In particular, we investigated the effect of the symbolic meaning of speed on horizontal TTC by presenting two images of people driving a motorbike (fast speed) and a bicycle (slow speed) that then disappeared behind an invisible occluder. In a second experiment, we investigated the effect of the symbolic meaning of speed on vertical TTC using a rocket (fast speed) and a hot-air balloon (slow speed). Thirty-two students were asked to judge the TTC of these moving pictures, which disappear behind an invisible occluder, with a black line that indicates the end of the occlusion. As we expected, we found a shorter TTC when images of a motorbike or a hot-air balloon were presented rather than of a bicycle or a rocket, but only when the stimuli moved at 3.5 deg/s. It was suggested that the symbolic meaning of speed holds only at low speed and long TTC because the sematic elaboration of the stimulus needs a deeper cognitive elaboration. The current results have interesting implications in real-world situations that continuously involve both a perceptual and semantic judgment of moving vehicles.

Decoding integration and segregation over different time scales from the ongoing neural oscillations

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Two stimuli presented in rapid succession can be either integrated into a unique percept or segregated into two events. This process has been theorized in terms of temporal integration windows (TIWs), in which particular brain states, such as the phase of ongoing neural oscillations, determine whether two stimuli are integrated or segregated. However, the TIW duration varies across tasks, raising the question of whether these different TIWs map onto unique oscillations or, rather, reflect more general fluctuations (e.g. in the alpha band). We used multivariate decoding of electroencephalography (EEG) data to investigate perception of stimuli that either repeated in the same location (two-flash fusion task) or moved in space (apparent motion task). By manipulating the inter-stimulus interval (ISI), we created bistable stimuli that caused subjects to perceive either integration (fusion/apparent motion) or segregation (two un-related flashes). Training a Naïve Bayes classifier searchlight on the whole times/frequencies/channels space, we were able to reliably decode the perceptual outcome (integration vs. segregation) from the phase of pre-stimulus oscillations in right posterior-parietal channels. The highest decoding accuracy for the two-flash fusion trials (ISI=40 ms) was evident in the phase of alpha oscillations (8-12 Hz), while the highest decoding accuracy for the apparent motion trials (ISI=120 ms) was evident in the phase of theta oscillations (6-8 Hz). These results show a relationship between specific TIW durations and particular neural oscillations, suggesting that oscillations at different frequencies may provide a hierarchical framework for the temporal organization of perception.

Images from the darkside. On the psychology and aesthetics of blind Art

Tobias Teutenberg

Zentralinstitut für Kunstgeschichte

Eşref Armağan is a congenitally blind contemporary painter from Turkey, whose ability to organise pictures in perspective has drawn much attention from the worlds of neurology and cognitive psychology in the last few years. The main aim of scientists like John M. Kennedy (University of Toronto) and Alvaro Pascual-Leone (Harvard Medical School) is to answer the question of how it is possible for a painter who has never even experienced such concepts as light, to create visually comprehensible images.

My presentation will first give a brief introduction on the the history of Blind Art from the Early Modern period until the 20th century. Secondly I will engage critically with the unique drawings and paintings of Eşref Armağan, which invite us to think about the possibility of a completely non-visual conception, creation and reception of images as well as about the comparability of tactile and visual data in general. Thirdly, it will take a critical look at the psychological and neurological research on Armagan's output and methods as well as at the different hypotheses on spatial perception gained from this research. Finally, it will review the problems which arise from the use of art within the realm of scientific investigation.

Effects of color on time perception: Blue induces an overestimation of stimulus duration

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Eye tracking during viewing photos for visual attention questions in talent exams in photography departments

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Purpose: To examine whether the use of visual attention questions in viewing photos are apropriate for talent exams for photography departments. Methods: "Photography professionals and duayens"(33 subjects) , "starters" (1st and 2nd year in photography education, 33 subjects) and two age and education matched groups without photography education (21 and 33 subjects each) have undergone eye tracking with Tobii X2-60 Eye Tracker during watching six photographs one after another with following questions about the content details after each photo. The viewing time was 5 seconds and answering time 10 seconds after each photo. "Area of interest" and "heat map" of eye tracking in different groups were evaluated and compared. Results: There were statistically significant differences in some aspects of viewing of visual attention questioning photos. Conclusion: Using eye tracking for the visual attention photos may give some hints how the photography student can be chosen. On the other hand, the eye tracking results may give hints how to teach students to give attention to the visuals.

ERP responses to artworks, natural and uncomfortable images

Louise O'Hare

University of Lincoln

The visual system is metabolically costly (Lennie, 2003), and therefore images need to be processed efficiently (Barlow, 1961). The visual system is optimised to process natural images efficiently (Field, 1987; Field, 1994; Field, 1999). Abstract artworks have been suggested to be aesthetically pleasing as they are supposed to be particularly easy for the visual system to process (e.g. Mather, 2014; Ramachandran and Hirstein, 1999). Discomfort arising from certain striped and filtered noise patterns could be due to inefficient processing of visual information (Juricevic et al., 2010), and this has been supported by both computational modelling (Hibbard and O'Hare, 2015; Pennachio et al., 2015), and behavioural discomfort judgements (Juricevic et al., 2010; O'Hare and Hibbard, 2011). However, there are fewer studies directly measuring neural responses to uncomfortable stimuli in comparison to artworks and natural images. The current study demonstrates differences in ERP responses in contrast-matched stimuli of these three image classes (artworks, uncomfortable, and natural stimuli), supporting the efficient coding hypothesis.

Kandinsky or me? How free is the eye of the beholder in abstract art?

Doris Braun & Katja Dörschner

Justus-Liebig-Universität Gießen

Abstract artworks represent complex compositions of shapes, colours and graphic elements. Instead of aesthetic ratings we took a different approach and investigated abstract art perception by assessing (i) how the artist's colour palette of a painting influenced observers' colour choice for a single segment in the same painting (ii) if observers preferred their colour choices over the original and (iii) how the composition of the painting affected its perceived balance. 20 European and 20 Chinese participants (i) adjusted the colour of segments in 24 abstract paintings of Baumeister, Hoffmann, Delauney, Kandinsky and Klee, such that the segment 'best fits' with with the painting. Subsequently, in a separate experiment, they indicated (ii) their preference for the painting with the original or their colour choice. To measure the perceived balance (iii) observers indicated the "center of gravity" for each artwork by adjusting location and size of a black circle on an adjacent white rectangle. For both groups of observers colour settings were systematic, differing significantly from a random distribution of CIE-LAB samples and they were frequently not the same as the artist's choice. Unlike European observers, colour settings of Chinese observers were systematically related to the paintings' hue variance. Moreover, Chinese observers preferred darker and less saturated colours for the selected segments compared to Europeans. In both groups, observers' preference for their own versus the artist's original segment was similar. There was also a remarkable consistency between the two groups in the perceived center of gravity of the artworks.

Mobile eye tracking in the Royal Academy - analysing the interaction with abstract paintings.

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Studying eye movements when looking at artwork has a long tradition of lab-based experiments in which seated observers were presented with paintings – gaze patterns were interpreted as perceptual and cognitive processes contributing to aesthetic experience. The advent of mobile eye tracking now offers opportunities to study the experience of observers interacting with paintings in museums. We recorded eye movements of 24 participants moving freely in the Royal Academy of Arts (London) while looking at two abstract paintings by Jackson Pollock ('Mural' 1943, and 'Blue Poles' 1952). In these recordings we found extensive head and body movements, leading to rapid changes of viewpoints, head orientation, distance to the painting, and gaze jumps across the giant canvases: characteristics of spontaneous behaviour of the observer exploring art in the real world that were not allowed in the laboratory conditions. The spatial distribution of 36,637 fixations, in total, was visualised as 'heat maps' where the probability of fixations on image locations is aggregated for each observer and painting, and displayed in pseudo colour code on top of the painting. These distributions allow qualitative and quantitative analysis of gaze patterns, such as the centre, dispersion, and cluttering of gaze, size of shifts between preferred locations, and focal points in the paintings that preferentially attract observers' attention. We found considerable individual variations, and characteristic hotspots of fixations around distinct image regions, such as geometric singularities or shapes resembling familiar objects. Furthermore, temporal changes of fixation distributions reflect gradual formation of an internal representation of the painting.

Pupil constriction reflects not only facial attractiveness, but also appraisal evaluation for natural scenes

Hsin-I Liao, Makio Kashino & Shinsuke Shimojo

NTT Communication Science Laboratories

Our previous study showed that pupil constricts stronger when seeing attractive faces and the effect is specific to faces in contrast with making an attractiveness judgment for a line-drawing geometric figure (Liao et al., 2015, APCV). However, considering the inherently huge difference between faces and line-drawing geometric figures, it remains an issue whether the attribution of attractiveness judgment to pupil constriction is specific to biologically tuned stimulus such as faces, or can be generalized to intrinsically aesthetic visual objects other than faces. In the current study, we thereby used natural scene images to examine whether pupil constriction reflects appraisal evaluation for intrinsically aesthetic but not biologically tuned visual stimulus. Computer-generated face images, as used in the previous study, and natural scene photos collected from internet were image-processed to have equal average luminance. Each image was presented at the center of the screen until a decision was made. Participants judged the attractiveness of the images by giving a number from 1 (least attractive) to 9 (most attractive) while an infrared-based eye camera recorded their pupillary responses. Results showed that during inspection, people's pupil constricted stronger for the faces that were judged as more attractive thereafter. The result replicated our previous finding by using equal-luminance face images. Importantly, for natural scenes, the correlation between pupil constriction and attractiveness rating was also clearly observed. The overall results indicate a broader prediction power of pupil constriction to attractiveness judgment for intrinsically aesthetic visual objects such as natural scene images.

Wednesday August 30th Oral presentations

The role of attention in eye movement awareness

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We are surprisingly poor at reporting on our own eye movements. We previously found that people performed at around chance levels when reporting which objects they fixated in a photograph they just viewed, when selecting which of two scanpaths is their own, and when judging whether an animation of an eye movement matches the one they just executed (Clarke, Mahon, Irvine and Hunt, 2017). This finding seems to run counter to theories that there is an obligatory coupling of attention with eye movements, but the relationship between attention and awareness is still debated. Using an oculomotor capture paradigm, we found that people made frequent eye movement errors towards irrelevant sudden onsets and were unaware of these errors about half the time. Longer fixations on the onset were associated with increased awareness. To test the role of attention in eye movement error detection, we placed an irrelevant letter inside the onset. When the letter was compatible with the letter inside the target that participants had to report, responses were faster than when the orientation was incompatible. Importantly, whether or not participants were aware of their error did not influence the magnitude of this compatibility effect. This suggests greater attention to a fixated letter does not elevate awareness that the eyes landed on it, and that attention effects can be observed to a similar extent with and without awareness.

Single-cell study of higher-order disparity selectivity in the extrastriate cortex of the macaque brain

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Binocular disparity provides a strong, unambiguous depth cue in primates. Previous fMRI studies in monkeys (Van Dromme et .al, PloS Biol, 2016) revealed stronger activations in response to higher-order (curved and slanted surfaces) compared to zero-order (flat) stimuli in the medial bank of the caudal intraparietal sulcus (area PIP) and in area TEO of inferotemporal-cortex. The current study investigated the disparity selectivity in area PIP and TEO at the single-cell

level. We recorded 207 visually responsive neurons in area PIP of 3 monkeys. Eighty-seven PIP neurons (42%) exhibited significant disparity selectivity that could not be explained by the monocular responses. A sizable proportion of PIP neurons (27/69) preserved their preference across position in depth for first-order stimuli (five positions-in-depth, mean disparity -0.5 to +0.5). However, none of the PIP neurons tested (N=56) were position-invariant for second-order stimuli. The average response to the second-order stimuli at three positions-in-depth (-0.25 to +.25) was significantly higher than the response to zero-order stimuli at the same positions-in-depth, which could explain the fMRI activations. Out of 123 visually responsive neurons recorded in TEO, only 20 (16%) showed disparity selectivity, but no neuron preserved its preference across positions in depth for planar nor for curved surfaces. We suggest that – contrary to the predictions of the fMRI study - PIP primarily contains a representation of first-order disparity variations, whereas TEO did not exhibit any higher-order disparity selectivity.

The birth of a strong representation: Tracking the spatio-temporal neural trace of visual images

Caitlin Mullin, Yalda Mohsenzadeh*, Dimitrios Pantazis & Aude Oliva

Massachusetts Institute of Technology

Not all images are perceived equally — some have a higher likelihood of sticking in your mind. How does the brain process these images compared to those that fade into oblivion? Here we test the hypothesis that more memorable images show a greater neural perceptual trace (robust and sustained brain signals) than those that are less memorable. In order to access both high spatial and temporal neural signals, we employed the novel approach of fusing MEG and fMRI data (Cichy et al., 2014; 2016) using representational similarity analysis (Kriegeskorte et al., 2008). From the LaMem Memorability image set (Khosla et al., 2015), we constructed a subset of more and less memorable images balanced for both low-level image statistics and high-level semantic categories (faces, objects, scenes, animates). Results revealed that more memorable images recruited the medial and lateral regions of the occipito-temporal processing stream to a greater degree than the less memorable images. By 100ms after image onset, we find a more robust representation for high memorable images in the fusiform gyrus, lateral occipital and parahippocampal cortices. In addition, the neural representations of memorable images were more sustained in time both during (online perception) and after (iconic memory) image presentation. This robust and sustained representation found in high level brain regions for more memorable images could point to the processing of perceptual hooks (details) that encourage the system to encode the information into iconic and long term memory. *these authors contributed equally

Set size manipulations reveal boundary conditions of learning of statistical properties of perceptual ensembles

Árni Kristjánsson, Gianluca Campana & Andrey Chetverikov

University of Iceland

How do observers represent variation in the environment such as the colors in a moss-covered lava field or the brightness distribution in snow covered landscape? Recent evidence suggest that observers can assess surprisingly complex variations of feature ensembles in the environment. In visual search tasks where all distractors are randomly drawn from a certain distribution (e.g. unimodal, Gaussian versus bimodal), rather than being all homogeneous, observers are capable of learning highly complex statistical properties of distractor sets. After only a few trials (learning phase), the statistical properties of distributions - mean, variance and, most surprisingly, shape (Chetverikov et al., 2016, Cognition, 153(2016), 196-210), can be learned, and these representations affect search performance during a subsequent test phase. To assess the limits of such distribution learning, we varied the information available to observers about the underlying distractor distributions by manipulating set size of the visual search task during the learning phase in two experiments. We found that robust distribution learning only occurred for larger set sizes, suggesting that the smaller set sizes do not contain enough information for learning. Furthermore, we used set size to assess whether the learning of distribution properties increases search efficiency finding some evidence of faster search that was correlated with distribution learning. Overall, the results reveal how a certain minimum of information is required for learning of distribution charcterisitics, delineating the boundary conditions of learning of statistical variation in the environment.

Cortical origins of flash-lag effect distortions

Manuel Vidal, Sandrine Chemla & Frédéric Chavane

CNRS / Aix-Marseille Université

Perceiving the spatial location of static and moving objects involves distinct mechanisms. This was first evidenced with the flash-lag effect (FLE) where a dynamic object is perceived ahead in its trajectory compared to a flashed static object (Mackay, 1958). This effect has since initiated numerous theoretical debates on the brain's predictive vs. postdictive nature and its relation to phenomenal awareness (Eagleman & Sejnowski, 2000). In this project we relate physiological properties derived from recordings in V1 of awake monkeys with perceptual distortions of the FLE. First, a moving bar produces a propagation wave via lateral connections in V1 that starts increasing neurons activity before reaching their receptive fields. Second, this anticipatory activity increases with travelled distance. Third, this anticipatory activity is reset after crossing the vertical meridian (VM). In a series of experiments, we measured the FLE of humans in particular conditions. Consistently with the 1st & 3rd physiological evidences, we found a drastic reduction of the FLE just after crossing the vertical meridian, but not the distance relationship predicted by the 2nd. Measuring the FLE at every 0.5° of eccentricity showed a rapid and continuous decrease in anticipation when entering the VM area from petal to fugal. Since cortical density variations around the fovea could also contribute to such asymmetry, the FLE was measured vertically along the VM to disentangle between these sources of distortion. The petal/fugal asymmetry was not observed; instead, top-down influences from possible gravitational expectations introduced an opposite asymmetry. Theoretical implications will be discussed.

Saccade reorienting is facilitated by pausing the oculomotor program

Robert McIntosh[1] & Antimo Buonocore[2]

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As we look around the world selecting viusual targets, competing events may occur at other locations. Depending on current goals, the viewer must decide whether to look at new events, or ignore them. Two experimental paradigms formalize these response options: double-step saccades and saccadic inhibition. In the first, the viewer must reorient to a new appearing target; in the second, they must ignore it. The relationship between reorienting and inhibition is largely unexplored. In three experiments, we found saccadic inhibition 100 ms after a new target onset, regardless of the task instruction, to reorient or to ignore. Moreover, if this automatic inhibition is boosted by a large irrelevant flash at the time of new target appearance, reorienting is more successful. This suggests that, far from being a bug in the oculomotor system, saccadic inhibition plays a crucial functional role, as a bottom-up brake that buys the time needed for decisional processes to act. Saccadic inhibition may be a ubiquitous pause signal that provides the flexibility for voluntary oculomotor behaviour to emerge.

A key role for proscription in perceptual integration

Reuben Rideaux & Andrew E Welchman

University of Cambirdge

Human perception integrates multiple visual cues to achieve robust and accurate estimates of 3D structure. When small discrepancies are present, cues are weighted according to reliability. As discrepancies increase, perceptual integration gracefully degrades, preserving more reliable cue estimates. Here we develop and test a biologically-inspired model of integration that captures improved performance when information is consistent, but unlike previous models (Ohshiro et al., 2011), shows robust behaviour in the face of discrepancies. Our model makes use of the observation that many neurons are sensitive to unrealistic cue combinations (Gu et al., 2008). The central premise of our model is that incongruent neurons are used proscriptively to drive suppression of unlikely interpretations of the local environment, implying a central role for suppression in supporting robust integration. We therefore sought to test for neural signatures of proscription in the human brain. We first tested whether there is an association between robust integration and concentrations of the inhibitory neurotransmitter GABA in an area of the human brain intricately involved in cue fusion (V3B/KO). We show that GABA around V3B correlates strongly with perceptual cue integration. We then sought to perturb suppressive processing, using transcranial direct current stimulation to disrupt the excitatory/inhibitory balance in the region of V3B. We show that this leads to impaired perceptual integration. Together our modelling and empirical results point to a central role for proscription in supporting robust perceptual integration. This suggests a generalised mechanism for sensory processing that exploits 'what not' information to facilitate perception.

Representation of visual-scene boundaries in the human occipital place area

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What are the specific functional roles of the scene-responsive areas in the human brain? What are the visual features that our visual system rapidly extracts to recognize a scene, or to guide navigation within the scene? In this study, we test the hypothesis that the human visual cortex encodes the spatial layout of a scene, as defined by the boundaries of the visual environment. We constructed altogether 32 different spatial layouts, using all possible combinations of five walls (left, right, back, ceiling, floor), in three different textures (empty, fence, urban). The resulting 96 scenes were shown to 22 subjects during functional magnetic resonance imaging (fMRI). The scene-responsive brain regions occipital place area (OPA) and parahippocampal place area (PPA) were identified using an independent functional localizer. OPA and PPA as well as the primary visual cortex (V1) all responded to the scene stimuli, but evidence for spatial layout-based representations was only found in OPA. In OPA, the different spatial layouts elicited distinct response-patterns, and more importantly, OPA response-patterns showed successful generalization across the different textures. Similar cross-decoding results were not found in V1 or PPA. Moreover, the same subjects participated in a magnetoencephalography (MEG) experiment. The cortical representations in fMRI response-patterns and evoked MEG responses are characterized using representational distance matrices, and compared to each other. Taken together, our preliminary results suggest a rapid extraction of the spatial layout of the scene in the human OPA.

Short-term expectation influences visual function via a dissociable combination of motor and perceptual biases

Christoph Teufel

Cardiff University

Observers sometimes report seeing stimuli even if none are present. The nature of the processes underlying these false alarms has been a fundamental question ever since the early days of psychophysics. Conventionally, expectation is thought to affect false alarms by influencing strategic response rates. Recent work, however, highlights the role of expectation in shaping perceptual processing itself. The aim of the current experiments was to study the processes underlying the influence of expectation on perceptual performance in general and, particularly, during false alarms. I used a statistical learning paradigm, in which observers implicitly learned to expect a non-uniform distribution of orientations of Gabor patches. This expectation leads to predictable and systematic biases in orientation estimates in response to stimuli that are presented at threshold and that observers report having seen. Critically, a similar pattern is seen for false alarms: even on trials when no stimulus was presented, orientation estimates accord with the distribution of expected orientations if observers report having seen a signal. In two experiments, I demonstrate that this pattern of estimates can be explained in part by a motor bias acquired during the initial learning of orientation distributions. However, a robust

bias remains even when opportunities for motor learning are eliminated. The current results thus suggest that false alarms are not simply due to strategic responses. Rather, in the absence of sensory input, and having accounted for motor biases, the visual system internally generates a genuine percept through top-down influences of expectation.

Surprise! Violations of predictive coding result in sped recurrent sampling, which can enhance objective sensitivity and distort time

Derek Arnold & Alan Johnston

The University of Queensland

When an 'oddball' stimulus is embedded in a train of repeated standard stimuli, its duration can seem relatively protracted. One possible reason is that 'surprising' oddballs speed recurrent processes that contribute to estimating time. If these processes also extract information, this could promote a more rapid accrual of information. However, it is also possible that oddball durations are constant, with repeated standard events instead seeming shortened due to adaptation effects. We addressed both issues. First, we found evidence that oddball durations seem protracted, and repeated standard events seem constant, by having people mimic event durations, instead of taking relative time measures. We then examined sensitivity. All stimuli consisted of flashed split-half Gabors, with novelty adjusted by manipulating stimulus orientations. Sensitivity was assessed by adjusting spatial frequencies, with waveforms on either side of split-half tests adjusted up and down – a 2afc higher frequency detection task. Sensitivity was enhanced for oddball content, relative to tests following trains of randomly oriented stimuli. Moreover, we found that oddball sensitivity improvements had a marked temporal profile, absent for very brief (8ms) and long (>1000ms) tests, but pronounced for intermediate durations. These data are consistent with information being extracted from inputs via recurrent sampling, which is sped when a surprising input is encountered. This permits an advantage when tests last long enough to permit recurrent sampling, which is eliminated for even longer tests that permit sufficient sampling from both low and high frequency processes.

Eye movements in response to illusory shifts of visual targets

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We studied the subjective appearance, and saccades made, in response to illusory shifts of a target. In a modified version of the flash-grab illusion (Cavanagh & Anstis 2013), a target flashed repetitively in the same place, being colored alternately red and green. A moving background made the red target appeared to lie subjectively to the left of the green target, even though the targets were really congruent. Observers reported that they were saccading leftward and rightward toward the red and green targets. This is puzzling if the targets never actually moved, but recordings revealed that observers were also unknowingly tracking the moving background, in directions opposite to their saccades. Not all eye movements reach consciousness.

Monocular deprivation affects BOLD responses and spatial frequency tuning as measured with ultra-high field MR in adult humans

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Recent studies have shown that the adult visual cortex retains a high degree of plasticity as short-term monocular deprivation shifts ocular dominance (measured with binocular rivalry) in favor of the deprived eye (Lunghi et al. CurrBiol 2011). This form of plasticity is mediated by GABAergic inhibition: after deprivation, GABA concentration decreases in adult visual cortex proportionally to the increase in the deprived eye dominance (Lunghi et al. CurrBiol 2015). Here we investigated how short-term monocular deprivation affects BOLD (Blood Oxygenation Level Dependent) responses to monocular stimulation using ultra high field fMRI (7T). In 20 participants, we measured BOLD responses to white noise images, filtered to match 5 different spatial frequency (SF) channels. Stimuli were shown separately to the deprived and non-deprived eye, before and after 2h of deprivation. We also measured binocular rivalry to obtain a plasticity index for each participant. We find that deprivation enhances V1 BOLD responses in the deprived eye, while suppressing responses in the non-deprived eye. Using a modified version of the "population Receptive Field" model (Dumoulin & Wandell, Neuroimage 2008), we additionally estimate the shape of SF tuning curves in V1 voxels and found that, after deprivation, curves become broader for the deprived eye.

Given that GABAergic inhibition participates in regulating the strength of visual responses as well as neural selectivity (e.g. through lateral inhibition), we propose that lower concentrations of GABA after deprivation may result in stronger BOLD responses with broader tuning.

Lateral and ventral category-selective areas show a differential response to moving and static visual stimuli

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Functional magnetic resonance imaging (fMRI) studies have identified brain areas that respond selectively to different categories of visual stimuli. Multiple face, body and scene selective areas are found across the brain, but the functional distinctions between these areas remain unclear. To address this issue, we measured the fMRI response to dynamic and static stimuli in category-selective regions involved in face, body and scene perception. Participants (N=22) were scanned using fMRI at 7 Tesla while viewing short movie clips containing faces, bodies, scenes, objects or scrambled objects, as well as static images taken from these movies. Results demonstrated a functional dissociation between category-selective areas. Lateral areas, including face-selective regions of interest (ROIs) in the posterior and anterior superior temporal sulcus (STS), extrastriate body area (EBA) and the occipital place area (OPA) responded more to moving than static stimuli. By contrast, ventral and medial category-selective regions, including the fusiform face area

(FFA), occipital face area (OFA), face-selective voxels in the amygdala, fusiform body area (FBA), retrosplenial complex (RSC) and parahippocampal place area (PPA) all responded equally to moving and static stimuli. These results demonstrate a common functional dissociation between category-selective areas that respond to faces, bodies and scenes.

No external feedback is needed for perceptual learning to occur in local and global orientation tasks

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University of Essex

The necessity for external reinforcement, such as response feedback, during perceptual training is a topic of debate. Additionally, internal reinforcement may act in a similar way as external reinforcement, where easy trials act as the basis for learning. Liu et al, 2012 (Vis Res, (61) 15-24) found learning without feedback when mixing high and low accuracy trials, a result not replicated by Seitz et al, 2006, (Vis Res,(6) 966-973) using a global orientation task. A potential reason for this difference is that the stimuli used in the latter study involved low signal strength stimuli masked by background noise. To test this we performed two experiments, using local and global visual stimuli, respectively, in an orientation discrimination task. Fifty-six observers were assigned to one of four groups according to the type of task (global, local) and feedback (with or without). Detection thresholds were measured daily before and after training. A 75% detection threshold was determined for each session with training levels set daily at 65% (difficult) and 85% (easy) accuracy levels. While training thresholds were different for the feedback and no feedback conditions, significant learning occurred in all four groups. Therefore we replicate the findings of Liu et al., (2012) and extend them to global stimuli. In conclusion, interleaving high and low accuracy trials both local and global orientation tasks leads to perceptual learning independent of the external feedback. Perceptual learning occurs without feedback even for global tasks in which low strength stimuli are masked by background noise.

Adaptation to the locomotion speed of point-light walkers

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University of Lincoln

Adaptation to slowed-down or speeded-up videos of natural scenes depicting human locomotion causes later videos played at standard playback speed to appear too fast or too slow respectively (re-normalisation; ECVP 2015, 2016). Psychophysical data shows that the effect is qualitatively different from that obtained in retinal velocity after-effect experiments, and implicates a higher level process that encodes objective velocity. As a test for the involvement of high-level motion processes, we measured adaptation to locomotion speed using point-light walker (PLW) stimuli which varied in retinal size and facing direction while walking at a fixed locomotion speed. An after-effect of apparent locomotion speed was obtained using PLW adapting and test displays which was similar to the effect obtained with full-videos, and also transferred to test displays containing full-cue videos. To test whether the measured adaptation was due to a perceptual bias or to response or decision bias, we also measured the effect using a bias-free 2AFC method, rather than the method of single stimuli used in previous experiments. A significant adaptation effect was still obtained, indicating that a perceptual shift was responsible for the effect.

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A multistable gravitational potential approach to fixational eye movements

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Multistable perception occurs when a single but ambiguous stimulus drives perceptual alternations. Understanding its mechanisms has a direct impact on perceptual inference and decision making. A model proposed by Shpiro and colleagues explains the dynamics of bistable perception through neural adaptation and driving noise. Eye movement data from an experiment, in which participants observed a moving Necker cube in a continuous viewing paradigm, revealed that micropursuit-like fixational eye movements (FEM) can occur; a type of movements not accounted for in current FEM models. Our analysis also suggested that FEM can have an influence on adaptation and noise (Parisot et al., ECEM'17, Hicheur et al., JOV'13). Therefore, we propose a model that could help predict and explain away interactions between FEM and multistablity dynamics. It is based on gravity potential fields where their distortion by attractors allows the generation of multistability for the position of the gaze w.r.t. the different attractors. Adaptation and noise can be used as mechanisms to simulate the impact of stimulus motion and the task on FEM. Perceptual memory and/or anticipation of stimulus motion can be taken into account through potential field distortion. The model is able to generate drift, tremor, microsaccades, and micropursuits, showing that stimulus motion can influence the trajectories of drifts and microsaccades. Using attractors provides a link between models of multistable perception and FEM based on the mechanisms of noise and adaptation; making it possible to find correlations between perceptual and oculomotor dynamics.

Depth perception from ocular differences in input contrast

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Primary visual cortex (V1) uses two neural channels to encode stereo inputs: one each for the sum and difference of the inputs to the two eyes (Li and Atick 1994). While the summation signal dominates perception of non-stereo features such as motion, tilt, and face identity, aftereffects following adaptation to inputs from either channel show the influence of the difference signal on such percepts (May, Zhaoping, Hibbard 2012, May and Zhaoping 2016). However, the difference signal's role in depth perception is unclear, especially

when contrasts rather than positions of the inputs differ. This is despite the sensitivity to contrast differences of V1 neurons tuned to non-zero binocular disparities. Here, I show that making input contrast polarities opposite between the eyes can cause large changes in perceived depth. Furthermore, for inputs of the same polarity, an ocular difference in input contrast can make a surface appear slanted in depth. I presented observers with two zero-disparity, dark, surfaces, identical to each other in width and height, which were displaced and separated from each other vertically on a white background. One surface was darker in the left than the right eye, and the other was darker in the right than the left eye. Observers reported after a brief view whether the lower surface appeared slanted (rotated about a vertical axis) in one or the other direction relative to the upper surface. Their responses depended significantly on whether the lower surface was darker in the left or the right eye.

Subjects only prefer to view a linear image when the dynamic range of the displayed image matches that of the original scene

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As the dynamic range (DR) of an image/scene increases, the luminance distribution becomes increasingly positively skewed (Kane and Bertalmío, 2016). This effect is so strong that at very high DRs at least 99% of pixels lie within the first 1% of the total luminance range. The notion of efficient coding suggests that the visual system must counter this effect via the application of an adaptive, compressive nonlinearity, either by using the luminance distribution, or the DR of a scene, as a cue. To investigate this, we present images on various sub-ranges of a calibrated HD monitor (SIM2; DR>10^6), by keeping either the log-DR fixed (at 50% of the full range) and varying the mid-luminance level, or by fixing the mid-luminance level and varying the log-DR (from 100% to 50%). The images used are from the Fairchild database (2007) which span a wide distribution of DRs (from 10^2 to 10^7). Subjects viewed each image under a variety of power-law transforms which either darken ($\gamma>1$), or lighten ($\gamma<1$), the relative luminance distribution. The results show that subjects only prefer to view a linear image ($\gamma=1$) when the DR of the original scene and the DR of the displayed image are matched. Other factors such as the mid-luminance play a significant, but relatively small role. The results indicate that visual adaptation is primarily determined by the DR of the presented image, not the skew of the presented image.

Role of color in ocular dominance plasticity

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Temporarily depriving one eye of its input, in whole or in part, results in a transient change in perceptual eye dominance with the deprived eye becoming stronger and the nondeprived eye weaker. By measuring the relative contribution of each eye to the binocular percept, we determined the role of color vision in initiating and reflecting these neuroplastic changes.

Using dichoptic movie viewing in which the information to one eye is altered over a period of 2 hours, we show that the monocular deprivation of either chromatic information alone or achromatic information alone is capable of producing neuroplastic changes in ocular dominance. The changes in ocular dominance are very subtle for color deprivation but very obvious for the achromatic deprivation. On the other hand, once produced by however means, neuroplastic changes in ocular dominance affect achromatic and chromatic sensitivity equally. A picture emerges in which interocular imbalances in purely achromatic contrast are best at driving plastic change in perceptual eye dominance (induction selectivity) and these plastic changes once produced are reflected in similar sensitivity changes to both chromatic and achromatic stimuli (response unselectivity).

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Saccadic inhibition as an index of anticipation in a discrimination task

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Predicting the timing of upcoming events improves resource allocation and action preparation. Temporal anticipation is most commonly estimated using behavioral measures: when visual stimulus onset can be predicted, its perception is enhanced, as indicated by increased accuracy-rates and decreased reaction times in detection and discrimination tasks. However, these measures are indirect as they evaluate temporal anticipation retrospectively rather than index the process in real-time. A recent study has shown that temporal predictions can be assessed directly by measuring prestimulus suppression of saccades in a detection task. Here we investigated whether the inhibition of fixational saccades can serve as an index of temporal anticipation in a discrimination task and compare to behavioral indices of temporal sensitivity. In each trial, observers were requested to discriminate the orientation of a central slightly-tilted grating stimulus. This stimulus was preceded, with a varying stimulus-onset-asynchrony (SOA), by a cue which was either informative or non-informative regarding the timing of the target. Our results showed that fixational saccades were suppressed before a predictable, but not before an unpredictable stimulus. This effect decreases linearly as SOA duration increases and is more robust than accuracy or RT measures. Additionally, a Bayesian classifier was trained to predict the stimulus' class (predictable/unpredictable) based on the single-trial oculomotor events preceding their onset with 63.8% accuracy. We conclude that the oculomotor system is sensitive to anticipation, and that saccadic inhibition can be used as an index for temporal anticipation, even when little or no effect is seen in other measures.

Oculomotor adaptation to natural environments: The empirical isovergence surface

Agostino Gibaldi & Marty Banks

UC Berkeley

The functional characteristics of binocular vision have been shown to be adapted to the statistics of the natural 3D environment, so to optimize stereoscopic perception. When a target is statically fixated, retinal correspondence and eye cyclotorsion are adapted to simplify the solution of stereo correspondence problem. Since these statistics provide a useful and stable prior, we investigated whether the visual system exploits this same information for planning and executing binocular eye movements. In these experiments, we measured the transient vergence performed during saccadic movements for horizontal, vertical, and oblique saccades. The fixation target was presented at different eccentricities relative to the head from -8° to 8°, both in monocular and binocular viewing. The results show that binocular eye movements are consistent with natural disparity statistics. For example, when subjects look up, they make divergent movements, and when they look down they make convergent movements, just as predicted from the natural disparity statistics. This occurs both with monocular targets, where there is no disparity to guide vergence, and with binocular targets where there is usable disparity. We computed the 3D surface that contains these obtained vergence distances. That surface is pitched top-back much like the empirical horopter, which is measured with perceptual judgments. In summary, our results support the hypothesis that eye movements are adapted to the statistics of the 3D environment, so that the transient saccadic vergence reduces the corrective disparity vergence that would be needed at the end of the saccadic movement to tertiary gaze directions.

A pupil near response to illusory nearness

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The pupil constricts when fixating a nearby object, and dilates when fixating a far-away object; this is the pupil near response. Recent findings have shown that the pupil light response (related to the near response) is modulated by illusory brightness and visual attention; however, similar effects had not yet been shown for the pupil near response. Therefore, we tested whether illusory nearness triggers a pupil near response. We presented a nearby object on the left side of the display, and a far-away object on the right side, or vice versa; stimuli were 3D renderings presented on a 2D display. Participants reported the orientation of a target line that appeared within the nearby or far-away object; the location of the target was predicted by a central arrow cue. In one condition (Eyes Free), participants moved their eyes toward the cued object; we found that the pupil constricted during and after an eye movement toward a nearby, compared to a far-away, object, consistent with a pupil near response. In another condition (Eyes Fixed), participants kept their eyes in the display center, and covertly shifted their attention toward the cued object; in this condition, we found no evidence of a pupil near response, suggesting that covertly attending toward illusory nearness is insufficient to trigger a pupil near response. We conclude that a pupil near response seems to be triggered by illusory nearness, at least when an eye movement is made toward a (seemingly) nearby object.

Contrast dependency of trans-saccadic feature integration

Lukasz Grzeczkowski, Heiner Deubel & Martin Szinte

Ludwig-Maximilians-Universität München

Across eye movements, the visual system receives two successive static images of the pre- and the post-saccadic retinal projections of the visual field. The existence of a mechanism integrating these images across saccades, and in particular the features they contain, is still nowadays a matter of debate. One way to study trans-saccadic integration is to use the blanking paradigm. Indeed, while a small trans-saccadic object shift normally stays unnoticed, blanking the object after the saccade makes the same shift easily noticeable. Recently, it was shown that the blanking effect is reduced when the trans-saccadic object is isoluminant relative to the background. Here, using the blanking paradigm, we study the transfer of a visual feature across saccades. Observers saccaded to a grating and discriminated an orientation change occurring during the movement. The post-saccadic grating was either presented with or without a 200 ms blank, and was either non-isoluminant or isoluminant. With non-isoluminant objects we observed an improvement of discrimination with a blank, i.e., a blanking effect for orientation. Interestingly, the blanking did not bring benefit to the discrimination of the isoluminant object. We propose that these effects reflect the existence of a trans-saccadic feature integration mechanism that is contrast dependent.

Continuous flash suppression is strongly tuned for low temporal frequencies and high spatial frequencies

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Continuous flash suppression (CFS) uses rapidly flickering Mondrian patterns in one eye to suppress a target in the other. CFS is widely used to study unconscious visual processes, yet its temporal tuning is unknown. We used spatio-temporally filtered dynamic noise patterns to produce narrow-band maskers and probed the temporal, spatial and orientation tuning of CFS. Surprisingly, CFS suppression peaks very prominently at 1 Hz, well below typical CFS flicker rates of 10 Hz, and is greater for high spatial frequencies. Orientation filtering revealed CFS suppression is strongly orientation tuned at low temporal frequencies, but much less so at high frequencies. CFS suppression also increased with the size of the masker and its contrast. The observed selectivity for low temporal and high spatial frequencies, and a rising monotonic contrast function, suggest parvocellular/ventral mechanisms underlie CFS suppression, similar to the mechanisms thought to underlie binocular rivalry. At the level of modelling and theory, our analysis of the spatiotemporal tuning of CFS therefore unifies two phenomena previously thought to require different explanations. On a practical level, a better understanding of the tuning parameters of CFS suppression will help optimise this popular technique for removing target images from conscious awareness so that the processes of unconscious visual processing can be better examined.

Mechanisms of coarse-to-fine perceptual dynamics

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Multiple studies support the notion that the human visual system follows a coarse-to-fine dynamics. A recent study suggests that this dynamics results from the natural alternation between saccades and fixational eye movements (Boi et al., 2017).

To further elucidate the mechanisms underlying perceptual dynamics, here we examine the interactions between the dynamics of the visual input signals during eye movements and the characteristics of parvocellular and magnocellular neurons in the primate retina. We analyzed the time-course of neural activity during natural post-saccadic fixation in standard models of retinal ganglion cells. These models enable analytical expressions of the temporal evolution of neuronal correlations. Immediately following a saccade, correlations in cell responses are dominated by the low spatial frequency components of the visual input. However, in neurons with a transient temporal response, sensitivity quickly shifts toward higher spatial frequencies and they no longer respond to low spatial frequencies by approximately 150ms from fixation onset. Our theoretical analysis shows that this shift is due to two factors. First, the transient temporal response to a non-changing input reduces cells' sensitivity to low spatial frequencies within a short period from fixation onset. Second, after a transitory period, fixational eye movements increase cells' sensitivity to higher spatial frequencies.

These results carry important implications for the encoding of visual information. They suggest a scheme of neural encoding in which visual representations are timed to the occurrence of saccades. In this scheme, neurons with sustained and transient temporal responses encode different components of the visual input.

Mechanisms of stereopsis in the praying mantis

Vivek Nityananda, Ghaith Tarawneh & Jenny Read

Newcastle University

Praying mantises are the only insects known to have stereo vision. We know little, however, of the mechanisms underlying their stereopsis, especially in complex visual scenes such as those used to investigate human stereo vision. We presented mantises with moving virtual 3D targets with either near or far disparity relative to a background. Both target and background were random dot patterns. First, we manipulated the interocular cross-correlation between the dot patterns. This has a devastating effect on human stereopsis, which is one of the key pieces of evidence suggesting that human stereopsis works by cross-correlating the two eyes' image. However, we found that mantises were unaffected by this manipulation, implying that their stereopsis uses a fundamentally different mechanism. In follow-up experiments, we examined the effect of interocular velocity differences, luminance polarity changes and local motion direction on target depth perception. We found that mantises could detect targets in all these scenes and correctly judge their depth, striking predominantly at targets whose disparity indicated they were within range, and ignoring those with the opposite disparity sign. Together, these data indicate to us that mantis stereopsis is insensitive to the pattern of luminance but computes depth based on the positions at which temporal change occurs.

How immediate feedback reinforces efficent saccades

Preeti Verghese & Saeideh Ghahghaei

The Smith-Kettlewell Eye Research Institute

Saccades are influenced by both stimulus salience and by task demands. We have shown previously that gaze-contingent feedback considerably improves the efficiency of saccades in a challenging, time-limited task (Verghese & Ghahghaei, VSS 2017). Here we examine how immediate reinforcement confers a benefit compared to delayed feedback.

The task was to actively search for an unknown number of targets among distractors in the presence of uncertainty and time pressure. Targets disks were brighter than distractors on average, with luminance values that were drawn from separate Gaussian distributions. These distributions overlapped considerably, so there was uncertainty about whether a disk with a luminance value in the overlap zone was a target or distractor. A saccade to a disk with luminance in this uncertain zone yielded feedback about its true target/distractor identity. Saccades to a disk with luminance values outside this zone yielded no feedback. Feedback occurred either immediately after the saccade, or was delayed to the end of the 11000 ms trial. Eight observers participated in the experiment, with separate sessions of delayed and immediate feedback, in counterbalanced order.

A trial-by-trial analysis showed that observers fixated more informative locations with immediate compared to delayed feedback. Specifically, with immediate feedback they took longer between their first and second saccade indicating a more deliberate saccade strategy. Here we show that when saccades receive immediate feedback that resolves ambiguity, observers can modify their saccade strategy to seek out non-salient yet informative locations in a complex search task

Learning binocular disparity selectivity through spike-timing dependent plasticity

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There is converging evidence supporting the claim that the visual systems of animals adapt their limited resources to the regularities of the surrounding environment. This sparse coding model has been shown to successfully predict units with Gabor-like receptive fields close to those observed in V1 simple-cells. However, most of these studies remain limited in their scope because they rely on 2-D statistics of natural images, while the scene is 3-D.

Here, we propose a novel model which uses a biologically inspired learning rule (spike-timing dependent plasticity or

STDP) to simulate the learning of binocular properties from natural stereoscopic images. First, the stereoscopic images were convolved with ON/OFF centre-surround filters to simulate LGN activity. These responses were converted to spikes and thresholded such that only the most active units could fire. 1°×1° spatial pools from this LGN layer were then used to train an STDP based neural network composed of 300 integrate-and-fire neurons with lateral inhibition.

Our results show that most units develop Gabor-like receptive fields similar to those observed in V1 simple-cells, with a continuum of ocular dominance – from highly monocular to binocular. In line with single-unit recordings in primates, binocular disparity selectivity was principally observed along the horizontal dimension, where it ranged between -0.5° and 0.5°. Although less pronounced, the neurons also showed selectivity to vertical disparity within a narrow range centred at zero. When tested with phase-shifted sine gratings, the units were also found to show disparity-tuning curves close to those observed in electrophysiology.

Wednesday August 30th Symposia presentations

Perceptual rehabilitation of prosopagnosia

JAson BArton, Jodie DAvies-Thompson, Kim Fletcher & And Sherryse Corrow

University of British Columbia

Prior attempts at rehabilitating prosopagnosia have usually involved single cases and had variable efficacy. We evaluated a perceptual learning approach that was designed to enhance ecological validity and to evaluate generalization, transfer and maintenance of the effects. The experiment included an 11-week training program and an 11-week control task. Training required shape discrimination between morphed facial images, whose similarity was manipulated by a staircase procedure to keep training near a perceptual threshold. Training progressed from blocks of neutral faces in frontal view through increasing variations in view and expression. The control task involved watching a television series for a similar duration. In one cohort of ten subjects with acquired prosopagnosia, the control task did not change perception, while training improved perceptual sensitivity for the trained faces and generalized to new untrained expressions and views of these faces. There was significant transfer to new faces and benefits were maintained over 3 months. A similar but smaller pattern of benefit was obtained in a second cohort of ten subjects with developmental prosopagnosia. We conclude that perceptual learning can lead to persistent improvements in face discrimination in prosopagnosia. This reflects both acquisition of new skills that can be applied to new faces, as well as a degree of overlearning of the stimulus set at the level of three-dimensional expression-invariant representations.

Configural-superiority effects in stroke patients: Insights into the neural correlates of Gestalt perception

Jutta Billino[1], Sylvia Heck[2], Klaus-Dieter Böhm[2] & Nele Grewing[2]

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There is consistent evidence that grouping processes provide a powerful mechanism of visual perception. However, the neural foundations of Gestalt phenomena, showing that the whole is qualitatively different form the sum of its parts, are still not well understood. A functional network involving inferior parietal, temporal and prefrontal areas has been proposed, but specific contributions have remained elusive. We aimed to shed light on critical specialisation of cortical areas as well as possible hemispheric dominance by investigating perceptual grouping in patients with focal brain lesions. We studied an established Gestalt phenomenon, the configural-superiority effect, in 15 stroke patients without visual field deficits. Individual lesions were determined based on clinical brain scans and affected various cortical areas including frontal, parietal, and temporal structures. Lesions were located to the right hemisphere in 8 patients and to the left hemisphere in 7 patients. Patients had to identify an odd element in a visual display either when presented without context or when integrated in a context. Performance of patients was compared with data from an age-matched healthy control sample. We found superiority effects preserved in all patients, indicating that perceptual organization provides a robust resource despite cognitive deficits documented by standard clinical tests. Moreover, patients with right-sided lesions profited less from context information than patients with left-sided lesions. Our findings indicate a dominant role of the right hemisphere for Gestalt perception and suggest that grouping processes contribute to compensation of cognitive deficits after brain lesions.

Saccades and pupillary responses in neurological disease

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Queen's University

An extensive neural circuit that includes regions of frontal and parietal cortex, basal ganglia, thalamus, superior colliculus, brainstem, and cerebellum provides control of saccadic eye movements. Because this circuit spans almost the entire neuraxis, eye tracking can be used to identify key biomarkers of neurological disease. There are key links between saccade and pupil premotor circuitry so that key biomarkers of disease may also be present on the pupil. To test these hypotheses, the Munoz lab has been recording eye movements and pupil responses in many neurological patient groups. The goal of this talk will be to highlight key potential biomarkers of neurological disease that are present on saccade and pupil responses in Parkinson's disease, Alzheimer's disease, Mild Cognitive Impairment, Huntington's disease, amyotrophic lateral sclerosis, frontotemporal dementia, vascular cognitive impairment, attention deficit hyperactivity disorder and bipolar disease. Patients are asked to perform the interleaved pro- / anti-saccade task that requires them first fixate

a central visual cue and then either generate an automatic pro-saccade to look at a peripheral visual stimulus, or generate a voluntary anti-saccade by looking away from a peripheral visual stimulus in the opposite direction.

The role of thalamic feedback projections in visuomotor integration and learning

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The visuomotor system represents a particular instance of a sensorimotor system where the sensor (the retina) is frequently displaced by the system's motor output (saccadic eye movements). Integrating the visual inflow across self-induced discontinuities and translations may be aided by an internal monitoring of oculomotor outflow signals. A corollary discharge (CD) of the oculomotor command may be used to predict the visual consequences of corresponding saccades. I will summarize recent work where we demonstrated deficits in the perceptual integration of space across saccades in patients with focal lesions of central thalamus, i.e., within a putative relay station of oculomotor CD signals. CD information may be useful for another notorious problem of sensorimotor systems: A mapping of sensory input and motor intention to the appropriate neural command has to be learned and afterwards flexibly adapted, e.g., in the face of changes in the command signals or the motor periphery due to fatigue, age, degeneration or focal lesions. Prediction errors, i.e., discrepancies of CD-mediated internally predictions and the experienced action consequences could represent a powerful mechanism driving such an adaptation of sensorimotor mapping. I will show results of an ongoing project where patients with lesions of cerebellar-recipient thalamus exhibit deficits in a saccade adaptation task, consistent with deficient prediction error-based learning. Different trans-thalamic feedback projections may provide the cortex with oculomotor monitoring information critical for perceptual stability across eye movements and adaptation of oculomotor commands in face of systematic targeting errors.

Attention for action: evidence from peripheral and bimanual reaching in left visual neglect and extinction

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It is well established that patients with visual neglect present with severe attentional impairments, but the impact of these on visually-guided actions has been hotly debated in the last two decades. Here we examined the right and left hand reaching performance of a patient with left visual neglect and extinction (DA) following a right-hemisphere stroke when compared to a sample of age-matched controls on two separate experiments. In Experiment 1, we investigated how DA performed on the classical diagnostic task for optic ataxia, reaching in central and peripheral vision to left and right targets with each hand separately. In contrast to patients with optic ataxia, DA reached as accurately as controls in all conditions, even in her peripheral neglected field. Our results suggest that DA's attentional deficits are not accompanied by the classical visuomotor symptoms of optic ataxia. In Experiment 2, we investigated patient DA in congruent and incongruent bimanual reaches toward left and right targets placed at different depths as well as unimanual reaches of comparable-amplitudes. Despite her visual neglect and extinction DA's left and right hands were significantly coupled in bimanual reaching in a similar magnitude to controls. However, we found a significantly greater bimanual cost for DA than controls when performing bimanual reaches to incongruent locations. Interestingly, this higher bimanual cost was observed not only for DA's left contralesional hand, but for her right hand also. These findings suggest that executing bimanual competing movements impaired DA's ipsilesional performance and these effects probably relate to her attentional impairment.

Eye movements as early indicators of cerebral small-vessel disease

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Cerebral small vessel disease is a neurodegenerative condition affecting the smallest blood vessels in the brain. It may present with strokes, cognitive impairment, dementia, or functional decline. The disease often progresses insidiously, and is not diagnosed until symptoms are severe. Our study aims at identifying pre-symptomatic high-risk patients by using eye movements as a tool. We developed an eye-movement test battery that includes the following tests: visually-guided and predictive smooth pursuit tracking of small spots moving at different speeds and in different directions, saccades and antisaccades to peripheral visual targets, and self-paced saccades to investigate the ability to initiate a movement without an external trigger. Preliminary findings in n=15 patients with small vessel disease reveal strong relations between eye movement accuracy and symptom severity across all tasks. A comparison with n=18 neuro-normal, age-matched controls further shows that all eye movement tests discriminate patients from controls, even in the earliest stage of the disease (as assessed by neuroimaging). These findings indicate that eye movements may be useful indicators of the disease. Our test may enable earlier diagnosis, thus facilitating early, aggressive treatment of vascular risk factors to prevent progression to stroke or dementia.

Decoding the representation, selection and maintenance of invisible stimuli along the visual hierarchy

Jean-Rémi King

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The computational architectures discovered in vision neuroscience and developed in computer vision are remarkably converging. For example, it is now clear that visual processes are implemented through a long hierarchy of processing stages, structured by multiple semantic (sensory to abstract) and spatial gradients (small to large receptive fields).

However, the dynamics of these architectures remain underspecified. Here, we show how the neural architecture of visual processes, as well as the evoked and oscillatory dynamics of each processing stage, can be automatically identified with time-resolved neuroimaging and machine learning. In a series of four studies, human subjects were either presented with low (Gabor patch) or high level (digit, letter) stimuli that had to be either detected, integrated, memorized or ignored. We show that a rich spectrum of visual features are simultaneously and automatically encoded in the early visual cortices independently of the task. By contrast, our results reveal i) that only relevant features are maintained in associative cortices and ii) that these high-level representations specifically correlate with subjective reports. We show how these results call for a partial revision of current theories of visual perception. More generally, our studies illustrate how machine learning and time-resolved neuroimaging techniques can automatically reconstruct the computational architecture of complex cognitive processing.

Using MEG to track attention during naturalistic visual search

Daniel Kaiser, Elisa Battistoni, Nikolaas N. Oosterhof, Clayton Hickey & Marius V. Peelen

University of Trento

Efficient attentional selection in cluttered environments is crucial in many everyday situations. Here, we used multivariate classification of MEG data to investigate the neural dynamics underlying such selection processes. In two experiments, we show that attention can rapidly bias visual processing towards behaviorally relevant objects. Participants detected categorical targets (cars or people) in briefly presented natural scenes. In the first experiment, classifiers were trained on sensor patterns evoked by people and cars in isolation. When testing these classifiers on scenes containing people or cars, they could more accurately discriminate targets (e.g., people when looking for people) than distracters (e.g., people when looking for cars) from 180ms after scene onset, reflecting enhanced category information for behaviorally relevant objects. In the second experiment, classifiers were trained on a separate task in which physically salient items were placed left or right of fixation. When testing these classifiers on scenes containing objects on the left or right side, they could accurately predict the location of target objects present in natural scenes already at 90ms after scene onset, revealing a rapid increase of visual salience for behaviorally relevant objects. Remarkably, both category and location information were modulated by attention as early as they could be retrieved from MEG signals. Additional sensor-space searchlight analyses revealed that these early attentional biases were localized over lateral occipitotemporal cortex. Taken together, our results provide evidence for changes in early visual processing that may subserve the demands of natural vision by prioritizing information that is important for our current goals.

The spatiotemporal pattern of task and object processing

Martin N. Hebart, Brett Bankson, Assaf Harel, Chris I. Baker & Radoslaw M. Cichy

National Institute of Mental Health

Adapting to the demands of the environment is key to survival, suggesting that processing of visual objects may differ depending on the task that is currently employed. While much work has focused on the perceptual processing of visual objects, much less is known about the task context in which these objects occur, and where, when and how task and object processing interact. To address these questions, we used MEG to study the temporal dynamics of the processing of task, of objects, and their interaction. To access spatial information, we used a previously acquired fMRI dataset and combined it with MEG data using representational similarity-based MEG-fMRI fusion. Participants were shown 8 visually-presented objects embedded in one of four task contexts. Using time-resolved multivariate decoding, we found that after presentation of the object stimulus, object information increased rapidly as expected. In contrast, task information increased relatively slowly, peaking around 500 ms post stimulus onset. Temporal cross-classification indicated that task context is processed in multiple, distinguishable but partially overlapping stages, likely reflecting processing of task cue, working memory retention, and encoding of stimulus-response mapping rules. MEG-fMRI fusion revealed that ventral visual areas preferentially processed stimulus information and dorsal regions task context. In addition, after onset of the object stimulus, we found co-occurring signals reflecting category and task that were particularly evident in higher visual areas, again peaking at later time periods. These results suggest a postperceptual involvement of task context in the processing of visual objects and highlight the representational dynamics of task and object processing, and their interaction.

Oscillatory signatures of object recognition across cortical space and time

Leila Reddy, Radoslaw Martin Cichy & Rufin VanRullen

University of Toulouse/ CNRS

Numerous theories propose a key role for brain oscillations in visual perception. Most of these postulate that sensory information is encoded in specific oscillatory components (e.g., power or phase) of specific frequency bands. These theories are often tested with whole-brain recording methods of low spatial resolution (EEG or MEG) or depth recordings (LFP) that provide a local, incomplete view of the brain. Opportunities to bridge the gap between local neural populations and whole-brain signals are rare. Here, using representational similarity analysis (RSA) between separate MEG and fMRI datasets we systematically explored the correspondence between whole-brain oscillatory signals and local activity in specific brain regions (V1 and IT), while 15 subjects viewed 92 different stimuli. Time-frequency (TF) analysis for each trial and MEG sensor was performed. Two oscillatory components (power and phase) were extracted at each TF coordinate. MEG representational dissimilarity matrices (RDMs) were computed for the two oscillatory measures at each TF coordinate, and fMRI-RDMs were computed for V1

and IT. Finally, RSA was performed between the MEG- and fMRI-RDMs. The RSA showed that at stimulus onset, most oscillatory signals correlated first with V1, and then with IT representations. However, later in the trial, different brain areas simultaneously carried stimulus information, but in different frequency bands. Additionally, power and phase oscillatory components at a specific frequency could simultaneously match representations from distinct brain regions. These results set the stage for a systematic understanding of the relation between whole-brain oscillatory signals and local neuronal activations.

Alpha-band and raw EEG reflect distinct maintenance mechanisms during working memory

Johannes J. Fahrenfort, Jonathan Van Leeuwen, Joshua J. Foster, Edward Awh & Christian N.L. OliVers

Free University Amsterdam

Recent work has shown the ability to decode working memory contents from EEG measurements. Here we investigate to what extent different task requirements may promote distinct neural mechanisms to sustain the underlying working memory representations. We employed two working memory tasks with identical items, but different tasks at test time. The memoranda always consisted of oriented bars. However, participants either had to reproduce the correct orientation by clicking on a location in space (position task), or they had to identify the correct orientation among competing similarly oriented bars (search task). We decoded memory contents during maintenance using both raw EEG and time-frequency decomposed EEG. This revealed a dissociation, with higher decoding accuracy within the alpha frequency band for the position task than for the search task, while the pattern for raw EEG signal was reversed, showing higher decoding accuracy for the search task than for the position task. In addition, raw EEG decoding remained selectively intact when applying a band-stop filter in the alpha-range. Conversely, alpha-band decoding remained selectively intact when subtracting out evoked responses, decoding only on the induced portion of the time-frequency signal. Finally, preliminary analyses using a forward encoding model suggest that the different tasks result in different channel tuning properties in alpha and raw EEG. Together, these interactions between task type and EEG measure strongly suggest that alpha and raw EEG reflect distinct WM maintenance mechanisms, the first favoring a spatial representation, while the second may represent the global orientation and/or perceptual organization of a stimulus.

Choosing the dissimilarity measure for RSA in MEEG research

Matthias Guggenmos[1] & Radoslaw Martin Cichy[2]

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Representational similarity analysis (RSA) applied to magneto- and electroencephalography (MEEG) data can characterize the temporal dynamics of distributed neural representations. At the core of RSA is the dissimilarity measure used to characterize the representational space in representational dissimilarity matrices (RDMs). However, little is known about the performance and characteristics of different dissimilarity measures for MEEG RSA. Taken together, our results advise the use of multivariately noise-normalised and cross-validated measures for RDM construction in MEEG research, and highlight the Euclidean distance and decision values of WeiRD as particularly attractive dissimilarity metrics.

Temporal integration of visual information across visual cortex

Geoffrey K. Aguirre

University of Pennsylvania

Human visual perception is both stable and adaptive. Perception of complex objects, such as faces, is shaped by the long-term average of experience as well as immediate, comparative context. Measurements of brain activity have demonstrated corresponding neural mechanisms, including norm-based responses reflective of stored prototype representations, and adaptation induced by the immediately preceding stimulus. I will discuss recent work that examines the time-scale of integration of sensory information, and explicitly tests the idea that the apparently separate phenomena of norm-based coding and adaptation can arise from a single mechanism of sensory integration operating over varying timescales. We used functional MRI to measure neural responses from the fusiform gyrus while subjects observed a rapid stream of face stimuli. Neural activity at this cortical site was best explained by the integration of sensory experience over multiple sequential stimuli, following a decaying-exponential weighting function. While this neural activity could be mistaken for immediate neural adaptation or long-term, norm-based responses, it in fact reflected a timescale of integration intermediate to both. We then examined the timescale of sensory integration across the cortex. We found a gradient that ranged from rapid sensory integration in early visual areas, to long-term, stable representations towards higher-level, ventral-temporal cortex. These findings were replicated with a new set of face stimuli and subjects. Our results suggest that a cascade of visual areas integrate sensory experience, transforming highly adaptable responses at early stages to stable representations at higher levels.

Is it blue or green? Investigating how priors for object color are learned from visual input

Maria Olkkonen & Toni Saarela

University of Durham

Both long-term and short-term experience with object color affects color perception. Memory colors (typical colors of familiar objects such as fruit) draw perceived color towards them, but colors can also be biased toward a recently learned average color, an effect called the central tendency bias (CTB). We have only recently begun to understand the parameters of these kinds of sensory learning processes. In this talk, we will address several fundamental aspects in the learning of color priors, such as the effect of noise on prior weighting; the time course of learning; and the learning of priors for different objects. We use delayed color matching as the general paradigm to study the learning and employment of

priors. On a typical trial, participants compare the color of two shapes – reference and test – shown in succession with a delay of a few seconds. From participants' responses, we can track the perceived color of the reference. In different experiments, we study learning of color information for one shape at different levels of uncertainty, and the learning for two distinct shapes. Our results generally show that memory biases of perceived color develop rapidly and can be shape-dependent. Finally, we will discuss the relationship between shape-dependent color adaptation and learning.

Colour generalisation in chicks: What do chicks learn about two-dimensional colour variation?

Christine Scholtyssek, Daniel C. Osorio & Roland J. Baddeley

Sussex University

We effortlessly recognise and categorise objects within a fraction of a second, but computationally, object recognition and categorisation remains a formidable challenge. Objects belonging to the same category can vary substantially in their appearance along multiple dimensions, such as size, shape, or colour, so that correct interpretation of variation along specific dimensions may be essential to the successful categorisation of novel objects. Furthermore, different viewing conditions cause unlimited variation in the retinal image of each object. We ask how animals learn about dimensional variation, and how this information is used to categorise novel objects. To do so we train young poultry chicks to discriminate between rewarded and unrewarded two-dimensional colour distributions, and subsequently test how the training generalises to novel colours. We then compare the chicks' generalisation behaviour to the distinct predictions of four main theoretical accounts of how animals should classify complex stimuli. Three of these models are well established in the human literature. The fourth, a generative model, is derived from previous studies on colour generalisation in chicks on single dimensions and with only two training colours. Here we demonstrate that the generative model also predicts generalisation under more natural, noisy conditions: When stimuli vary along more than one dimension whilst some of this variation is completely irrelevant for a successful performance.

Perceptual learning of complex patterns

Zahra Hussain, Ali Hashemi, Allison Sekuler & Patrick Bennett

American University Beirut!

Practice improves identification of unfamiliar and familiar patterns (e.g., random textures and faces). Here, I review the similarities and highlight some differences between perceptual learning in identification tasks and learning of simple sensory discriminations, motor skills, and certain cognitive judgements. Improvements in texture- and face identification show a characteristic timecourse and stimulus specificity that is similar to that found in other perceptual learning tasks. Specifically, i) performance is related to the logarithm of the number of trials, ii) the effects of practice are retained over long periods of time, and iii) improvements are, at least to some extent, specific to the trained stimulus identity, orientation, contrast polarity, and position in the visual field. Generalization to novel stimuli increases when observers are exposed to a greater variety of stimulus exemplars, and generalization is successful across non-diagnostic stimulus contexts if the trained information is held constant whilst observers are exposed to a variety of contextual exemplars. Unlike learning in other domains, stimulus specific improvements in identification tasks emerge early in practice and require no consolidation period. These characteristics of learning may account for features of recognition of overlearned classes of objects (e.g., the face inversion effect), and suggest more generally that common principles govern the encoding of a variety of stimulus and object classes.

Learning new senses and sensory mappings: humans, ideal observers, and ideal learners

Marko Nardini, James Negen, Renata Kiryakova, Ulrik Beierholm & Lore Thaler

University of Durham

A key problem observers must solve is mapping sensory inputs to useful representations or actions. For example, humans learn to use various visual depth cues in the first year of life. Much later, at 12 years of age, they also combine depth estimates via different cues to reduce uncertainty (Nardini et al, PNAS 2010; Dekker et al, Curr Biol 2015). The processes by which humans learn to use and combine such cues have been difficult to study, as (1) exposure to natural sensory input is difficult to control, and (2) most learning occurs during childhood, when learning abilities themselves are also developing. We are approaching this problem by training participants to locate hidden targets using a "new sense" (echo perception) or new, arbitrary shape or sound mappings. We are identifying conditions in which new mappings are successfully learned and combined to reduce uncertainty, but also those in which adult participants fail to learn or combine cues. Major questions include (1) how information is represented, as evidenced by abilities to generalize (e.g. to new reliabilities, locations, tasks); (2) how performance compares with the "ideal observer" (who has an accurate generative model of the environment) as well as the "ideal learner" (who only has the data points provided so far); (3) how these and other aspects of learning change with age. Understanding how humans learn to use the regularities in sensory input has applications to rehabilitation / sensory substitution and the design of intelligent agents who can learn from their environment.

Challenges to pooling models of crowding reconsidered

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Peripheral object recognition is highly vulnerable to clutter, a phenomenon known as crowding. Object recognition involves a series of hierarchical processing stages followed by a decision stage. According to a popular class of crowding models, known as pooling models, one of those stages (beyond V1) involves pooling over sizeable regions that grow at a rate of approximately 0.5 x eccentricity. This pooling causes loss of information, particularly in the presence of clutter,

leading to crowding. Versions of pooling models have been popular at least since the 1970s. However, as researchers have studied a wider range of stimuli and tasks, a complex pattern of results has emerged, challenging the relatively simple pooling model. It has seemed that pooling over a handful of image features might not suffice. Researchers have instead proposed more complicated models, with dynamic mechanisms that adapt to the stimulus, acting at later or multiple processing levels, and/or requiring feedback processing. Questions remain, however, as to whether these challenges truly eliminate pooling models. We argue that some of the phenomena may confound crowding with decision factors such as target cueing effects. Furthermore, high-dimensional pooling models preserve considerably more information than models pooling only a handful of features. Utilizing our Texture Tiling Model as a candidate model, we revisit phenomena purporting to challenge pooling models, gaining insight into multi-level crowding, grouping effects, and availability of information in a crowded display.

Crowding as 'pooling' – simplifying the visual field

John A. Greenwood

University College London

Crowding limits perception over more than 90% of the visual field, disrupting the recognition of both simple features (orientation, colour, motion, etc.) and complex objects (e.g. faces). The errors that arise from crowding are not random, but rather reflect the combined appearance of the to-be-identified target object and surrounding flankers. 'Pooling' models attribute these crowded errors to an unwanted combination of target and flanker signals via processes such as averaging, substitution, or both. Pooling models can not only explain the range of effects that crowding has on appearance in peripheral vision (from assimilation to repulsion), but also the errors that arise when foveal crowding is elevated, as in clinical conditions such as amblyopia ('lazy eye'). Additionally, we have recently observed that crowding can independently disrupt judgements of colour and motion for the same target object, a finding that suggests the existence of multiple instances of crowding. Pooling models can incorporate this via independent pooling processes operating within distinct neural populations. Together, these findings depict crowding as a general 'pooling' algorithm that arises when neural resources are insufficient to represent the fine detail within an image, leaving a 'best guess' in its place. Of course, fundamental processes of this nature will inevitably interact with processes such as attention and grouping, but this does not mean that crowding is the same as these processes. Rather, pooling models present a physiologically plausible 'low-level' account of crowding, and an insight into why this disruption occurs.

The Hierarchical Sparse Selection model accounts for crowding at multiple stages of visual processing

David Whitney

UC Berkeley

Crowding defines the spatial resolution of conscious object recognition. Although crowding is usually explained by low level mechanisms such as pooling of inputs from earlier stages of visual processing, there is converging evidence from many studies that crowding can occur selectively at several levels of visual processing: between low-level features, letters, characters, objects, faces, and point-light-walkers. Paradoxically, although crowding prevents conscious access to object information, it does not always destroy or dismantle these object representations. Detailed feature and object representations can get through the bottleneck of crowding to influence or prime subsequent perception. Most models of crowding, including pooling, substitution, and resolution limits alone cannot explain these results because they predict substantial information loss. Here, I will review evidence that crowding occurs at multiple levels, including new evidence that crowding can even be determined by the interpretation of lighting direction in a scene. I will also discuss how the Hierarchical Sparse Selection model of crowding can account for the seemingly paradoxical finding that crowding prevents conscious access without degrading object representations.

How grouping determines crowding

Michael H. Herzog

EPFL

Crowding is traditionally thought to occur by local interactions between the target and the neighboring flankers, for example, by pooling neural responses corresponding to both the target and flankers. Accordingly, crowding is thought to occur within a small region around the target (Bouma's window). Most of these explanations fit well in the classic hierarchical, feedforward framework of vision, where spatially confined neural circuits determine perception. We will show that crowding of a Vernier depends on the spatial layout of the entire stimulus configuration across large parts of the visual field. Obviously, low level vision cannot be explained by classic models of vision and crowding. We propose that grouping is key in crowding. Only when the Vernier groups with the flankers is crowding strong. When the Vernier stands out from the configuration, crowding is weak. Hence, one needs to understand how humans perceive the overall configuration to understand low level crowding. We will discuss the philosophical implications of our approach and present a large scale neural model, where neurons communicate across the entire visual field to compute grouping.

Thursday August 31st Poster presentations

Interocular correlation sensitivity and its relationship with stereopsis

Alexandre Reynaud & Robert F Hess

McGill University

We benefit greatly from having two frontally placed eyes with a wide binocular overlap in the field of view. The brain has a duplicated view of everything in the world albeit from a slight displacement of around 6cm, the interpupillary distance. This not only enables a strong correlated signal from the two eyes but the ability to use any slight difference in the spatial distribution of the signals between the two eyes

to derive 3D estimates. Here, we sort to provide a measure of the strength of binocular vision at the level before disparity processing. In particular, we determine the spatial dependence of interocular correlation (IOC) sensitivity. We use dichoptic stimuli with bandpass textures whose IOC is sinusoidally modulated at different correlation frequencies. Sensitivity to these stimuli is compared with analogous stimuli corrugated in depth. We show that the IOC sensitivity is lowpass/bandpass and increases with stimulus duration and contrast in a similar way as disparity sensitivity does. IOC sensitivity is only weakly (though significantly) correlated with disparity sensitivity in the population, suggesting that it could provide a much needed measure of binocular function prior to stereopsis.

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Assessing the perception of egocentric distance and pictorial depth in strabismus

Giedre Zlatkute, Charlotte Sagnay Delabastida & Dhanraj Vishwanath

University of St Andrews

How depth and distance perception is experienced by individuals with strabismus (eye misalignment) is poorly understood. We carried out experiments comparing the way stereotypical individuals (controls) and strabismics with no or limited stereovision perceived object size, egocentric distance, and equidistant intervals in pictorial images (relative depth). Under different viewing conditions (monocular & binocular) and distances (3.5 & 1.75m) participants made size judgments about objects displayed on a computer monitor. We used these judgments to infer perceived distance (size-distance invariance hypothesis). Under both monocular and binocular viewing, controls underestimated object size, and thus the perceived distance, at far viewing but not near viewing conditions. However, for strabismic participants this underestimation of the object size was not significant for either of the viewing conditions. In order to measure the influence of pictorial depth, we asked participants to make equidistance judgments in intervals between lines overlaid on pictorial images with perspective information. They were instructed to make the judgments either on the plane of the monitor (2D-judgment), or in the depicted 3D space of the image (3D-judgment). Both controls and strabismics were biased by the background image when making the 2D judgments. However, when making 3D equidistance judgments strabismics appear to be influenced by the visual information to a lesser degree than the controls. These findings suggest that while there are similarities in perceptual judgements about depth and distance between stereotypical and strabismic observers, there are some interesting differences in the visual information used by the two groups.

Size constancy in consumer virtual reality

Rebecca Hornsey[1], Paul B Hibbard[1] & Peter Scarfe[2]

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Compared with perception in physical space, in virtual reality there is a compression effect on the perception of both distance and object depth (Creem-Regehr, Stefanucci & Thompson, 2015). Research suggests that for stimuli presented on a computer monitor, an object should be presented as being systematically larger at further distances in order to maintain a perceptually constant size (Brenner & van Damme, 1999). We investigated the accuracy of size perception in consumer virtual reality, where observers (n=25) held a tennis ball in one hand while viewing a virtual ball, presented at eye-height. Stimuli were created using Unreal Engine and presented using an HTC Vive. On each trial, the virtual ball was presented at a randomly chosen distance between 40 and 100cm. Using the Vive hand controller, the observers' task was to set the size of the virtual ball so that it matched the felt size of the tennis ball (Brenner and van Damme, 1999). We found a significant correlation between the set size of the ball and its distance, such that observers set larger spheres at further distances. This distance constancy failure is consistent with a progressive underestimation of distance with increasing distance. The mean slope of a linear regression of apparent against actual distance (0.6) was similar to that found with carefully calibrated stimuli, viewed in a fully-lit laboratory (Brenner & van Damme, 1999). Thus, while size constancy in consumer virtual reality is not perfect, it is no worse than that found when rich, real-world distance information is available.

Out of sight, out of mind: Complete occlusion destabilizes moving multi-stable structure-from-motion displays

Alexander Pastukhov, Johanna Prasch & Claus-Christian Carbon

Otto-Friedrich-Universität Bamberg

Does the visual system anticipate a reappearance of a temporarily occluded object by maintaining and extrapolating its representation even is the absence of momentary sensory evidence? The tunnel effect studies indicate that this could be the case, although neither the neural mechanisms underlying the effect nor the nature of persisting representations are fully understood. We used a moving ambiguously rotating structure-from-motion display and investigated the persistence of the bi-stable rotation following episodes of invisibility. In three experiments the moving object was fully or partially occluded by 1) a cardboard that covered part of the screen to maximize the physical plausibility of the occlusion, 2) visible or invisible CGI objects with various apertures, and 3) observers closing their eyes in response to the auditory signal. We found that the complete occlusion strongly and significantly destabilized the perception of rotation across all occlusion paradigms. In the first experiment, the persistence of rotation was linked to the object's visibility at the moment of the maximal occlusion. In the second experiment, persistence of partially occluded objects was facilitated by the visibility of the occluding object. Finally, in the third Experiment, prompted and spontaneous blinks as well as the auditory signal itself strongly and significantly destabilized the

perception. We conclude that representations of fully occluded multi-stable objects do not persist even in cases of a brief, predictable, physically-plausible, but complete occlusion. We surmise that the persistence of stable objects in the tunnel effect relies on additional mechanisms, such as higher-level memory.

Stereomotion processing in the non human primate brain

Yseult Héjja-Brichard, Samy Rima, Jean-Baptiste Durand & Benoit R. Cottereau

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Motion perception is a fundamental property of the visual system in most animal species. Although numerous studies examined how the primate brain processes 2D motion, much less is known about how it encodes 3D motion. A few neuroimaging investigations in human found that stereomotion is mostly processed within the hMT+ complex and its neighborhood. Here, we extend this work to non-human primate. Functional MRI data were recorded in two behaving macaques at 3 Teslas during a passive fixation task. Our main condition (changing disparity over time, CDOT) consisted of a central disk filled with dynamic random dots (diameter = 19°, refresh rate = 30Hz). The dots' binocular disparity changed over time along opposite directions in the upper and lower parts of the disc (triangular functions between +/- 23 arcmin at 1 Hz). In two control conditions, we scrambled the temporal (TS) or spatial (SS) structure of the CDOT condition. All conditions were monocularly identical, shared the same disparity distributions but only the CDOT condition had uniform and continuous motions in depth. We interleaved those conditions with a baseline (fixation point) in a bloc-design paradigm. From a general linear model computed using SPM 12, we found that the CDOT condition led to stronger responses than the control conditions in the superior temporal sulcus, the parieto-occipital cortex and the posterior part of the intraparietal sulcus. Our results suggest that multiple regions process stereomotion in macaque and encourage further investigations in human.

Disparity, parallax and perspective in the perception of natural scenes

Brian Rogers

University of Oxford

The use of random-dot images in studies of binocular stereopsis and motion parallax has been useful in demonstrating the effectiveness of these sources of 3-D information when presented in isolation but they tell us very little about their roles in natural scenes. We know that reversing the disparities in stereoscopic images of natural scenes does not reverse perceived depth and that eliminating the conflicting disparities of flat paintings with monocular or synoptic viewing enhances perceived depth. In this study, we exploited the fact that while motion parallax typically enhances perceived depth, there is no "stationarity assumption" (Rogers, 2016), meaning that the perceived rotation of a 3-D structure with respect to the line-of-sight (with or against the observer's movement) can reveal the strengths of different sources of 3-D information. Large field images (25˚ x 20˚) of natural scenes were shown to twelve observers under four different viewing conditions: (i) monocular, (ii) stereoscopic, (iii) pseudoscopic (reversed disparities), and (iv) synoptic (no disparities) and using four different parallax arrangements: (i) stationary observer, (ii) no parallax, (iii) normal parallax, and (iv) pseudo-parallax (reversed parallax). Perceived depth with monocular and synoptic viewing was enhanced with either stationary observer, normal- or pseudo-parallax but abolished with no parallax. Pseudoscopic viewing failed to reverse depth for stationary observers but produced enhanced depth (in the direction of perspective information) with either normal or pseudo-parallax. These results reveal the importance of, and tight link between, perspective and parallax gradients that overrides conflicting disparities.

Priming effects depend on relative stimulus strength during continuous flash suppression

Christian Valuch & Uwe Mattler

University of Goettingen

Visual awareness of a static stimulus presented to one eye can be strongly suppressed by continuously flashing high-contrast patterns to the other eye. Here we employed Continuous Flash Suppression (CFS) to examine stimulus processing in the absence of awareness. Simple arrow stimuli pointing left or right were employed as primes which were suppressed by CFS. Visible arrow stimuli (targets) followed 100, 200, or 300 milliseconds after the onset of primes. Participants performed two tasks, randomly intermixed across trials. In half of trials, participants gave speeded manual left / right responses to the visible targets. In the other half of trials, participants discriminated whether primes were pointing left or right. In Experiment 1, we manipulated prime strength (low vs. high contrast). Response times and accuracy were reduced when prime and target were congruent rather than incongruent. This priming effect was larger with high-contrast primes than with low-contrast primes, where the effect increased with prime-target onset asynchrony. Moreover, priming effects varied considerably across participants with a strong linear relationship between individual depth of suppression (indexed by prime discrimination performance) and the size of the priming effect. In Experiment 2, we individually adjusted the contrast of CFS suppressors to different prime discrimination thresholds. Thereby, we equalized relative stimulus strength across participants and confirmed the results of Experiment 1 within participants. We discuss our data with regard to the notion of stimulus strength in binocular rivalry and outline implications for the use of CFS in priming experiments.

Modification of stereoscopic depth scaling by reaching movement and its visual feedback

Hiroaki Shigemasu & Sho Yamane

Kochi University of Technology

Distance information is necessary for veridical perception of relative depth from binocular disparity. Previous studies reported that perceived depth became distorted from misestimated distance when the distance cue was not reliable. We

examined whether visuo-motor reaching tasks influence the perceived depth. In experiment 1, we investigated whether reaching to target objects provide better distance perception and contribute to perceive veridical depth. To manipulate depth structure and distance systematically, we showed simulated cylinder through a head-mounted display (HMD). Participants adjusted the depth of the cylinder to have an apparently circular structure followed by a reaching task or without a task. While the results showed a tendency that the reaching movement made the depth judgment more veridical in every distance condition (40, 50, 60 cm), there found a significant interaction of the effect of executing reaching task and initial depths of cylinder at 50 cm condition, suggesting that around 50 cm is the switching point of under/over-estimation of distance and the effect of reaching showed an opposite direction of modification to the depth judgment. In experiment 2, based on the previous study which showed visuo-motor adaptation effect with displaced visual feedback of reaching finger on the perceived depth (Volcice et al., 2013), we manipulated the extent of the similarity of the visual feedback of participants' own hand (dot, rod, and realistic virtual hand) with HMD. The results showed a significant difference among feedback condition and the extent of the similarity to self-hand changed the modification of the three-dimensional spatial perception.

Defocusing flankers in real depth reduces crowding

Lisa Valentina Eberhardt & Anke Huckauf

Universität Ulm, Institut für Psychologie und Pädagogik

Crowding describes the phenomenon of impaired recognition of peripherally presented stimuli when they are surrounded by similar stimuli. The extent of crowding depends on the spatial arrangement of stimuli, usually stimuli's eccentricity and spacing. We manipulated stimuli's configuration in the spatial dimension depth. Crowding was examined when flankers were defocused in real depth while all other visual stimulus properties were kept constant and compared to a focused presentation. Real depth was created by using two screens and merging their displays via a semi-transparent mirror. Stimuli consisted of bright Landolt rings of 0.6° of visual angle. Targets were presented at 2° of eccentricity on the fixated depth (190cm). Flankers were presented with a spacing of 1° either on, in front of (150cm, 170cm) or behind (215cm, 240cm) the fixated depth. Recognition performances revealed crowding effects for all flanking conditions. This was confirmed by the finding of slower reaction times in flanked conditions. Crowding was remarkably reduced for flankers presented in different depths than the target. This shows that even in crowded displays flankers' depth is perceived and processed distinctly. The fact that increasing the depth distance between target and flankers led to more crowding might be attributed to double images in binocular observation. Interestingly, crowding was more pronounced when flankers appeared in front of the target compared to behind the target. This may indicate certain attentional processes contributing to three-dimensional spatial interactions. In future studies we will examine the influence of defocusing target stimuli on crowding.

Mask spatial density determines optimal masking frequency

Jan Drewes[1], Weina Zhu[2] & David Melcher[1]

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Continuous Flash Suppression (CFS) has become a popular method to investigate visual processing in the absence of awareness, even though the underlying neural mechanism is not fully understood. As spatial and temporal properties of stimuli are major determinants of visual perception, we hypothesized the according properties of the CFS masks to be of significant importance to the achieved suppression. In previous studies however, these properties of the masks themselves have received little scrutiny and masking parameters vary widely across studies, making a meta-comparison difficult.

To address these issues we varied temporal and spatial properties of randomly generated Mondrian masks and compared them to random noise masks following various spatial frequency distributions. We found optimal suppression to be achieved with colorful Mondrian masks with small-size patches (avg 0.4deg) presented at about 6Hz. An increase in patch size (reduction in number of edges) led to a reduced suppression effectiveness, but with a simultaneous increase in optimal temporal frequency (up to about 15Hz@2.0deg patch size) which correlated with the decrease in spatial density. Noise stimuli exhibited optimal suppression when the noise spectrum followed a 1/f1.5 characteristic, but overall did not achieve the same suppression duration as the Mondrian masks.

Conclusion: edges are important to CFS. Masks with a reduced number of edges might require more masks per time frame to optimally bind processing resources. Our findings are consistent with our hypothesis that CFS disrupts the normal temporal processing of target stimuli prior to them reaching awareness.

Investigating interactions between spatial and sustained attention in young and older adults

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University of Glasgow

Young adults show a processing advantage for the left side of space across spatial tasks but with age, this spatial bias is eliminated or shifted towards favouring the right side of space due to possible right hemisphere decline. We extend the work by O'Connell, et al.,(2010) and Newman et al.(2013) who reported that asymmetries in spatial attention might be influenced by the varying degree of engagement of nonspatial attention, which overlap with neural circuits in the right hemisphere. Here, we probed the impact of high vs low attentional load on spatial attention asymmetries and whether attentional load affects older adults differently compared to young. We tested 20 young (18-25) and 15 older adults (62-83), on a dual spatial/sustained attention task. Participants made a speeded response to a target presented laterally (spatial attention) while simultaneously monitoring a central alphanumeric stream for the presence of a pre-defined target (sustained attention). The sustained attentional load was either low (red target letter in a green letter stream) or high

(green number in a green letter stream). There was a side x age interaction (p=0.029), but young adults were slightly faster to detect targets in the right side of space relative to the left (p=0.065). Similar to O'Connell et al.(2010) and Newman et al. (2013), there were no main effects nor interactions involving attentional load on behaviour. We now plan to investigate the ERP and oscillatory correlates of spatial and sustained attention across the lifespan.

Children's estimations of object size at varying distances: A meta-analysis

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A meta-analysis combined data from 32 published studies, with approximately 3000 total participants, to examine the effects of age, distance, and several methodological variables on children's and adults' abilities to estimate object size. This meta-analysis found several clear effects. Children and adults make approximately accurate size estimates at distances less than 3 m, and no age-related differences in near-distance size estimation accuracy are apparent. As distance increases, children's size estimates become less accurate. Children from 5 to 10 years of age make progressively larger size-estimation errors with increases in distance. Age differences are greatest at distances farther than 10 m. At these distances, 5- to 6-year-olds underestimate object size by more than 20%, 9- to 10-year-olds underestimate by about 10%, and adults make approximately accurate size estimates. Some methodological variables affect children's size estimates. Children estimate object size more accurately when stimulus objects are viewed simultaneously than when they are viewed sequentially. Instructions also affect size estimates. Children and adults make more accurate size estimates when judging an object's objective size than when judging the size that an object "looks." This effect increases as distance increases. Other variables do not affect children's or adults' size estimates, including monocular vs binocular viewing and the angle of separation between the target object and the comparison objects. The findings of this meta-analysis have implications for theories of perceptual development and raise several questions for future research.

Hybrid (combined visual and memory) search in aging

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In "Hybrid Search" observers look through visual displays for instances of any of several types of targets, held in memory (Schneider & Shiffrin, 1977). Hybrid search thereby constitutes a promising tool to assess declines in attention and long-term memory (LTM), two hallmarks of normal cognitive aging, within one single task. Does aging impact attention, memory, or both in hybrid search, and does that impact involve a qualitative change beyond the usual quantitative slowing of response times (RTs)? To answer these questions, we replicated Wolfe's (2012) paradigm in a sample of older observers. Observers searched for any of 1-16 target objects held in LTM in visual displays containing 1-16 objects. Wolfe (2012) found that, in young observers, RTs increase linearly with the number of objects in the display, while RTs increased logarithmically with the number of objects in the memory set. The linear increase of RTs with visual setsize was stronger in older than younger observers, supporting age-related decline in visual selective attention. The older observers produced logarithmic memory search functions that looked strikingly similar to those in younger observers, with comparable costs of increasing memory load on RTs after correcting for generalized slowing. This suggests that memory search for at least up to 16 learned target objects is largely preserved in older age. However, older observers made significantly more false alarms compared to younger observers, particularly when visual and memory setsizes were large, suggesting that older adults may change their response criteria when memory search gets harder.

Is scene and face perception preserved in the central visual field of people with glaucoma?

Alexia Roux-Sibilon[1], Floriane Rutgé[2], Florent Aptel[2], Arnaud Attye[3], Nathalie Guyader[4], Muriel Boucart[5], Christophe Chiquet[2] & Carole Peyrin[1]

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Primary open-angle glaucoma is an ocular disease characterized by a progressive destruction of the optic nerve. At early stages the disease affects peripheral vision but later progresses towards the central visual field (CVF). The visual field defect is assessed with static automated perimetry based on luminance increment detection of small dots. Several studies support now the idea that visual defects extend in parts of the CVF classified as normal by perimetry, in particular for high-level visual tasks such as categorization of low contrasted objects or motion detection. Here, we presented low-contrasted complex stimuli (natural scenes and human faces) in the CVF of three groups of participants: Patients with a CVF defect, patients without a CVF defect, and age-matched controls. They were asked to perform monocularly two different go/no-go tasks: a perimetry-like detection task of stimuli, and a higher level categorization task in which they had to recognize indoor scenes among outdoor ones (or the opposite) and faces among animals and vehicles. Compared to controls, patients with a CVF defect showed a deficit in scene and face perception, more pronounced for categorization than detection. Patients without a CVF defect showed a deficit for scene categorization, while performances were well preserved for scene detection, as well as for face detection and categorization. This study revealed subtle deficits in the CVF of people with glaucoma that were not predicted by the automatic perimetry assessment. These defects can be thought as a result of trans-synaptic degeneration in glaucoma following the optic nerve damage.

Disturbance levels of different noise types: A study with young and elderly observers

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While most cinema productions relied on traditional film cameras until 2011, digital cameras have taken over the last years. As digital camera noise differs significantly from film grain, there is a variety of opinions and theories about preferable noise/grain types in motion pictures. To find out what noise levels are disturbing and how this level may depend on the noise type, we investigate the visibility and the disturbance level of film grain and digital noise. Since elderly people might be more used to high levels of film grain noise, we invited different age groups to participate in our study and compared their results. Our subjective test included 18 people aged 23-30 years and five aged 57-68 years. We measured the disturbance and visibility thresholds in separate tests performed consecutively. The experiment included 13 noise types of different frequency distributions. We compare the disturbance and visibility based on threshold PSNR, a standard measure for noise in digital video, and on RMS contrast, which allows a better comparison to the contrast sensitivity function. We draw the conclusion that the disturbance level strongly correlates with visibility level except for a small offset. Comparing the disturbance results of the two age groups shows that the elderly people are generally less disturbed by all the noise types. The younger age group is more disturbed by high spatial frequency bands. However, we suggest this is not due to viewing habits but instead must be explained by the poorer vision of the elderly people.

What scroll can teach us about web users ?

Alexandre Milisavljevic[1], Karine Doré-Mazars[2], Bernard Gosselin[3], Matei Mancas[3] & Coralie Petermann[1]

[1]Sublime Skinz Labs; [2]Institute Imagine / University Paris Descartes; [3]University of Mons

Understanding why a user is on a webpage is a good way to infer his or her interest in the content. To measure this interest, Eye-tracking is a precise tool that allows to estimate goal impact on user's eye-gaze. However, this method is hard to scale up, that is why mouse-tracking models emerged as an efficient proxy to determine user's attention. These models mainly use mouse movements, mouse clicks and hovered page elements while considering scrolling as a simple model feature. In addition to these analyses, other studies focused on how the eye behave during onscreen reading using scroll. During our exploratory research we analysed users' eye-gaze behaviour on webpages while scrolling. In order to accomplish this, we asked applied science students to visit ten websites divided in three task groups : target finding, free viewing and text reading. Our preliminary results show a link between initial eye position and scroll speed. We divided the screen in six different areas and found out that depending on which area the eye was focusing on, participants adapted their scroll speed. This could reflect cognitive load in progress. Furthermore, we discovered that when the eye-gaze preceding the scroll goes in the same direction as the scroll, the scroll is faster.

Suprathreshold contrast discrimination in migraine

Amelia Aldrich, Paul B Hibbard & Arnold Wilkins

University of Essex

Individuals with migraine have a cortical hyperexcitability and are unusually susceptible to perceptual distortions in patterns of striped lines (Wilkins et al., 1984). They are sometimes impaired at perceiving the relative contrast of gratings, when the reference patterns are of high contrast (Shepherd, 2000), possibly as a result of brain damage from repeated attacks. We assessed suprathreshold contrast discrimination for low (10%) and high contrast (50%) sine wave gratings. Participants with migraine, 24 with aura (MA) and 15 without (MO), and 23 headache-free controls viewed 4 grating patterns, one in each quadrant, presented simultaneously for 200ms. Three of the patterns had the same contrast, and the contrast was higher for the fourth. The participants were required to detect the pattern with the highest contrast. Contrast discrimination thresholds were higher at 50% contrast, and did not differ overall between the three groups. For the MA and MO groups, the length of time since the most recent migraine attack was not related to discrimination threshold. Six of the seven participants in the MA group, who experienced consistently lateralised visual aura had lower discrimination thresholds in the affected field. Individuals with migraine may be abnormally sensitive to contrast because of a cortical hyperexcitability until sensitivity is diminished as a result of repeated migraine attacks.

Retinal dysfunction of contrast processing in depressive disorder

EVelyn Friedel[1], Michael Bach[2], Ludger Tebartz Van Elst[1] & Emanuel Bubl[3]

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Purpose: We had reported changes in the visual contrast processing at multiple levels in patients with major depression (MDD). Assessing the retina with the Pattern Electroretinogram (PERG) and the cortical stages with the visual evoked potentials (VEP) we observed alterations in both. Due to conflicting evidence in another study (normal PERG responses but differences in psychophysical contrast sensitivity), we re-assessed the contrast processing of patients diagnosed with MDD at all three levels with a new PI, in a different lab and different patients. Methods: PERG and VEP of 17 MDD patients and 17 matched healthy controls were recorded in response to both size variants of checkerboard stimuli used in the previous studies (0.5°/0.8°). Additionally, we estimated the contrast sensitivity of the participants psychophysically using a Landolt-C-based contrast test (FrACT). Results: PERG-based contrast gain from patients was equally reduced (down to 76% and 75%) for both check sizes (each $p = 0.003$, permutation test) compared to healthy controls, whilst the VEP and the contrast sensitivity remained unchanged. Conclusion: Considering our results and recent findings from a study of 2017, describing alterations in the flash-ERG of patients with MDD, we assume the modulation in the visual signal transduction at the retinal level, to be a robust marker for depression. The steady results at higher levels (VEP and contrast sensitivity) may point to normal func-

tioning contrast gain control or reflect higher-order compensatory mechanisms. With respect to the application as an objective marker, the PERG has the advantage of being a low level signal.

Predictors of motion sickness in women

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Visually induced motion sickness (VIMS) is commonly experienced when visual motion information is in conflict with motion information provided by the vestibular system and/or tactile and kinesthetic senses. According to some studies, women experience higher levels of VIMS than men, whereas others do not find this to be the case. This study investigates whether these results can be attributed to changes in VIMS-susceptibility due to the menstrual cycle. We measured the influence of estimated concentrations of four sex hormones and other menstrual parameters, such as menstrual pain, on the magnitude of self-reported VIMS levels and on measured postural stability. Hormone levels were estimated using data from Stricker et al. (2006). Participants were presented with a continuous ten-minute recording of a bike ride across mountainous terrain. Subjective VIMS was measured at one-minute intervals during stimulus presentation using the Fast Motion Sickness Scale (Keshavarz & Hecht, 2011); postural sway was recorded immediately before and after stimulus presentation. Understanding the gender-specific mechanisms involved in the elicitation of VIMS would broaden our understanding of its pathogenesis and allow for better prediction, prevention, and treatment.

Is the attentional spotlight asymmetrical?

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Cognitive load influences distractibility; distractors are more likely to be processed and decrease reaction times during low load. Attentional resources are more limited during high load, limiting our ability to process peripheral stimuli. Therefore, reaction times are quicker in the presence of distractors during high cognitive load. We manipulated distractor location to determine whether location differentially influenced the degree of distractibility. Participants completed an irrelevant-distractor paradigm. On 80% of trials participants identified whether the target was 'X' or 'N'. During low load, non-target stimuli consisted of lower case 'o' letters, whereas during high load, heterogeneous angular letters, with the same dimensions as the target were used. In the remaining 20% of trials, a cartoon character appeared in the periphery (above, below, left or right of the visual search array). Reaction times were recorded on each trial. There was a strong effect of cognitive load, as RTs were faster during low load than high load. Importantly, the interaction of cognitive load and distractor location was significant. During low load, reaction times increased equally for all distractor locations. In contrast, left distractors speeded reaction times significantly more than did right distractors during high load. We suggest that the attentional spotlight was sufficiently large to encapsulate both the distractor and the visual array during low cognitive load, leading to increased distraction, whereas the attentional spotlight split across the two visual stimuli during high load. Further, executive control is better in the left visual field, which prevents distraction and provides a greater performance benefit.

What limits visual search for feature conjunctions?

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In spite of 40 years of research we still do not know for sure the roles of internal noise, attention, and crowding in search for conjunctions of simple visual features. In this study, I combined several improvements to the classic design of conjunction search experiments. In order to match exactly the proportions of simple features, two different targets were presented in target-present trials – vertical red and horizontal blue bars among vertical blue and horizontal red distractors. Length of the bars was varied from 3 to 16 pixels, and number of objects in a display (set size) was varied from 2 to 24. Positions of objects were selected for minimal crowding effects (all inter-object distances were larger than usual critical distance of crowding). Exposure duration was 60 ms, and proportion correct was used as the measure of performance. The results were different for different observers, but none of these were consistent with unlimited capacity SDT, or simple serial search models. A similar experiment of feature (orientation) search produced very different results, close to an unlimited capacity SDT model. I propose that a limitation on the complexity (or spatial-frequency bandwidth) of the distribution of spatial attention may play an important role in search for feature conjunctions. This study was supported by the Estonian Research Council grant PUT663.

Learning to shield visual search from prominent distractors

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When we search through our environment, our attention commonly gets captured by irrelevant objects (like flashing traffic lights or brightly colored billboards). In similar visual searches, interference by prominent singleton distractors (i.e. distractors that stand out by a single characteristic) can be more effectively overcome if they consistently appear in particular display regions (Goschy et al., 2014). Our line of studies probed into the cognitive mechanisms underlying this 'location probability cueing' effect: (1) Is the effect spatial in nature or bound to characteristics of the to-be-suppressed object? In specific, does the suppression mechanism depend on the feature/dimension relationship between the prominent distractor and the to-be-attended search target? (2) Is this kind of statistical learning reflected in the amplitude of the N2pc, a common EEG/ERP marker for shifts in spatial attention? (3) Is the probability cueing effect persistent over time? After training on the first day, will we still see a bias towards the former frequent distractor region after 24 hours, even if the distractor is now evenly distributed? (4) Results indicated that for some distractors, observers who were

'aware' of the distractor distribution showed a larger probability cueing effect. So, can it be systematically enhanced by having explicit knowledge about the distractor distribution in advance? Our line of studies is the first to systematically investigate these questions and provide answers.

Captured by movement: The effect of motion on transient attention

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Studies addressing the time course of attentional selection have identified two components—transient and sustained attention—which have distinct yet overlapping time courses. In response to the sudden appearance of stimuli, transient attention rapidly deploys, enhancing performance within 100-200ms, after which it declines. Sustained attention is slower to rise, enhancing performance around 300ms, after which it is maintained. Sudden onset cues are typically used, but no study has examined the effect of a cue that onsets then moves, which was the subject of our experiments. This study may be the first to investigate the ability of motion to summon transient attention. Using a spatial cuing paradigm, we conducted four experiments in which we manipulated cue speed (moving or stationary) and stimulus onset asynchrony (SOA; time between cue and target onset) to examine the effect on performance in acuity (Experiments 1 and 2) or brightness discrimination (Experiments 3 and 4) tasks. No effect of speed was found in Experiments 1 and 2. Participants in Experiment 3 performed better in the stationary cue condition, an effect not replicated in Experiment 4, which used a different motion cue. Across all experiments, transient attention deployed rapidly, reaching peak performance between 125-167ms. Subsequently, performance fell for both cue conditions in all experiments except Experiment 4 where performance rates remained high for both speeds. Our results suggest the type of movement cue influences the time course of transient attention indicating the way motion elicits transient attention may differ from that of stationary objects.

Study of visual search in 3D space using virtual reality

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Very little is currently known about how humans perform search tasks in immersive 3D environments with more numerous objects (~1000) than in traditional 2D visual search experiments (~50). For designing efficient VR user-interfaces, it is important to thoroughly investigate perception in 3D. In this study, we designed the classic feature and conjunction search experiment in VR, modelling 3D virtual-space using a spherical coordinate system. The target was presented in one of 32 equally-sized regions centered at the participant, blocked with 45 degree increments in radial angle and elevation. The target was a red cube embedded in 96, 480, 768, or 1024 equally distributed distractors. Distractors were either green cubes (feature-search) or red spheres and green cubes (conjunction-search). The task was to find the target as quickly as possible using eye, head, and/or body-movements. We studied slopes of reaction times with respect to number of distractors for different regions of the sphere. Based on data from 25 participants, the typical pattern of slope of feature- and conjunction-search was observed. More interestingly there was a distinct inter-region variation. Reaction times were smaller in the left hemisphere compared to the right, probably due to left-right bias typical of English readers. Participants preferred counterclockwise head / body rotations when searching for targets not immediately in their field of view. Interestingly, regions below eye-level were favored more than those above. Finally, we find that occlusion can be a nuisance variable in search tasks. These findings seem robust.

High test-retest reliabilities of attention capture effects as revealed by linear mixed models

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In a series of experiments, we analyzed the temporal stability or test-retest reliability of bottom-up and top-down attention capture as well as intertrial priming of capture. Using a visual search protocol, in most of the trials, participants searched for a target of a specific color and reported a stimulus inside the target. In some trials, a matching or non-matching distractor was present. The matching distractor had the same or a similar color compared to the target, whereas the non-matching distractor had a different color than the target. Bottom-up capture was defined as the difference between trials with a non-matching distractor and trials without a distractor showing a singleton target only. Top-down attention capture was defined as the difference between trials with a matching and a non-matching distractor. Additionally, we defined top-down matching distractor trials preceded by a similarly colored target as being distractor-primed and matching distractor trials preceded by a differently colored target as being unprimed. We analyzed the temporal stability of bottom-up as well as distractor-primed and unprimed top-down capture effects by measuring manual response times and target fixation latencies of non-instructed eye movements on two different points in time, separated by one week or four weeks. Correlations based on linear mixed models revealed high temporal stability of capture and priming effects. Our results demonstrate the suitability of linear mixed models for calculating correlations of difference scores of cognitive performance that otherwise suffer from cumulative error noise as a major problem in research on individual differences or cognitive enhancement.

Common or independent attentional maps across modalities? An investigation into the curvature of concurrent eye and hand movements.

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When interacting with objects in the environment, humans often perform eye and hand movements in parallel. Previous research has reported inconsistent results: while some studies suggest that attentional resources for the eye and hand are independent, others argue for shared attentional mechanisms. Thus, it is still unclear whether the target for the eye and the hand are selected by a common attentional mechanism. In the present study, we investigated whether the target selection process of saccadic eye and reaching movements influence each other. Participants performed simultaneous eye and hand movements on a monitor towards the same or different visual target locations. We examined movement curvature as a sensitive measure of interference processes reflecting a competition between different effectors' movement plans. The results showed that, when the eye and hand target location was different, eye movements curved away from the hand target location. Moreover, saccade endpoints were shifted away from the hand target location. Similarly, hand movements curved away from the eye target location. Also, reaching endpoints were shifted away from the eye target location. These results show a clear influence of the hand movement on the properties of the eye movement and vice versa. This suggests that response competition between the movement plan of the hand and eye is resolved by inhibiting the other effector's target location. Taken together, this points towards a common attentional mechanism for eye and hand target selection.

Spatial attention and eye movements: A diffusion model study

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Executive control networks of attention (e.g., Posner & Peterson, 1990) are responsible for different tasks including inhibiting reflexive responses, resolving conflicts, and detecting errors. One way to research their interactions is with the attentional networks test (ANT, Fan, McCandliss, Sommer, Raz, & Posner, 2002), the experimental paradigm that allows to look into interaction between executive control function and other functions, such as alerting and orienting. To investigate how the executive control network of covert attention is connected with eye movements, we further developed one version of ANT (Callejas, Lupiáñez, & Tudela, 2004) by switching the response modality from manual to saccadic and using anti-saccades as the executive control component. Further, a drift-diffusion model (Ratcliff & McKoon, 2012) was fit to the baseline condition data (unalerted neutrally cued trials) to determine the parameters that differentiate reaction times in saccades versus antisaccades. Initial results show that the mean value of drift rate that corresponds to the across-trial variability in the nondecision component, was almost three times as high for antisaccades than for saccades (81 versus 35.4), while the drift rate and the bias component were smaller for antisaccades than for saccades. Based on that, we propose that with the executive control network being triggered subjects are less biased when planning a saccade. Comparisons between drift models for manual and saccadic executive tasks also suggest significant differences between response modalities.

Attentional capture and voluntary orienting modulation: An ERP study

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In previous research we have found that voluntary attention modulated and overcame the negative effects from incongruent capture produced by a transient luminance change on an irrelevant location. This happened even though the spatial cue for voluntary orienting and the transient change were simultaneous in our task. In the present research we try to obtain information about the differential ERP components locked to capture, voluntary attention and the modulation of capture by voluntary spatial orienting. We compared different conditions: baseline task , task with valid spatial orienting, task under incongruent capture and task under simultaneous incongruent capture and voluntary orienting. We did this under conditions of different perceptual load. Incongruent capture was always contralateral to the stimulus and the valid orienting cue. As in our procedure exogenous capture and spatial orienting are previous to the stimuli, we focus on the time previous to stimulus onset for the ERPs analysis. Our results show that the effect of the valid orienting cue is locked to a greater amplitude of a late P1 in Fz and also in the N1 in parietal areas. Incongruent capture is locked to a greater N1 in ipsilateral parieto-occipital areas with low perceptual load and, also, with high load for capture in the right VF. The modulation of voluntary attention on incongruent capture is also seen in parieto-occipital areas with the amplification of N1, contralateral to capture and ipsilateral to the cued visual field. However, not in all cases does the modulation exist, it depends on perceptual load.

The role of motor processing in position monitoring

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The position monitoring task is a measure of divided spatial attention in which observers track the changing positions of one or more objects, attempting to represent positions with as much precision as possible. Typically observers show a decline in precision of representations with each target object added to their attention load. Since the motor system regularly requires precise representations of target positions as well as change in position over time, we sought to investigate whether directly engaging the motor system would aid in position monitoring. Using motion capture, we recorded the positions of observers' index finger during pointing responses. Observers attempted to monitor the changing positions of between one and four target discs as they moved randomly around a large projected display (90x60 cm). After a semi-random period of disc motion, all discs disappeared and observers were prompted to report the final position of one of the targets, either by mouse click or by pointing to the final perceived position on the screen. For mouse click responses, precision declined with attention load. For pointing responses, precision declined only up to three targets and remained at the same level for four targets, suggesting obligatory attention to all four objects for loads above

two targets. Deceleration profiles for pointing responses reflected the difficulty of pointing to very precisely represented locations as well as effects of load. This work was partially supported by a grant (#318/14) from the BIAL Foundation.

Dynamic change of spatial attention measured by event related steady state visual evoked potential

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Steady state visual evoked potential (SSVEP) of electroencephalogram (EEG) signals has been used to investigate both spatial and temporal attention with the benefit for measuring attentional effect around the attention focus without any probe, which is required for event related potential (ERP). We developed a technique to measure spatiotemporal property of visual attention using SSVEP to investigate interaction between top-down and bottom-up attention. In our previous studies, we estimated attentional modulation, where both SSVEP and ERP showed attentional facilitation at the location attended with different effect at adjacent areas (SSVEP showed broad but P3 of ERP showed narrow tuning). The difference may be caused by presentation of probe target for ERP. Since the SSVEP was an average over several seconds, no information was available right after the probe presentation, which reflects the effect of bottom-up attention by the probe. We developed an analysis of event related SSVEP (ER-SSVEP), which is the SSVEP time course after target presentation, in order to explore dynamic changes of visual attention. The attentional state was assumed to be controlled by top-down attention before target presentation as SSVEP in previous studies showed. Our question here is whether the bottom-up attention due to the target changes the attention state. The obtained ER-SSVEP showed that the peak of spatial attention shifted to the target location with broad spatial tuning. This supports different attention processes at different stages of the visual process, ruling out the possibility that target presentation changes spatial tuning of visual attention.

Subliminal spatial word cues trigger visual attention shifts: Evidence from event-related potentials in visual search

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We investigated, if subliminal spatial word cues, presented below the threshold of conscious perception, trigger shifts of spatial attention. To that end, masked word cues, "left" and "right", were shown prior to visual search displays in half of the trials and prior to visible congruent and incongruent target words in the other half of the trials. We measured both response times to targets and event-related brain potentials (ERPs) reflecting attention, such as the LDAP (Late Directing Attention Positivity) to the cues and the N2pc to the targets. In the visual search task, we found an LDAP contralateral to the subliminal word cues and different N2pc amplitudes to targets depending on the congruency between subliminal words and target locations. In addition, in the word task, differences in the N400 component (an ERP deflecting semantic relatedness) depending on the congruency between subliminally presented word and target were found. Together, our results show that at least task-relevant subliminal prime words can elicit attention shifts.

Preparatory orienting of spatial attention reduces feature-based contingent capture

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Cueing spatial attention to the location of upcoming targets speeds response times to feature-defined target objects in visual search tasks, suggesting that the guidance of attention by known target features can be confined to specific spatial locations. Here, we investigated how the attentional selection of target features in visual search displays is modulated by spatial cues. Participants had to respond to target objects defined by one particular colour or by one of two possible colours (single-colour or two-colour search) in search displays preceded by precues. Diffuse cues specified the task-relevant hemifield, and precise cues the exact target location. Target-colour objects at uncued locations could be ignored. N2pc components to target-colour objects were substantially larger at cued versus uncued locations. N2pc components were also entirely absent for target-colour objects at uncued locations during two-colour search. Experiment 2 demonstrated that similar effects of spatial attention on the feature-guided allocation of attention occurred regardless of whether or not target-colour objects were feature singletons. These results show that the preparatory orienting of spatial attention modulates feature-based selection processes in visual search, and attenuates contingent attentional capture by target-defining features at task-irrelevant locations.

Distortions of event perception by stimulus contrast: The role of attention

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In most cases, when a brief, low contrast stimulus follows another one with high contrast, they are more likely to be perceived as part of a single event, that is, to be temporally integrated and judged to be simultaneously presented. We found that this pattern completely reverses, such that perceptual segregation actually becomes more likely, when a relatively long first stimulus is combined with a short second stimulus (e.g., 70ms and 10ms). To further study the processes underlying this unexpected result, we subsequently measured event-related potentials. Amplitude on components previously implicated in temporal integration, such as the N1, N2pc, and P3, was modulated by stimulus contrast. Compared to conditions featuring stimuli with mixed contrast, or with a low contrast first stimulus, the condition with a low contrast second stimulus elicited higher N1 amplitude. This differential amplitude effect further developed on the N2pc and P3. These outcomes suggest that attention plays an important role in the unusual stimulus segregation that occurs for the aforementioned presentation conditions.

Given the development of the event-related potential differences, it furthermore seems likely that both earlier and later phases of attentional processing are involved. A conceptual model based on simple neural activation dynamics is presented to account for the results.

The impact of the black and white stylization of video advertisements on emotional impression

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When creating TV ads designers often use discoloration technic to improve the products promotion efficiency. The principal aim of this study was the research of psychophysiological correlates of emotions that occurs during watching video advertisements in chromatic (in color) and in achromatic (in black and white) versions. The participants were sixteen adults (8 males). Four video advertisements of the perfumery products were used as stimulus. All videos were performed in two versions. The first experimental group watched video advertisement number 1 & 3 in achromatic version, 2 & 4 in chromatic version. Conversely, the second group has seen 2 & 4 in achromatic version and 1 & 3 in chromatic version. EEG data, skin conductance responses (SCR), heart rate and pulse wave amplitude by photoplethysmogram were collected. Subjective values of advertisements measured by questionnaire. The analysis didn't reveal any significant differences between experimental groups' results. This means that chromaticity of clips did not influenced on the subjective evaluations, as well as on physiological indicators. At the same time we found that the data were changing in depending on the videos' content and sex of the participants. ANOVA RM found the significant main effect of number of video for the scale «general impression» as well as for the theta power in F3 and alpha power in P4. Women more positively evaluated all videos and had significant greater overall EEG power values in time of perception of each stimulus. SCR amplitude was changing in depending of the target audience (gender) of advertisements.

Modelling the design of efficient animal warning signals

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Many species in the animal kingdom use visual camouflage to reduce the likelihood of being detected or recognised by predators. Aposematic species embrace a contrasting strategy: they endorse conspicuous, distinctive patterns called warning signals to advise would-be predators that they are well defended by being toxic, for example, or more generally unprofitable. Visual warning signals have been shown to enhance predators' unlearnt wariness and avoidance learning. What makes an efficient and effective warning signal however has not been explored yet. A seemingly consistent feature is that warning signals often contain highly contrasted repetitive patterns, reminiscent of the patterns known to cause visual discomfort in humans, typically stripes or regular arrangements of dots. A growing body of work associates visual discomfort with excess of neural activity in the visual cortex. In this study, using a generative model of images (randomly generates images, then iterates) we investigate computationally what image features maximally activate a generic model visual system whose fundamental component are edge detectors. We show that the visual features that maximise the activity of the model share many characteristics with the features involved in animal warning signals. This suggests that aposematic patterns will deliver excess neural activity in predator visual systems. We speculate that such activity could be part of the design of warning signals.

The stability of preferred retinal locus for fixation across different time scales

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Earlier studies have shown that the retinal location human subjects use to fixate a visual stimulus is often consistently displaced from the point of highest cone density. This study asked how stable this preferred retinal locus (PRL) is across various time scales. Fixation data were gathered from 5 subjects with an adaptive optics scanning laser ophthalmoscope at 30 Hz sampling rate. The subjects fixated on a maltese cross (diameter 5.5 arcmin), which shifted randomly every 3-5 seconds. Data from 500 ms after each stimulus shift was excluded. The displacement of PRL from the point of highest cone density was replicated. The standard deviation of fixation within one 30 sec video was approximately 2 arcmin (range 1.6 to 2.7). The standard deviation between the average PRLs between such videos taken during the same session was roughly 0.6 arcmin (range 0.2 to 1.5). The largest separation between average PRLs from any two days for the same subject was on average 0.8 arcmin (range 0.3 to 1.1). Thus, differences between days are extremely small relative to the fixational eye movements and are likely to be completely caused by measurement error. We conclude that whatever the retinal location a subject uses to fixate a visual target, that location is extremely consistent, even across days. The displacement of the PRL from the point of highest cone density observed here and in earlier studies is not caused by random fluctuations in the error signal to the oculomotor system or the oculomotor system's correcting actions.

The relocation of the preferred retinal locus under progression of a central scotoma

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Patients with central scotoma use healthy retinal locations to perform visual tasks. The consistent use of such a retinal location is referred to as preferred retinal locus of fixation (PRL). Most of the conditions that cause central scotoma are progressive and as a consequence, fixating strategies need to be adjusted throughout the progression of the condition. The present study investigates the changes in PRL when subjects undergo a simulation of progressive central scotoma. Five normally sighted subjects participated in the study. A foveally centered mask was presented to simulate the scotoma. Initially subjects developed a PRL under simulation of a six degree scotoma, which was used as a baseline. The

simulation consisted of a gradual increase, and an abrupt increase of scotoma size in separate conditions. In the incremental progression, the diameter of the scotoma increased by a fixed amount of either one or two degrees of visual angle, thus scotomas of eight, ten and eleven degrees of visual angle were simulated. In the abrupt progression, the diameter was adjusted individually to span the area of the visual field used by the current PRL. Subjects located the PRL along the same meridian under simulation of scotoma progression. Furthermore, no differences between the fixation stability of the baseline PRL and the gradual progression PRLs were found, whereas in abrupt progression, fixation stability dropped significantly. These results provide first insight into fixation behavior in a progressive scotoma and might contribute to the development of training tools for patients with progressive central maculopathies.

A mathematical model of microsaccade properties

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Microsaccade is a component of fixation eye movements and occurs involuntarily even when gazing at a specific visual target. In order to elucidate the relationship between microsaccadic motion and visual perception, simulation research using a mathematical model of retina has been reported (Kohama et al., ECVP2012). However, since the mathematical model of microsaccades in this model is different in detail from actual microsaccades, validity of the simulation results have not been properly evaluated yet. In this study, we proposed a mathematical model to reproduce the dynamic characteristics of microsaccades. We obtained certain length of segments which contained a microsaccade from fixation eye movement data, and calculated their ensemble averages. Since the amplitude of a micorosaccade varies widely and changes depending on the shape of fixation target, we categorized the microsaccadic amplitude at intervals of 0.3 deg and calculated ensemble averages for each category. As a result, it is shown that dynamic characteristics of microsaccades are described by combination of nonlinear functions which have amplitude, overshoot, and displacement of eye position as parameters. By combining the proposed model with the conventional model which reproduces the mean square displacement characteristic of fluctuation of fixation eye movements (Tokudome et al., 2015), a more realistic simulation of fixation eyemovements was generated.

Combinatorial processes of enumeration and arithmetic are evident in patterns of eye movements and response times for number stimuli with varied spatial grouping

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Dot enumeration speed predicts arithmetic performance in children and adults leading to the proposition that arithmetic ability may develop from core spatial abilities. The counting processes may be facilitated by grouping dots into subsets that are more efficiently accumulated, in an operation that is similar to combining numerals in an addition display. It has been proposed that eye movements reflect the grouping and combinatorial processes that participants use to enumerate dot displays. There is a high correlation between fixation number and enumeration response times for randomly placed dot displays. If eye movements do reflect the combinatorial process used to enumerate dots and a similar combinatorial process is used to perform addition, then we would expect eye fixations to correlate with response time in conventional arithmetic tasks. We measured response times and recorded eye position while sixty undergraduate psychology students performed a number task. On each trial the participants enumerated displays of dots or added numbers that totalled 1 to 16. We manipulated the spatial grouping of the dot and arithmetic displays to influence the combinatorial complexity of the displays. Response times varied with the grouping of the dot displays and the arrangement of the numerals in the addition display. Fixation number was highly correlated with addition response time for both dot enumeration and arithmetic displays regardless of combinatorial complexity. Our data provide support for the idea that dot enumeration involves combinatorial processes that may be a scaffold for the development of arithmetic.

Revealing the impairments of thalamic lesions using a neuro-computational model of saccadic suppression of displacement

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We here address how the combination of lesion studies, behavioral observations and neuro-computational modeling helps to reveal the function of the lesioned brain tissue. In particular, we aim to explain the role of the thalamus in maintaining the subjective experience of a stable world during eye movement, motivated by recent studies (e.g. Sommer&Wurtz, 2004, J Neurophysiol 91: 1403-1423; Sommer&Wurtz, 2008, Annu Rev Neurosci, 31:317-338). Ostendorf, Liebermann and Ploner (2010, Proc Natl Acad Sci USA 107:1229-1234; 2013, Front Syst Neurosci 7:10) presented data of patients with different thalamic lesions showing impaired performances in the saccadic suppression of displacement (SSD) task. According to our model (Ziesche&Hamker, 2011, J Neurosci, 31:17392-17405; Ziesche&Hamker, 2014, Front Comput Neurosci, 8:25), such lesions my either affect the representation of corollary discharge, proprioceptive eye position or both. We fitted the model to the individual patient data to reveal potential outliers in the parameters which in turn indicates the properties affected by the lesion. One main finding is, that a lesion in the thalamus apparently distorts the corollary discharge signal which results in a declined ability to detect small stimulus displacements in backwards direction.

No exception from Bayes' rule: There is a range effect in the saccadic system

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The last decade has seen an impressive number of demonstrations that human motor movements are the result of a near-optimal Bayesian decision process, which is based on a combination of noisy sensory information and learned prior knowledge about the fundamental statistics of the task such as the range and the likelihood of response alternatives (Wolpert & Landy, 2012). Depending on the nature of these task statistics prior knowledge often generates motor range effects such as a central-tendency movement bias (Körding & Wolpert, 2004; Vilarez et al., 2012). However, when it comes to eye movements there is a recent controversy about the general existence of a range effect in the saccadic system (Gillen, Weiler, & Heath, 2013; Nuthmann et al., 2016). Here I argue that the studies, which claim to provide evidence that there is no range effect for saccades, draw their conclusions from experiments with uninformative priors and highly precise saccade targets, which contradict the presence of a range effect. Based on prosaccade experiments with informative prior distributions and reduced precision of the sensory likelihood I demonstrate that there is a range effect in the saccadic system. Furthermore, I show that the range effect varies in size depending on the nature of the prior and the sensory likelihood as predicted by a recent framework of Bayesian saccade planning (Engbert & Krügel, 2010).

The influence of language proficiency on visual search in letter charts

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In the current study visual search for lexical items was modeled. 34 subjects (19 native speakers of Russian and 15 B2 learners of Russian as a second language) were presented with letter matrices (15x15, filled with Cyrillic letters in random order), where they had to find 10 average-frequency Russian words in 40 seconds. We presented 6 matrices to each subject. Subjects' eye movements were recorded with SR 1000 eye-tracker. We used the procedure for distinguishing eye movement patterns of visual search based on intersaccadic angles and saccade directions as described in our previous paper (Blinnikova, Izmalkova, 2017, in print). The data indicates that subjects demonstrate different eye-movement patterns according to their language expertise: native speakers tended to have larger intersaccadic angles (mean=74.1, σ=11.3) as compared to B2 Russian language learners (mean=31.8, σ=14.7); the results were significant at $F(2;190)=479$, $p<0.05$. Language learners, therefore, showed sequential eye movement pattern with prevailing either horizontal, or vertical alignment of fixations (contingency coefficient=5.71, $p<0.05$), which can be attributed to the difficulty of lexical decision task, which was proved by search results (mean=2.1 out of 10, σ=1.5) as compared to native speakers (mean=2.9, σ=1.6), who demonstrated non-sequential search pattern. The data is in accordance with previous research on the efficiency of lexical decision task according to language proficiency (e.g. Bultena, Dijkstra, van Hell, 2014). The study was sponsored by the RFBR research grant № 16-36-00044

Do prototypical hues influence viewing behavior in natural scenes?

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A prototypical color is the most typical example of a color category. The hue that pertains to such a color can be defined as a "prototypical hue". We wanted to test if prototypical hues are more salient than others. We did so in a paradigm where we showed natural scenes to our observers and tracked their eye movements. We picked one critical non-color diagnostic object from each scene and changed its hue such that it was either prototypical for the categories "blue" and "green" or fell on a category boundary (khaki, turquoise), while saturation and luminance remained as in the original images. Each of the resulting four image variants was presented for four seconds in an interleaved design that comprised four blocks such that each image was seen only once per block. To prevent observers from consciously detecting the change in hue, we instructed them to memorize the number of people in the scene. Twenty-four of the overall 29 observers did not notice that the hue of the critical object changed during the experiment. In the first block, these 24 observers were more likely to fixate the critical object when it had a prototypical hue than when it did not. This effect was mainly driven by a trend to fixate objects more often when they were green than when they were turquoise or khaki. While generalization to other colors remains to be tested, our data provide a first indication that prototypical hues are more salient than other hues.

Cross-saccadic active vision from iconic to working memory

Jihyun Yeonan-Kim

Saccadic eye movement introduce abrupt changes to images in the visual field that nonetheless create smooth, uninterrupted, perceptual transition. An essential query thus is how visual system constructs such stable representation across saccades. Behavioral studies have suggested potential mechanisms such as perceptual reset and pre-saccadic attentional shift that enhance feature memory in a spatially-selective manner. As to physiological aspect, saccadic suppression of some motion sensitive cells is evidenced along the visual system hierarchy from ganglion cells to MT. These regulatory processes take place only at the presence of eye-movement and appear to actively adapt the entire system for scene scanning. Here I propose a comprehensive biophysical computational framework of the saccadic regulation mechanisms and assesses their impacts on iconic and working memory. First, Iconic memory formation is affected by abolition of the entire phasic transient ganglion cell circuitry (selective to any spatial changes of stimulation, including motion) during the saccadic cycle, which let sustained ganglion cells' signaling to cortex persists without interruption. This explains why cross-saccadic visual masking occurs retinotopically (Davison, 1973) unlike the pursuit eye movement case (White, 1976). Second, working memory is regulated by allocation of spatial attention to the saccade landing

position, which enhances encoding of the post-saccadic input to the sensory layer at the absence of the transient retinal signals. This may facilitate registration of new feature memory (e.g. Schneegans et al., 2014) as well as maintenance of the pre-saccadic feature memory presented at the saccadic landing position (Ohl & Rolfs, 2016) during the saccadic cycle.

Separating fixations driven by deep and low-level features

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Learning what properties of an image are associated with human gaze placement is important for understanding how biological systems explore the environment and for understanding behaviour on a more general scale. It is a subject of ongoing debate to which part fixations are driven by low-level features and to which part by high-level abstract features like faces or text. Recent advances in deep learning for the first time enabled significant progress on explaining fixations by high-level features: Our saliency model DeepGaze II uses the VGG network (trained on object recognition in the ImageNet challenge) to convert an image into a high-dimensional feature space which is then readout by a second very simple network to yield a density prediction. DeepGaze II is right now the best performing model for predicting fixations when freeviewing still images (MIT Saliency Benchmark, AUC and sAUC). Using the modular architecture of DeepGaze II, we also made significant progress in predicting fixations from low-level features: By replacing the VGG network with very simple isotropic mean-luminance-contrast features we created a model that outperforms all previous saliency models before the models that used pretrained deep networks (including models with high-level features like Judd or eDN). Using DeepGaze and the Mean-Luminance-Contrast model (MLC), we can separate how much low-level and high-level features contribute to fixation selection in different situations. Task and time greatly influence fixation placement. We explore how the features driving fixations change over different tasks or over presentation time.

Faces elicit differential eye movements depending on emotional expression, in the absence of awareness.

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Eye movements can be dissociated from visual awareness (reviewed by Spering & Carrasco, TINS 2015). Emotional information has been demonstrated to enhance visual perception and gain preferential access to awareness. Here we investigated whether emotional visual information is able to guide eye movements even in the absence of visual awareness. We presented upright and inverted face images with different emotional expressions – neutral, angry, and fearful – randomly in one quadrant of a dichoptic display. The faces were rendered unaware using continuous flash suppression and viewer's eye movements were recorded during successful suppression as determined by objective and subjective measures of awareness. Analyses of gaze locations demonstrate that participants move their eyes in response to an emotional face stimulus even when it is suppressed from awareness: Upright angry faces first attract eye movements and then lead to gaze aversion away from the angry face, whereas upright fearful faces attract eye movements later and longer, with no gaze aversion. These eye movement patterns did not emerge when faces were inverted. These results show that facial emotional expression is processed unconsciously and directs eye movements depending on emotional valence, exemplifying the unconscious power of emotions on our actions.

Smooth pursuit and saccades work to maintain tracking during naturalistic ball bouncing

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Smooth pursuit eye movements keep the fovea on a target moving at a few degrees per second, while saccades abruptly take the fovea from one position to a second one typically containing a feature of interest. We ask how these two interact to maintain tracking in a naturalistic psychophysics task in which a small circle (the ball) was horizontally projected from the centre of the screen under the impact of gravity and bounced off an invisible pair of virtual vertical walls along with a horizontal floor during each 2s trial period. We manipulate the speeds (4 or 16deg/s), the energy loss per bounce (flat vs normal), and in a second block tested the same variables under an antigravity condition. We found that a number of saccades and microsaccades were sustained during all conditions of this task, averaging over 2.5/s interspersed with periods of smooth pursuit. This is probably because of the unpredictability of the stimulus. The tracking position and velocity errors were highest within the first 100ms but systematically reduce between 0.5-1s. Tracking is best under the slower speed, the predictable downward gravity and for a normally bouncing ball. The largest of the detrimental effects was measured for the antigravity condition. Under more naturalistic stimulation, the pursuit system appears to work inseparably with saccades, increasing the latter to counter stimulus unpredictability.

Intra-saccadic large-field motion modulates the perception of trans-saccadic apparent motion

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To localize objects across saccades, the visual system can use efference copies of saccadic motor commands to anticipate and account for the retinal consequences the eye movement. In natural vision, however, saccades induce rapid shift of the entire retinal image. As this intra-saccadic large-field motion varies proportionally with the size and speed of a saccade, it could provide an additional cue that informs trans-saccadic localization. Participants made horizontal saccades of 16 degrees of visual angle (dva), and two probes vertically separated by 4.8 dva were presented, one

shortly before and one after the saccade, inducing an impression of vertical trans-saccadic apparent motion (Szinte & Cavanagh, 2011). We displaced the second probe horizontally by variable amounts, leading to a noticeable tilt (clockwise vs. counterclockwise), which participants had to report. Importantly, the background of the screen consisted of a noise field bandpass-filtered for low spatial frequencies and vertical orientations. To manipulate retinal velocity during saccades, we injected additional motion of 117 dva/s for 25 ms to this large-field background, either in or against the direction of the saccade. Post-saccadic masking prevented conscious detection of background motion. We found that tilt judgments were modulated not only by saccade length but also by retinal velocity: Reducing intra-saccadic retinal velocity altered the displacement necessary to achieve vertical apparent motion in the direction of the saccade, as if—in the computation of the apparent motion direction—the saccade's amplitude was underestimated. These results invite the intriguing hypothesis that intra-saccadic signals contribute to perceptual stability.

Body size adaptation for bodies and faces, but not across categories.

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The thin body ideal is shaped and reinforced by many social influences. Through the media we are bombarded with images of thin people. Several studies have shown that adaptation to thin bodies can bias participants' perceptions of what normal, ideal and attractive bodies look like. Here we aimed to investigate whether similar aftereffects occur after adaptation to faces, and whether such adaptation transfers between faces and bodies. We conducted three experiments. In Experiment 1, on each trial participants had to decide whether the body they saw was thinner or fatter than average. Participants performed the task before and after adaptation to a very thin body. Consistent with previous studies, after adaptation participants judged subsequently presented bodies to be fatter than at pre-test. In Experiment 2, we used the same procedures but with faces as both adapting and test stimuli. Our study showed that adaptation affects face size judgments: after adaptation to a gaunt face, participants judged subsequently presented faces to be fatter than at pre-test. In Experiment 3 we investigate whether body size aftereffects transfer between faces and bodies. Previous studies showed cross adaptation between faces and bodies for both identity and gender. Here, we used similar procedures as in experiment 1 and 2, with bodies as test stimuli but with faces as adaptors. Contrary to previous studies, we found no transfer from faces to bodies on the body size judgments. Adaptation to neither thin nor fat faces affected the perception of subsequently presented bodies.

Integration of expressive facial features

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Holistic face processing can be viewed as "strong fusion" of facial features, which is stronger than predicted by optimal integration of independent features. We studied the integration of facial features when discriminating facial expressions. Our stimuli included images of 60 identities from Radboud and Faces databases. We varied the strength of the expression by morphing full-contrast faces from angry to neutral to happy expression. The participant indicated whether a face was angry or happy, and we measured psychometric functions to estimate discrimination thresholds. Identity varied randomly from trial to trial. In separate blocks of trials, we measured discrimination thresholds with the individual features (eyes-only and mouth-only), and in three intermediate conditions with different relative strengths of the expression in the mouth and the eyes. We then compared the thresholds to predictions from a model that assumes optimal integration of independent features. For 7/8 participants, thresholds were either consistent with or lower than the predictions. In a second experiment, we fixed the expression strength and estimated d' values for identifying the expression using a single cue (eyes or mouth) in separate blocks. Three types of trial were interleaved: non-attended cue absent (baseline), congruent, or in conflict with the target cue. Congruent cues improved and conflicting cues decreased performance compared to baseline, the effects being stronger when eyes were the target cue. The results suggest compulsory integration of facial features in discriminating facial expressions.

Visual awareness of body posture contexts is necessary to influence categorisation of facial emotional

Katie Gray & Richard Cook

The perception of facial emotion is informed by our knowledge and experience. For example, the same facial expression varies in appearance when presented in the context of different body postures. The present study sought to determine whether visual awareness is necessary for this effect to occur. Ambiguous facial expressions (morphed expressions consisting of 50% angry and 50% disgust from the same identity) were presented either within a disgusted or angry body posture context. In visible trials, all parts of the stimulus display were presented. Using continuous flash suppression (CFS), trials were also created in which the body posture context was suppressed from awareness. After each 1 second stimulus presentation, observers categorised the expression of the face (angry or disgusted) before responding to a subjective awareness check. In a sample of 22 participants, there was a significant effect of context in visible trials: the ambiguous emotional expression was judged as angry more often when presented with an angry body posture, and as disgusted more often when presented with a disgusted body posture. This pattern was reduced, but remained significant when the body posture was presented in CFS. However, when trials were classified by subjective awareness into 'aware' and 'unaware' trials, the context effect was only evident in aware

trials. When observers' reported having not seen the context, body posture did not affect the categorisation of the emotional face. These results are important in our understanding of how emotional expressions are perceived, and how context influences the perception of emotional faces.

Support for the prediction hypothesis of visual stability: Invalid peripheral preview delays the fixation-locked N170 face inversion effect

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One explanation for why the visual world appears stable and continuous despite saccadic eye movements is that the efference copy of the motor plan is used to make predictions about what will be perceived after the saccade. If so, then a violation of this prediction should be detrimental to post-saccadic perceptual processing. In the present study, we investigated this hypothesis in a peripheral preview paradigm using combined EEG and eye-tracking. Participants were cued to make a saccade to one of two bilaterally arranged upright and/or inverted faces. During the saccade, the faces could change orientation (invalid preview; prediction violation) or remain the same (valid preview; prediction confirmation). After each saccade, participants reported whether the target face was tilted slightly left or right (tilt was independent of face orientation of upright/inverted). Consistent with the idea that valid predictions facilitate perceptual processing, participants were faster in discriminating target face tilt when face orientation remained the same across the saccade (valid preview) compared when it changed (invalid preview). Fixation-locked ERPs exhibited a larger N170 for inverted compared to upright target faces. The onset of this face inversion effect was delayed for invalid previews, suggesting that pre-saccadic peripheral visual input affected early stages of post-saccadic, foveal processing. This pattern was confirmed with an EEG decoding analysis of upright versus inverted faces. The results are consistent with the idea that perceptual predictions are created from peripheral input, influence post-saccadic processing, and contribute to the impression of visual stability despite saccadic eye-movements.

Effects of lip color on perceived lightness of facial skin depend on holistic processing of faces

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Whereas geometric illusions in human faces have been reported by several studies, illusions of color or lightness in faces have seldom been explored. Here we psychophysically investigated whether lip color influences facial skin's perceived lightness. Experiment 1 employed the method of constant stimuli and measured perceived lightness of facial skin with lips of different colors. Results demonstrated that darker lips made facial skin appear darker and that redder lips made facial skin appear lighter. Yoshikawa, et al. (2012) found that reddish faces appear lighter. If we assume that redder lips make facial skin appear reddish, then redder lips should lead to lighter appearance of complexion. Therefore, effects of both darker lips and redder lips can be considered illusions of color/lightness assimilation. These effects differ from the classical illusion of lightness contrast in non-face objects for two reasons. First, illusory effects in faces are more assimilative than contrastive. Second, the inducing area (i.e., lips) is much smaller than the influenced area (facial skin). Thus, these lightness-inducing effects observed in Experiment 1 may be unique to faces. Experiment 2 used the same method as Experiment 1 except that all the facial stimuli were inverted. Results showed that lightness-inducing effects were not observed in inverted face stimuli. Taken together, these experiments indicated that the assimilative lightness induction is caused by holistic processing of faces. This is the first study to scientifically substantiate the claim of cosmetics manufacturers and makeup artists that lip colors can alter perceived facial skin color.

Face description abilities predict line-up performance

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Verbal descriptions of unfamiliar faces have been found to impair later identification of these faces in children and adults, a phenomenon known as the "verbal overshadowing effect". The present study examined the person descriptive abilities of 7–8, 10–11, and 13–14-year-old children and adults and their influence on later identification performance. Our aim was to specifically assess the "content" hypothesis that suggests that a verbal overshadowing arises not just because participants generate a verbal description but when they provide inadequate descriptions upon which they rely during retrieval. For the first time, we showed that the type of descriptors provided by participants is related to line-up performance. Specifically, it seems that, in all age groups, the exactitude of the description of internal facial features provided predicts subsequent identification performance. Thus, we suggest that the "content" hypothesis might explain the verbal overshadowing effect.

Ultra-coarse human face detection in a dynamic visual sequence

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Detecting faces in our environment is a crucial aspect of natural vision, yet little is known about how basic units of visual information, i.e., spatial frequencies, contribute to this fundamental function. Here we identify the minimal and optimal spatial frequency content for driving face detection using frequency-tagged electrophysiological responses obtained during dynamic visual stimulation. Human observers (n=16) viewed rapid sequences of highly variable natural object images (e.g., plants, animals, buildings, artefacts, etc.) shown at a rate of 12 Hz (SOA = 83.33ms), with face images interleaved as every 8th image (12 Hz/8 = 1.5 Hz). We mimicked the naturally coarse-to-fine integration of spatial frequency by parametrically increasing spatial frequency content over the course of one minute. Initially blurry/indistinguishable

images progressively sharpened every four seconds, becoming easily recognisable towards the end of the sequence. Face-selective responses emerged on the basis of extremely coarse information (< 5 cycles/image), and gradually increased with additional spatial frequency content before reaching saturation at > 50 cycles/image. Thus, while very low spatial frequencies suffice to drive face detection in a dynamic and complex environment, additional higher spatial frequencies serve to refine this process. These observations shed new light on both face perception and perceptual categorisation in general, and pave the way for a new approach to visual evaluation in developmental and clinical settings – one in which low level visual capacities can be examined in the context of high level object recognition.

Similarity asymmetries in face image comparison

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Faces are a relatively homogeneous object class. Nevertheless, we are able to recognise familiar faces despite substantial variation in appearance from one encounter to the next. What representations support this ability? Prominent theoretical accounts propose that face images are encoded relative to both global population norms (representing between-face variance) and to person-specific prototypes of familiar faces (representing within-face variance). In a series of experiments, we draw on a well-known phenomenon in the category learning literature – similarity asymmetry – to test these theoretical positions. Similarity asymmetry occurs when perceived similarity of category members in one sequence (A → B) differs from similarity in the opposite sequence (B → A). Importantly, these asymmetries are systematically related to the relative typicality of category members. First, we measured similarity asymmetries between population norms and individual faces. Observed asymmetries were consistent with prototypical organisation of between face variation, and equivalent for familiar and unfamiliar faces. Second, we measured within-face similarity asymmetries – by creating face prototypes from multiple exemplar images of the same face, and asking participants to rate similarity of prototype and exemplar images. Again, we find asymmetries consistent with prototypical organisation of within-face variation. However, in this study, asymmetries were significantly stronger for familiar faces compared to unfamiliar faces. Further, for familiar faces only, typicality of exemplar images was negatively related to the strength of these asymmetries. These results provide the first direct evidence for prototypical organisation of within-face variation in representations of familiar faces.

Decoding categories shared by the face and body.

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Humans can easily categorize images of human bodies and faces according to their sex/gender and weight. Objectively speaking this is a difficult task due to category-independent variability in image size, lighting, facial expression and body pose. We investigated which brain regions code for the sex and weight of faces and bodies, and whether the representations would be face- or body-selective. We used fMRI to record the brain activity of subjects viewing faces and bodies that varied in sex, weight, and image size (factor 2). Using multivoxel pattern analyses, we found that the extrastriate body area (EBA), fusiform body area (FBA) and occipital face area (OFA) consistently discriminated bodies of different sexes, including in a cross-classification analysis where training and test data were based on different stimulus sizes. Body weight could be decoded in OFA and FFA, size-invariantly in the latter. When voxels of body-regions were pooled, the sex and weight of bodies could be decoded invariant with respect to image size. No region consistently decoded the sex or weight of faces, nor did face-related decoding work when voxels were pooled across face- or body-selective regions. We hypothesize that this may be due to the fact that neither weight nor sex appeared very prominently in controlled face stimuli used here (e.g. excluding hair). We conclude that information relating to the body categories sex and weight is found in both body and face responsive brain regions, but that size-invariant information is mostly located in body responsive regions.

Modulation of oscillatory activity and synchrony in V1 as a function of stimulus features

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Neurons in visual cortex exhibit gamma-band activity (30-80 Hz) in response to visual stimulation [4]. However, the relationship between visual input and oscillatory response is not yet completely understood [7]. Studies that have explored the correlation between the visual stimulus and gamma (frequency, power) [7] [6] [3] were restricted to only a limited range of visual features (e.g. contrast). Here, we propose a systematic exploration of the stimulus-response relationship, by presenting standardized visual stimuli that vary in contrast, brightness and orientation. We recorded neural activity in response to the stimulus palette and characterized gamma response: power and frequency in LFP [1], and firing rates and oscillatory strength in multi-unit activity. Results indicate complex relationships between stimulus parameters and features of emergent gamma. Specifically, luminance and contrast fluctuations induce different effects on gamma features: while contrast positively correlates with both frequency and power, luminance differentially modulates power and frequency [2]. Decoupling these two response features contradicts the assumption that frequency variation is a passive consequence of increased input drive [7] and reveals the potential of computationally complex underlying network mechanisms [5]. The systematic evaluation of causality between stimulus parameters and network response in V1 is instrumental to understanding the role of gamma activity in visual processing. Moreover, it can potentially reveal indicators of underlying mechanisms of oscillatory activity.

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The perception of noise in digital video: Influence of bandwidth

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With increasing resolution, photon shot noise has become the limiting factor for image quality in low light conditions. Although extensive knowledge based on five decades of perception research is available, most of these experiments focused on artificial signals, mainly sine waves. Building on our first study, which showed the perception of noise in digital video for different frequency bands, we now investigate the perception of realistic noise and noise of varying bandwidths. We conducted a noise-perception test with 22 observers. We included realistic noise types, i.e. traditional film grain, digital camera noise, and additive white Gaussian noise, and additionally study noise with different filter shapes, bandwidths and center frequencies. The noise was then masked with two different background sequences – one plain grey sequence and another with natural image content. We conclude that (1) camera noise was noticed earlier than film grain and additive white Gaussian noise was the least visible, and (2) increasing filter-bandwidth reduced the visibility of the noise. Our findings show that the composition of frequencies of image noise is essential for evaluating image and video quality. Our future work will focus on models that can reliably measure the quality of noisy digital videos.

The role of alpha oscillations in memory maintenance and distractor inhibition

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Only a small amount of visual information – as determined by the capacity of short-term memory – can be held in an active and accessible state. Thus, it is important to select and maintain information that is relevant while ignoring irrelevant information. However, the underlying neural mechanism of these processes has yet to be identified. One potential candidate are alpha oscillations (8-14 Hz), which have been shown to inhibit stimulus processing in perceptual tasks. During memory retention, alpha power increases with set size suggesting that alpha oscillations are involved either in memory maintenance or in the inhibition of task-irrelevant information in order to protect relevant information from interference. The need for such a protection should increase with the amount of distracting information, but most previous studies did not show any distractors. Here, we directly tested whether alpha oscillations are involved in distractor inhibition during memory retention. Participants memorized the orientation of one or two target lines embedded among irrelevant distractors. Distractors with varying strength were presented throughout the whole trial – including retention interval – after which participants reported the orientation of the probed target. Computational modelling showed that behavioral performance decreased with increasing set size and stronger distraction. Alpha power in the retention interval generally increased with set size, replicating previous studies. However, the set size effect was not enhanced, but diminished by distractor strength. In fact, strong distractors generally reduced alpha power. Thus, our data do not indicate a role of alpha oscillations for inhibition of distraction in visual short-term memory.

Tracking the content of visual working memory in EEG

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It has been suggested that working memory (WM) can be maintained in a silent neural network that is not reliant on continuous item-specific neural activity. In order to measure such activity silent networks, we recently developed an approach that is analogous to echolocation, where a neutral visual "impulse" stimulus can reveal otherwise hidden neural states in electroencephalography (EEG). Here we report the impulse-specificity of the revealed neural pattern to visual WM content at different time-points during a visual WM task, enabling us to track the dynamics of behaviourally relevant neural representations over time. Human participants performed a two-item WM task, while EEG was recorded. Two randomly orientated visual gratings were presented in the beginning of each trial, and a retro-cue indicated which item would later be tested, rendering the uncued item task-irrelevant. Two neutral impulse stimuli were presented at fixed time-points in the subsequent delay, before participants reported the cued item using free-recall. The neural responses elicited by the impulses contained activity patterns specific to the cued item. High accuracy trials were accompanied by more precise neural representations revealed by the impulses of the relevant item, establishing a clear link between content-specific neural patterns and the fidelity of the maintained information.

Image statistics and visual working memory of glossiness

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Perception of gloss is shown to have some constancy to changes of illumination. It is, however, not clear whether visual working memory too is capable of being robust against changes of illumination. To address this issue, precision and bias of visual working memory for two different aspects of gloss, contrast gloss and surface roughness, were measured by a matching paradigm. Participants were presented with an image of a computer-generated sphere and after the delay of 1 second, a probe sphere was presented and they adjusted its gloss or roughness to match the appearance of the preceding sample sphere. In some trials illumination was changed between study and test phases and in the other trials it did not change. Results showed that the precision of match, as evaluated in relation to perceptual baseline, was not impaired by the change of illumination, demonstrating constancy of visual working memory of gloss and roughness. Interestingly, different characteristics of memory bias between gloss and roughness were observed. We used image statistics to explain the results: moment statistics (mean, sd, skewness, and kurtosis) of bandpass-filtered images at different spatial frequencies were obtained, and similarities

of each moment between sample and test image could account for the observed biases in matching. In addition, these analyses suggest that effective image features may be different between perception and memory. Taken together, these findings provide a plausible mechanism supporting the illumination constancy of visual working memory of glossiness.

Examining the effects of contrast and speed on motion discrimination for coarse and fine-scale compound stimuli

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Motion discrimination is impaired when coarse- and fine-scale patterns move together at the same speed (Luna & Serrano-Pedraza, 2016). Here, we studied the effect of relative contrast and speed on motion discrimination of complex stimuli by measuring the probability of hits. In the first experiment, two types of stimuli were used: simple drifting vertical-Gabor patches of low (1c/deg, LSF) or high (3c/deg, HSF) spatial frequencies and complex vertical-Gabor patches made by adding the LSF and HSF Gabor-patches moving at the same speed (LSFm-HSFm). The drifting speed was always 2deg/sec, the size Sxy=4deg and presentation durations 25,50,100ms. We tested three contrast conditions, LSF=HSF (Michelson Contrast=0.275), LSF>HSF and HSF>LSF. In the last two conditions the contrast of HSF or LSF was divided by 4. In the second experiment we tested 6 speeds: 0.5,1,2,4,8deg/sec, being the contrast always 0.275 and presentation durations 25,50ms. Additionally, we tested two new complex stimuli: a moving LSF added to a static HSF (LSFm-HSFs) and a static LSF added to a moving HSF (LSFs-HSFm). Results from Experiment 1 indicate that, when the contrast of LSF was lower than HSF, performance at short stimulus durations for LSFm-HSFm was worse than for each simple component. Experiment 2 shows that, at 25ms duration and a speed of 8deg/s, performance was maximally impaired for LSFs-HSFm. Our results reveal that contrast and speed modulate the nonlinear interaction between motion sensors tuned to fine- and coarse-scales.

Possible mislocalisation of a moving flickering target

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Flashing lights are increasingly popular with cyclists. Such a dynamic stimulus should capture other road users' attention, but it could cause problems if its motion is perceived differently when compared to conventional non-flashing lights. Our purpose is to examine this possible downside. First, we extended our preliminary report that the well-known flash-lag effect (FLE) can be reduced with flicker of a moving target (Ashida & Scott-Samuel, APCV 2016) by testing more participants with modified parameters. The FLE was significantly reduced (by 35% on average) by 8Hz target flicker, as compared with a no-flicker condition with equal mean luminance over time. There were, however, large individual differences in the absolute value of the effect and also in the reduction by flicker. The FLE was not correlated with perceived speed. Second, we measured the 'representational momentum' (RM) by asking participants to mouse-click where the moving target disappeared. There was no consistent reduction by flicker up to 8 Hz. These results indicate that the target flicker can affect perception of the relative positions between objects, but the effect is not overwhelming and depends on both the task and the individuals tested. Nevertheless, some participants were affected more seriously than others, which could therefore represent a potential risk in the use of flashing lights, driven by individual differences in road users. Supported by JSPS Grant-in-aid for Scientific Research #26285165 for HA.

Testing predictive coding accounts: Delusion proneness is linked to a reduced usage of prior information in perceptual inference

Heiner Stuke, Veith Weilnhammer & Katharina Schmack

Predictive coding accounts state an aberrant weighting of prior and new information as a core alteration in psychosis. Specifically, it is supposed that an impaired ability to integrate prior probabilities in inferences leads to an instable and badly predictable environment and might hence increase proneness for delusional misinterpretations. In order to probe this theory, we carried out a behavioral experiment in 123 healthy individuals from the general population, using a paradigm dubbed "moving dots task". Here, participants have to judge on global motion direction of noisily moving dots. Crucially, participants were provided with probabilistic prior information on the direction of motion, allowing us to quantify the impact of prior information on perceptual decision making. By predicting perceptual decisions with logistic regression, we quantified the impact of prior and new information on each participants' perceptual decision making. We found a significantly decreasing impact of prior information on perceptual decisions with growing delusion-proneness of the participants, which we quantified with the Peters Delusion Inventory. This relationship remained stable after correcting for potential confounds like perceptual thresholds or information integration in an analogous probabilistic decision making task. Our results suggest that proneness for delusional ideation is linked to a reduced usage of prior information in perceptual inference.

Functional implications of glaucoma in dynamic local and global aspects of vision

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Purpose: To investigate the implications of glaucoma in visual functions of perceptual complexity, such as the motion processes mediated by local and global aspects of perception. Methods: The global and local motion perception task was measured in 13 patients (66.77 yrs ± 6.64) diagnosed with primary open glaucoma (POAG) and 9 healthy

subjects (63.56 yrs ±9.52). An adequately calibrated high-resolution computer screen supported the required luminance and temporal parameters of visual stimuli composed of dots, which varied in number (20, 50, 100) and exhibited random movement (KyberVision v.1.5.1, Tokyo, Japan). Measurements were performed at 2 and 10 degrees/sec, which are processed respectively by global and local processes. A percentage of these dots moved in the same direction (coherence) of horizontal movement (left, right). The subject's task was to inform perceived direction of movement on a computer keyboard. The coherence threshold was measured by a staircase method, in a two alternative forced choice task. Results: Only global motion perception was affected in glaucoma patients (49.34 ± 13.61; p=0.03) compared to the control group matched by age (80.22 ± 38.52). We did not found correlations with the impairment of the global motion perception to the visual fields index. Conclusions: The impairment of global motion perception in the cortex of glaucoma patients was not correlated to low level damage in the retina detected by visual field, suggesting that the visual field did not predict impairment of the dorsal pathway.

Moves like "Maluma": Effects of speed and path shape on motion-sound correspondences

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People consistently match non-words such as "takete" to angular shapes and words such as "maluma" to rounded shapes. This phenomenon is called the sound-shape symbolism. Although sound is an important factor for motion perception, associations between motion characteristics and non-words with a particular sound are mostly unexamined. This study aimed to investigate how motion speed and shape of the path influence associations between moving objects and non-words. Black discs moving along a path of fixed length were used as stimuli. Motion speed (30 cm/s, 6cm/s), direction (rightward, leftward) and shape of the path (circular, triangular) were varied. Participant's task was to rate each stimulus on four scales anchored with soft-sounding non-words (lula, maluma, bobolo, bouba) on one end and hard-sounding words (ruki, takete, dekter, kiki) on the other. Speed was statistically significant factor for two used scales – faster stimuli were evaluated as more ruki and kiki than slower stimuli. Shape of the path was a statistically significant factor for all four scales – stimuli moving along a triangular path were evaluated as more ruki, takete, dekter and kiki than stimuli moving along a circular path. Results demonstrate that associations between moving objects and non-words depend on speed of motion and path shape. Lower speed motion is mainly associated with the soft-sounding non-words. Motion along a triangular path leads to an estimation of moving objects as more associated with the hard-sounding non-words. These findings contribute to research area focused on correspondences between sound and different aspects of visual motion.

Auditory facilitation of visual speeded detection in the entire visual field

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There have been conflicting reports on the facilitative effect of auditory stimulus on detection or discrimination of visual stimuli. The effect has mainly been discussed in terms of central vs. peripheral visual presentation and spatial congruency of auditory and visual stimuli. However, in many of the previous studies, "peripheral" visual stimuli were actually limited to a relatively narrow visual field compared to the actual human visual field of almost 180 degrees. Furthermore, sound stimuli were often presented using headphones, which makes it difficult to systematically control the spatial congruency between auditory and visual stimuli. Here, we investigate how the presentation of an auditory stimulus affects visual speeded response in a wide range of visual fields by systematically varying the angular distance between the auditory and visual stimuli. To this end, we used multiple monitors and loud speakers covering almost 180 degrees of the horizontal angles. We show that when a visual target is presented in the central visual field, an auditory stimulus facilitates visual response time regardless of its location relative to the target. However, when the visual target is presented in the peripheral visual field (approximately 25 degrees to 90 degrees), the response time is almost linearly affected by the relative angular distance between the auditory and visual stimuli. Our results suggest that the conflicting previous reports could be consistently explained by their relatively narrow spatial range of visual stimuli and the difficulty in the control of spatial congruency due to the use of headphones.

Effects of executive working memory performance on inattentional deafness.

Masahiro Zaitsu, Tomoya Kawashima & Eriko Matsumoto

Some studies have shown that participants missed a task-irrelevant auditory stimulus when the visual perceptual load was high (inattentional deafness), indicating that attentional resources for auditory task were almost exhausted (Kreitz et al., 2016; Macdonald & Lavie, 2011). The present study investigated whether the individual differences of working memory (WM) capacity can predict inattentional deafness. We asked participants to identify color (low load) or length (high load) in visual task, where they also had to respond to an unexpected auditory stimulus (pure tone). Additionally, we asked participants to conduct two kinds of WM tasks: visuospatial WM task and N-back task (N = 2, 3, 4). N-back task has been used in many studies to measure WM executive function. Participants were divided into low and high WM score groups based on the score of each task (i.e. low and high visuospatial WM groups and low and high executive WM groups). Results showed that there was a significant difference in the rates of inattentional deafness between load conditions, which replicated previous findings. We also found that, only in low load condition, those who were assigned to low executive WM group were much more likely to miss the auditory stimulus. These results suggest

that inattentional deafness is related to centrally WM system that controls the distributions of attentional resources. In this study, participants were presented with the auditory stimulus unexpectedly, but we think that the expectation can contribute to top-down WM control. It may be important to compare expected and unexpected conditions.

Attention to pain stimuli affects the visual perception in proportion to the intensity of pain stimuli

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It has been well demonstrated that sustained attention to visual stimulus multiplicatively increases stimulus-driven responses of the visual neurons. However, it is unclear that when visual and pain stimuli are given at the same time and attention is given to pain stimuli, the visual response increases proportionally to the intensity level of the pain stimulus. Here, we tested this hypothesis by recording frequency-tagged steady-state visual and pain evoked potentials simultaneously. Observers viewed a series of circular gratings flickering at 3.57Hz to the left visual hemi-fields. At the same time, contact heat pulses from The Contact Heat Evoked Potential Stimulator (CHEPS) were applied to the proximal left volar forearm at the pulsing rate of 1.66Hz. In each trial, observers attended to one of two modalities (vision or pain), which was indicated by a cue appeared at the beginning of the given trial. In each trial, the intensity of pain and visual stimuli varied from very weak intensity to strong intensity in six steps, and there was no correlation between intensity of the two stimuli. We monitored frequency-tagged steady-state visual and pain evoked potentials, and found that voluntary sustained attention to pain stimuli increases visual stimulus-driven population electrophysiological activity of visual areas. Our results suggest that attention to pain stimuli affects the visual perception in proportion to the intensity of pain stimuli.

The ABBI kit: Optimization of experimental audio-motor assessment of visually impaired people

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Vision is crucial for the development of space perception and cognition. Blind people show an impairment in some auditory, motor and social skills. Early onset blindness also impacts on psychomotor, social and emotional development. Despite the huge improvement of technological devices, many of the solutions proposed to visually impaired people are not widely accepted by adults and not easily adaptable to children. The goal of our work was to develop an optimized assessment system for visually impaired people who are involved in training sessions for the improvement of audio-motor abilities, in particular children under a rehabilitative program with ABBI (Audio Bracelet for Blind Interaction). It was realized a new set-up to be used independently by rehabilitators without the supervision of the researchers. The new device is all-in-one wireless and sensitized set of loudspeakers, easy to mount, controllable from a free, dedicated Android app, offering to the therapist a complete testing kit for a periodically and short-lasting evaluation of children's response to the training.

The perception of urban vandalism: An eye-tracking study

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The main aim of the study was to assess the eye-tracking method in detection the persons involved in vandalism within the urban environment. This type of actions includes deliberate damage of property, e.g. wall painting, windows breaking, throwing stones in the municipal transport. Thirty two healthy adults volunteered to participate in the study. They were divided into two groups: 1. with experience of vandalism ("vandal"); 2. without experience of purposeful destruction ("non-vandal"). The "vandal" group participants reported about the experience of breaking windows in municipal buildings with stones and sticks. The image of a man breaking a window with a stick was presented to the participants of both groups. The duration of image exposure was 10 seconds. Pupil size and gaze behavior measured with SMI RED 500 eye-tracker were used as dependent variables. We found statistically significant differences in velocity and amplitude of saccades between the groups. Both parameters had the minimal values in the "non-vandal" group. Besides, average pupil size in the "vandal" group was significantly larger than in the "non-vandal" one (4.4 vs 4.05 mm, $p<0.05$). Moreover, regions of interest in "vandal" group included primarily the destructive tool and posture of the actor. Meanwhile the gaze of "non-vandal" participants was predominantly fixated at the actor's face and the object of destruction. The study was supported by the grant of RSF 17-18-01278.

The contribution of color to scene gist recognition at large visual eccentricities: Low level or higher order influence?

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Scene gist recognition is facilitated by diagnostic color in central vision. Peripheral vision is sufficient for scene gist recognition, but color vision is degraded there. We investigated the role of color in rapid scene categorization in peripheral vision. In a mixed design, 512 panoramic scenes belonged to four Natural and four Man-made categories. Scenes were shown in Normal or Inverted color, or Grayscale to 36 participants (12 Ss/color-type). Participants saw briefly flashed scenes on a panoramic screen, with a central occluding "scotoma" of varying size (0-70 deg radius), then selected each scene's category (8-AFC). Accuracy of Normal color > Abnormal (Normal color advantage), and Natural scenes > Man-made scenes (Natural advantage). However, the Normal color advantage was only for Natural scenes (i.e., the Diagnostic color advantage: Oliva & Schyns, 2000). We also

found a 3-way Scene-Type x Color-Type x Eccentricity interaction: For Natural scenes, the diagnostic color advantage extended to 60 deg eccentricity. Conversely, for Man-made scenes there was a non-diagnostic color advantage (Normal and Inverted color > Grayscale), but only to 30 deg eccentricity. The Natural scene advantage was disrupted by Inverted color, but not beyond 50 deg eccentricity. The diagnostic color advantage for natural scenes is explainable by prior knowledge facilitating rapid scene categorization, even in the severely degraded color vision of the far periphery. However, the non-diagnostic color advantage for man-made scenes, possibly explainable by facilitating image segmentation, is limited to the near periphery, assumedly due to degraded color vision and no prior knowledge facilitation.

Statistical perception to visual covariation: Feature-specificity and its robustness against attentional strategy

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Our visual system has a limited capacity to process information about multiple environmental objects. To overcome this limitation, we can aggregate redundant information about environmental visual elements/objects and form a statistical summary, such as mean and variance, by briefly viewing single visual feature. Furthermore, we might represent covariation among environmental visual elements/objects as a statistical description, which would help us to form a compact representation of the visual world. We investigated human sensitivity to statistical covariation in a visual scene by briefly presenting a display of several circles filled with sinusoidal gratings differing in their sizes, presentation locations and sinusoidal orientations. Three types of covariation between the presentation features were evaluated: size–orientation, orientation–location and size–location. The degree of covariation was manipulated by varying the Pearson correlation coefficient. Participants were asked to judge the strength of linear relationship between any pair of features through the two-alternative forced-choice task. Our results demonstrated a significantly lower performance in judging the covariation of the size–orientation pair compared with that of the location-related pairs, which suggests that during a brief viewing, human perception of statistical covariation is specific to the location dimension. The lower performance for the size–orientation pair also occurred when the circles were presented sequentially, suggesting that the feature-specific performance was not related to a scarcity of attentional allocation on each circle.

Exposure duration influences holistic vs. part-based learning in visual object recognition

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The visual system is capable of simultaneously integrating different information to recognize objects. Usually, objects are made of different features. In this study, we wondered whether visual object recognition is a holistic processing or whether people have a tendency to represent and encode objects on a part-by-part basis. To do so, we used computer generated 3D species of objects made of 5 different features, with no diagnostic single feature. We trained participants to recognize species. They learned to distinguish between 5 species at a subordinate level whereas 5 other species remained untrained. We used a sequential matching task to test species recognition before and after training. Participants were either trained with long exposure durations (800 ms) and 3D viewing or were exposed to the stimuli for a short time (200 ms), to ensure a single fixation on the object. We hypothesized that subjects would demonstrate a more holistic encoding of objects with 1D short exposure durations compared to 3D long exposure. During long exposure condition, we found that training transferred to untrained species and inversion did not hurt performance. On the contrary, during short exposure condition, no transfer to untrained species was observed and participants performed better for upright compared to inverted trained stimuli after training. Learning appears to be part-based during the long exposure condition and more holistic during short exposure condition, suggesting that combinatorial learning (perfect generalization to novel combinations of same feature set) depends on separate fixations to the different features.

Discrimination judgments alter the appearance of visual stimuli

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Perceptual decisions are often influenced by contextual information. For instance, when engaged in a fine motion discrimination task against a decision boundary, subjective reports about the direction of motion are biased away from the boundary – a phenomenon termed reference repulsion. Until recently, this phenomenon has been thought to reflect a perceptual illusion regarding the appearance of the stimulus, but new evidence suggests that it may rather reflect a post-perceptual decision bias. To shed light on this issue, we examined how orientation judgments affected the perceptual appearance of orientation. We used orientation-filtered noise stimuli and measured the perceived orientation of a target stimulus, in direct comparison to a reference stimulus visible at the same time, after the target stimulus was judged against a decision boundary. Preliminary results indicate that discrimination judgments alter the appearance of the judged stimulus: perceived orientation is biased away from the decision boundary. This perceptual repulsion is largest when the target stimulus is close to the decision boundary. Moreover, perceptual repulsion becomes larger with increasing stimulus noise. Our results suggest that decision boundary repulsion effects cannot be solely attributed to post-perceptual decisional biases, but are already visible at the perceptual level, affecting the appearance of visual stimuli. This supports theories of contextual biases in visual perception.

Prime competition in fast motor responses: Response activation and inhibition in a sequential-prime paradigm

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In response priming experiments, a participant has to respond as quickly and as accurately as possible to a target stimulus preceded by a prime. The prime and the target can either be mapped to the same response (consistent trial) or to different responses (inconsistent trial). Here we investigate the effects of two sequential primes followed by one target in a response priming experiment. Each prime can be consistent (con) or inconsistent (incon) to the target, resulting in four conditions (con-con, con-incon, incon-con, incon-incon). We designed a stimulus layout where any number of primes can be presented in sequence without mutual interference. Further, we employ a series of different stimulus-onset asynchrony (SOA) conditions, where the SOAs between primes 1 and 2 (SOA1) and the SOAs between prime 2 and target (SOA2) are manipulated. In order to explore the respective time-courses of the effects on the basis of individual response time distributions, we took a look at conditional accuracy functions (Panis & Schmidt, 2016). First, we found that sequential primes initiate sequential response activation, with earliest responses to a first prime, later responses to a second prime, and latest responses to the target. Second, differences in SOAs between primes result in equal delays of the responses to the second prime. Third, response inhibition can be observed in long SOA conditions, with a second prime delaying responses to the target. However, this delay increases with later appearance of the prime. Thus, we showed in which manner sequential visual stimuli affect response activation.

Impairment of automatic "vision for action" functions in the newly-sighted, following prolonged visual deprivation

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The ultimate goal of vision is to direct action. Some of our actions are triggered by automatic processes elicited by observing others' actions: Infants can recognize the target of gaze of others, and direct their gaze to the same object within months from birth (termed "shared gaze"). Similarly, we are faster and better imitating actions when they are spatially congruent with others' actions. Still, it is unclear if these automatic actions, elicited by viewing others, are innate or require visual experience to develop. We tackled this issue by studying a unique group of newly-sighted children that suffered from dense bilateral cataract from early infancy. After cataract removal surgery, their visual acuity typically improved allowing most of them to recognize hand actions or gaze direction. We then tested whether viewing a hand action (performed by others), would facilitate the response-compatible action and slow the incompatible one (automatic imitation effect). We also checked whether a pre-cue (showing a face with a specific gaze direction) would facilitate reaction to the gaze-compatible target (when compared to the gaze-incompatible location). The newly-sighted were less affected by task-irrelevant viewed-actions (hand action or gaze direction) than controls even two years after the operation. This strongly suggests that visual experience is necessary for the development of automatic imitation and shared gaze behavior. At the very least, our results indicate that if these behaviors were based on innate mechanisms, they are clearly susceptible to long periods of visual deprivation.

Action recognition following early-onset prolonged visual deprivation

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Understanding other's actions is an essential aspect of behavior (e.g. for predation or social interaction). In fact, we are often able to predict the outcome of an action well before its completion. But would you be able to do so if you were deprived of functional vision for years? We studied a unique group of newly-sighted children in Ethiopia that suffered from dense bilateral cataract from early infancy and were surgically treated only years later. The subjects watched videos of hand-action either grasping an object or pointing to it. The object was located at the left or right side of the screen (2X2 design with action type and direction as parameters). Their task was to report the action type (pointing / grasping) and direction (left/right) on each trial. We used an adaptive procedure, reducing the number of frames of the original action video, to assess the threshold length at which the children could still distinguish between the two action types and the two directions. The same procedure was applied to age-matched controls. The two groups had similar capabilities in the direction discrimination task. However, the newly-sighted children required longer action-video presentations to discriminate between the two actions, whereas age-matched controls performed equally well in both tasks. We find that action recognition is impaired following prolonged visual deprivation, even 2 years after the operation. This may be due to a critical period for development of this sophisticated behavior or a limitation imposed by the newly-sighted relatively poor visual acuity.

Steering a car to intercept a moving target: Can people learn better interception solution?

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As people steer a car to intercept a moving target, they keep the target at a roughly constant direction with reference to the car's heading, consistent with the constant target-heading strategy. This pattern of steering usually results in curved interception paths, which is suboptimal in terms of traveled distance as the traveled distance is longer compared to a straight path. In the current study, we examine whether people can learn better interception solutions. Participants (N=6) steered a car (moving at fixed speed 7 m/s) to intercept a moving target in a virtual environment. In the learning sessions, they intercepted in four target conditions, two target directions (horizontally left/right) by two speeds (4.5

and 5.5 m/s). The learning trials were run in the environment with textured ground and surrounding background image, which provided richer visual information. After 5 learning sessions on different days, participants were tested in two test sessions, each consisting of 20 target conditions, four target directions (horizontally left/right and approaching from left/right) by five speeds (4, 4.5, 5, 5.5, and 6 m/s). The first test session was run in the same environment as the learning session, while the second in an environment consisting of only a ground plane of solid green which provided poor visual information. The results indicated that participants learned to intercept the moving target more efficiently by steering a straighter paths. Moreover, the learned steering pattern could be generalized to the new target motion and the new environment.

Serotonin decreases the gain of the visual responses in awake macaque V1

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The serotonergic neuromodulatory system plays a critical role in a variety of affective, cognitive and sensorimotor functions. However, in primates, despite anatomical evidence for substantial serotoninergic projections to the primary visual cortex (V1) and high expression of serotonin receptors in this area, little is known about how serotonin modulates visual processing in V1. Here, we address this question in awake macaques to minimize state fluctuations known under anesthesia, using electrophysiology and iontophoresis. We examine the effect of serotonin on visual responses to drifting gratings presented at varying orientation, spatial frequency, contrast or size, and to flashed gratings of varying orientation in two awake monkeys. During a standard fixation task, we recorded the activity of 265 single units in V1 while iontophoretically applying serotonin (10mM; pH=3.5) or pH-matched saline as a control. The range of ejection currents was between 2 to 50nA (median: 10nA) for serotonin and 5 to 20nA (median: 11nA) for saline. Serotonin predominantly decreased the visual responses in V1 multiplicatively and slightly increased the orientation selective response latency. On the other hand, serotonin did not change the selectivity, variability of the responses or the inter-neuronal correlation. These data can be explained by a simple threshold-linear model but not by contrast-gain models. Taken together, our results showed that serotonin mainly decreases the gain of the visual responses without affecting selectivity. Our results indicate that serotonin is well suited to control the response gain of V1 neurons, complementing other known state-dependent gain control mechanisms.

A shared numerical representation for action and perception in blind and sighted individuals

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Humans share with other animals a system to estimate quantities in a rapid but approximate way, a "Number Sense". Anobile, Arrighi et al. showed that the number sense generalize even between action and perception, as they shown that the number of repetitions of self-produced movements distorted perceived numerosity of subsequent visual stimuli (Anobile, Arrighi et al., Elife, 2016). Interestingly, this cross-domain adaptation effect is spatially selective and coded in external, not hand-centered, coordinates. One possibility is that vision drives such development since it has been demonstrated that early visual deprivation alters the development of an automatic external coordinate system for perceiving touch (Roder et al., Curr. Biol., 2004) and magnitude (Crollen et al., Cortex, 2013). In our study, congenitally blind (CB) and sighted controls (SC) were asked to evaluate the numerosity of sounds after performing either slow or fast motor adaptation (tapping), with the dominant hand either in an uncrossed or in a crossed posture. A robust adaptation effect was observed in both groups of participants: an underestimation of the numerosity presented was observed after the execution of fast movements and an overestimation of the numerosity was observed after the execution of slow movements, in the crossed as well as in the uncrossed posture. Taken together, these results expand previous findings showing that adaptation to self-produced actions distorts perceived numerosity of sounds. Moreover, we demonstrate that visual experience is not necessary for the development of an external coordinate system for the shared numerical representation of action and perception.

Is access to low-level features suppressed or enhanced by high-level representations? Preliminary data from a local shape discrimination study using two-tone images.

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Research on the influence of high-level representations on lower-level features has led to mixed results. Some studies report enhanced access to low-level features, while others report impaired access. These contradictory findings may be reconciled by considering the congruency between low-level features and high-level representations: access to low-level features that are congruent with high-level representations might be enhanced, while access to incongruent low-level features might be impaired. Here we used two-tone images to investigate the hypothesis that high-level representations of an object impair access to incongruent low-level features. On first viewing, two-tone images are experienced as meaningless black and white patches. After exposure to the template image from which the two-tone was derived ("disambiguation"), observers are able to recognise objects in these images. Thus, after disambiguation high-level representations change while the low-level features of the two-tone remain identical. We conducted several local shape discrimination experiments with different patch locations on two-tone images, comparing performance with and without disambiguation (experiment 1 & 2). Contrary to our hypothesis, results showed a significant increase in performance after disambiguation. Given this finding, we investigated the possibility that a local reference frame or meaning to the shape

patch was induced by disambiguation, using shape patch locations that controlled for these factors (experiment 3). Additionally, we investigated the role of learning by providing no disambiguation (experiment 4). Results were inconclusive but suggest that these factors might play a role. In conclusion, future research is needed to better understand these factors, using other variations of the current paradigm.

The topographic representation of global object perception in human visual cortex

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Our visual system readily groups dynamic fragmented input into global objects. How such perceptual grouping is represented in the brain, however, remains unclear. Here we applied fMRI and population receptive field (pRF) modeling in normal healthy volunteers to investigate the fine-grained topographic profile of brain activity underlying the perception of two bistable arrays of dynamic elements. In their global state, these stimuli are perceived as shapes translating along a single motion trajectory, and in their local state, as distinct elements translating along individual motion trajectories. We recorded brain activity while observers viewed these bistable stimuli and indicated their percepts. We further estimated the pRF of each voxel in visual cortex and used these to back-project the brain response during stimulus perception into visual space. Relative to the local state of either of these stimuli, brain activity during the global state was generally reduced in V1, but increased in higher object-sensitive cortex. Remarkably, for both stimuli, the peak of V1 deactivation roughly coincided with the perceived motion trajectories of the grouped shapes during the global percept. This signature might thus constitute a label indicating a moving global entity. Our results point to a potentially crucial computational role of V1 in perceptual grouping of dynamic fragmented input and show that pRF-based back-projection techniques represent a promising tool for revealing signatures of visual perception.

How do we count at a glance?

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Many studies have examined peoples' ability to rapidly perceive the approximate number of elements in a scene, but there has been much less work on what computation underlies this ability. We measured psychophysical decision spaces for number judgements.

Observers judged which of two stimuli contained more dots. The reference stimulus had fixed area and density on all trials. The test stimulus had a wide range of areas and densities across trials. From 3,300 trials we created a 2D plot showing the observer's probability of choosing the test stimulus as more numerous, as a function of its log area and log density. Fifteen such plots (five observers, three reference stimuli; 49,500 trials total) showed that number judgements were based on log-area plus log-density, i.e., they were monotonically related to true number (consistent with Cicchini et al., 2016).

We fitted a generalized additive model (GAM) to this data, and found that number judgements were based on almost perfectly logarithmic transformations of area and density, again demonstrating that number judgements are tightly linked to true number.

Finally, we ran adaptation experiments to test whether number adaptation is based on adaptation of number channels or density channels. Observers viewed an adaptation stimulus, followed by a test stimulus that had higher density but lower number. The perceived number of the test stimulus decreased after adaptation, consistent with number adaptation and inconsistent with density adaptation. We conclude that number adaptation is not mediated solely by density adaptation.

The influence different patterns of orientation change have on performance in texture segmentation and detection tasks

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Orientation gradients are thought to play a fundamental role in orientation-based texture segregation. Studies have shown that segregation can occur when there is an abrupt change in orientation across space, i.e. a texture edge, but also in their absence. Here we investigated the role edges play in the segregation process. We measured participants' performance to segment and detect rectangular line texture figures of differing mean orientation from the background at 5 stimulus durations. The orientation change of figure from background was abrupt (Block), or varied spatially according to Cornsweet profile (Cornsweet) or a logistic curve (Blur). Performance at 3 values of orientation jitter was also measured. As a function of edge contrast (orientation contrast at the edge), the Blur profile had the lowest threshold, followed by the Block, then Cornsweet. When plotted as a function of center contrast (orientation contrast between background and center of figure), the Blur profile had the highest thresholds. We also found higher thresholds for the segmentation task compared to the detection task (especially for the Blur profile), and higher thresholds with increased orientation jitter and reduced display duration. Therefore texture properties over regions beyond the edge play a role in the segregation process. The results were modelled in terms of an integration region, which is an area over which an average signal on either side of the edge border is computed. We found that irrespective of stimulus duration, the integration region remained approximately constant.

Emergent features in the crowding zone

Natalia Melnik, Daniel R. Coates & Bilge Sayim

University of Bern

Identification of targets surrounded by flankers is impaired due to crowding. Crowding is usually stronger when the target groups with the flankers. Here, we tested whether specific target/flanker configurations can modulate crowding strength. A chevron target (pointing up or down), presented at 8 degrees eccentricity in the right visual field, was surrounded by four flankers. Three of the flankers varied

(pointing left or right), and one - the critical flanker (CF) - was fixed in one orientation (left, right, up, down). The CF's distance to the target was varied. Target identification accuracy depended strongly on the orientation of the CF. When the CF pointed up and grouped with the target into a diamond-like shape, performance was high if the CF was close to the target. Increasing the spacing between the CF and the target first decreased the positive effect of grouping into a good Gestalt (the diamond), and at larger spacings decreased the CF's negative effect of crowding. This u-shaped performance curve was not observed when the CF was pointing in one of the other three directions. Asynchronous presentation of the CF and the other items abolished the positive effect of grouping but not the negative effect of crowding. Our results show that the particular configuration of a target with a flanker modulates crowding. Strong target-flanker grouping can actually reduce crowding if the target and a flanker form a good Gestalt. We suggest that our results are due to the different spatial and temporal characteristics of grouping and crowding.

Contour integration with nonlinear connectors

Malte Persike & Günter Meinhardt

Johannes Gutenberg-University Maïnz

Contour integration is to the binding of disjoint local segments into contiguous global shapes. One central tenet in the study of contour integration has been the dependency of contour visibility on curvature. When contours become increasingly jagged, contour salience deteriorates down to the point of invisibility. Here we show that the deterioration of contour visibility due to sharp changes in curvature can be easily remedied by inserting nonlinear local elements such as corners, crossings, and junctions at the points of angular discontinuity. We further show that nonlinear connectors render even highly bent contours as salient as straight ones if and only if they provide unambiguous information for contour continuation. Nonlinear local elements thereby enable a more general form of good continuation which does no longer rely on smooth curvature but merely on the presence of sufficiently predictive signals of direction and directional change. This challenges established models of human contour integration which rely on local interactions between orientation sensitive neurons early in the visual pathway, the so called "association field" models. The capacity to seamlessly integrate orientation signals with vastly different complexities such as straight lines, corners, and crossings likely places contour completion with other image composition mechanisms beyond primary visual cortex.

LabVanced: Making professional online-studies simple

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Universität Osnabrück

Online-based research has recently gained increasing attention from various fields of research in the cognitive sciences. New possibilities such as online crowdsourcing (Amazon Mechanical Turk), open data repositories (Open Science Framework), and online analysis (Ipython notebook) offer rich possibilities to improve, validate, and speed up research. However, until today there is no cross-platform integration of these subsystems. Furthermore, implementation of online studies still suffers from the complex implementation (server infrastructure, database programming, security considerations etc.). Here we present LabVanced, a JavaScript framework that constitutes methodological innovation by combining three essential aspects for online research. With our framework studies can be implemented in an intuitive graphical user interface without programming. Second, the framework takes care about participant recruitment and third, it outlines options for data visualizations and statistical analysis. Additionally, the framework can be used for sharing not only the recorded data, but also the study design and the analysis. To demonstrate the functionality of the system we present the results of a cross-cultural spatial navigation study that was conducted with our system. In summary, we introduce a new powerful JavaScript framework for improving and accelerating online research.

Constricting hallucinatory feature-space for the psychophysical investigation of visual hallucinations

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Psychophysical examination of visual hallucinations can be facilitated by reducing the feature-space and improving predictability of induced hallucinations, allowing for insights into phenomenology, mechanisms and cognition. Uniform black and white flicker induces riotous hallucinatory structure, colour, and motion. However, a simple white flickering annulus only induces hallucinatory grey blobs moving around the annulus (Pearson et al., 2016). Using the method of constant stimuli to calculate the point of subjective equivalence, we estimated effective hallucination contrast by having participants compare concurrent hallucinatory and perceptual blob contrasts. Individual hallucination contrast varied considerably, and contrast peaked at 10 Hz. Participants reported detection of a physical blob probe moving congruently or incongruently with flicker-hallucinations. The method of constant stimuli was used with contrast, revealing greater sensitivity for probes with congruent rotational motion, and thus an interaction between hallucinatory and retinally-sourced perception. Participants viewed flickering annuli, or non-flickering annuli with perceptual blobs, and reported whether they thought the blobs were hallucinatory. Sensitivity of this discrimination was measured with d-prime. The capacity to discriminate hallucinations and non-hallucinations varied widely, and data suggest sensitivity was not related to participants identifying the contingency between flicker and hallucinations. Hallucination onset latency was shorter after prior spatially-overlapping flicker relative to non-overlapping flicker (with a short interstimulus interval), suggesting that a hallucinatory state restricted to discrete retinotopic regions of the visual field persists despite discontinued stimulation. These experiments demonstrate the utility of feature-space controlled hallucination induction for investigating the constructive nature of vision, and the mechanistic and cognitive characteristics of hallucinations.

High contrast stimulation with an optimized adaptive optics SLO for cellular level visual psychophysics

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Due to the enormous dynamic range of the human visual system, studying the response to scotopic and photopic stimuli in the intact retina challenges technical requirements of the stimulation instrumentation. The adaptive optics scanning laser ophthalmoscope (AOSLO) is an optical platform that can produce stimuli approaching the size of single photoreceptor cells. The current light modulation techniques, however, produce interfering visible backgrounds that fundamentally limit experiments to photopic viewing conditions. To improve optical contrast for high dynamic range visual stimulation in an AOSLO, we cascaded two commercially available fiber-coupled acousto-optic modulators (AOMs). By compensating for individual AOM switching behavior, we demonstrate multiplicative extinction ratios in the cascade in accordance with the extinction ratios of a single AOM. When latency differences in the drive signals were individually corrected, cell sized as well as larger complex stimuli could be reliably displayed with optical contrasts of up to 1:1011. We show psychophysically, that this contrast ratio is sufficient to stimulate single photoreceptor cells without a visible background, thus enabling tests of visual function with more freedom for custom adaptation regimes. The larger dynamic range of the display could also drive photoreceptor responses in cone as well as in rod photoreceptors.

Photoreceptor-resolved visual psychophysics with and without adaptive optics

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In vivo characterization of the functional architecture of the human retina is one of the aims in visual neuroscience and investigative ophthalmology. Recent studies conducted with an adaptive optics scanning laser ophthalmoscope (AO-SLO) demonstrated the potential of photoreceptor-resolved psychophysics. Employing adaptive optics, however, entails high demands on instrument operation and maintenance, algorithmic, optical, and electronic performance, and physical space and cost. A preferred solution would be one that is simplified in those aspects of the instrumentation, while maintaining important structural and functional information in image quality and stimulation performance. We designed and build a scanning laser ophthalmoscope without adaptive optics with variable field size (between 0.85 and 5 degree of visual angle) that is capable of resolving and stimulating parafoveal cone photoreceptors as close as 1 degree from the foveal center. Combined with real time eye tracking capabilities, this platform allows cell resolved visual testing in the fields of spatial vision, motion, and color. We conclude that in eyes with few higher order aberrations, this approach enables similar options for photoreceptor targeted psychophysics than the more complex AO-SLO.

Comparison of scotopic and photopic visual acuity and hyperacuity

Philipp Freundlieb, Michael Bach, Hagen Thieme & Michael B. Hoffmann

Visual acuity (VA) measures are an important determinant of visual function. Here we extended conventional VA-testing with optimized protocols for scotopic VA and hyperacuity (HA) measurements. Using the Freiburg Visual Acuity Test [1] we determined in 10 controls photopic (luminance: 220 cd/m^2) and scotopic (luminance: 0.004 cd/m^2; 40 min dark-adaptation) visual acuity ('pVA' and 'sVA') and hyperacuity ('pHA' and 'sHA') for two contrast polarities, i.e., black optotypes on white background and vice versa. To assess intersession effects, two sets of measurements were performed on different days.

Compared to pVA [decimal: 1.34 = -0.12 logMAR], the pHA [decimal: 14.43 = -1.16 logMAR] scaled on average with a factor 10.7, sVA [decimal: 0.12 = 0.91 logMAR] with a factor of 0.1, and sHA [decimal: 1.5 = -0.17 logMAR] with a factor of 1.1. Our pVA and sVA values compare well with previous findings [2]. There were neither significant effects of contrast polarity ($p>0.12$) nor of session ($p>0.28$). Further, no significant correlation of pVA with the other acuity measures was observed (r^2: pHA=0.02; sVA=0.24; sHA=0.1), indicating that neither individual photopic and scotopic acuity measures nor visual acuity and hyperacuity are strongly related. The lack of intersession effects demonstrates that no training session is needed for scotopic and hyperacuity measurements. This simplifies the application for the investigation of scotopic visual function in participants with healthy vision and in ophthalmological patients.

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Investigation of scotopic vision with multifocal evoked potentials (mfVEPs)

David Muranyi, Anika Wolff, Hagen Thieme & Michael B. Hoffmann

Background: Photopic multifocal visual evoked potentials (PmfVEPs) allow for objective visual field testing [1]. In contrast, the scope of scotopic mfVEPs (SmfVEPs) remained is unexplored. To fill this gap we investigated SmfVEPs its potential and aimed to detect the central scotoma and increased response latencies typical of scotopic vision with SmfVEPs.

Methods: In 10 participants PmfVEPs (mean luminance = 103 cd/m2; contrast = 95%) and SmfVEPs (0.00016 cd/m2; 30 min dark adaptation) were recorded for 36 visual field locations of a circular checkerboard pattern (25° radius) and analyzed in an eccentricity dependent manner. Latency shifts between PmfVEPs and SmfVEPs were determined with cross correlations. Signal-to-noise ratios (SNR) [2] were compared between two time windows, one for photoptic (phTW) the other for scotopic (scTW) response latency.

Results: SmfVEPs were delayed by 103 ms compared to PmfVEPs. For the phTW SmfVEP-SNRs were less than half of

the PmfVEP-SNRs. For the scTW SmfVEP-SNRs were only centrally reduced [by 77% foveally and by 35% parafoveally], peripherally they were increased by up to 20% compared to PmfVEP-SNRs.

Conclusion: SmfVEPs were delayed compared to PmfVEPs and demonstrated the central scotoma typical of scotopic vision. This provides proof-of-concept of the SmfVEP. Consequently, SmfVEPs have the potential for an objective, spatially resolved visual field test in patients with ophthalmologic diseases specifically impairing scotopic vision.

References: [1] Herbik et. al. (2014) Ophthalmic and Physiological Optics 34: 540-551 [2] Hood et. al. (2003) Progress in Retinal and Eye Research 22: 201-251

The role of focal attention in foveal crowding and its relationship with reading in the lifespan

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Crowding characterizes normal visual periphery, where objects above acuity, such as letters, are unrecognizable because surrounded by nearby stimuli. Many studies have supported the evidence that crowding affects reading and, in some cases, concurs to reading impairments in atypical development (e.g. developmental dyslexia), after brain lesions (e.g. neglect dyslexia) or degeneration (e.g. posterior cortical atrophy). Crowding refers to a phenomenology, but there is no agreement about the mechanisms underlying it. Recently, some data suggested that visuo-spatial attention is involved. However, this influence was not always observed, particularly in central vision. We will present some data, coming from different studies with different populations, in order to support the hypothesis that the focal component of spatial attention counteracts the effect of crowding in central vision. In particular, by using a paradigm of focal vs orienting attention, reading and crowding tests, we assessed groups of healthy primary school children, young and old adults. Accordingly, we found convergent evidence that when the focal component of spatial attention is not completely developed, or declining, crowding is enhanced and reading becomes difficult.

ECoG signals from macaque primary visual cortex: High-precision decoding of stimulus location from single-trial responses.

Benjamin Fischer, Andreas Kurt Kreiter & Detlef Wegener

Electrocorticography (ECoG) allows for the analysis of distributed cortical activity with high temporo-spatial resolution. Yet, as compared to intracerebral single-electrode recordings, ECoG signals represent the integrated activity from a large population of neurons. Here, we investigate the spatial resolution of ECoG population receptive fields recorded with a high-density multi-electrode array from macaque primary visual cortex, and address the question, whether ECoG single-trial signals convey sufficient information to decode the location of a stimulus in a multi-item display. We briefly presented visual objects at one out of nine closely adjacent locations in the lower quadrant of the right visual hemi-field. We found that activity at single electrodes was usually modulated by several spatially distinct stimuli, while in response to the same stimulus there were strong trial-by-trial signal fluctuations, making a single electrode-based classification of stimulus locations obsolete. Yet, when considering the distribution of activity over the entire electrode array, a multi-class Support Vector Machine (SVM) allowed for more than 90% correct classification of the stimulus location at the level of single trial activity. SVM performance was superior when event-related potentials from single electrodes were reduced to their mean high-gamma power (120-160 Hz), and gamma power distribution over the array was used as classification feature. The results show that high-density ECoG arrays not only constitute a promising tool for future basic research regarding the population dynamics of visual processing but also for applied research using visual activity for brain-computer interfacing.

Quasi-continuous unconscious processing precedes discrete conscious perception

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Perception seems to be a continuous stream and, for this reason, we often implicitly assume that perception is continuous. In fact, many models of vision rely explicitly and implicitly on continuous perception. However, continuous perception is challenged by many phenomena such as apparent motion, in which we do not perceive first a static disk and then another static disk but a smooth trajectory, favoring discrete accounts. What is the sampling rate of discrete perception? Usually, the sampling rate is determined by temporal resolution. If we cannot perceive two flashes of light presented 40ms after each other, discrete sampling cannot be faster than 40ms. However, different paradigms have shown evidence for sampling rates ranging from 3ms to 300ms challenging discrete models. To overcome these challenges, first, we propose a two-step model, in which a quasi-continuous unconscious processing stage with a high temporal resolution precedes conscious discrete perception, occurring at a much lower rate, in the range of 400ms. Second, we provide evidence for this model from a set of TMS and visual masking experiments. Finally, we compare a series of mathematical models with each other and show that one stage models, continuous or discrete, cannot explain the experimental results, thus, further favoring two stage models of perception.

Crowding in the time domain

Yaffa Yeshurun & Shira Tkacz-Domb

University of Haifa

Temporal crowding refers to impaired target identification when it is surrounded by other items in time (i.e., items that appear before and/or after the target). In previous studies we demonstrated that target identification was impaired by preceding and succeeding stimuli even with SOAs longer than 400 ms. These long-lasting temporal effects did not depend on temporal or spatial uncertainty, but they were reduced when the target location was attended. Interestingly, we did

not find an interaction between spatial and temporal crowding. In the current study we tried to gain some insight regarding the processes underling temporal crowding by employing a continuous measure of perceived orientation. A single trial included a sequence of three randomly oriented lines. The target was always the second line. SOAs varied between 175 to 475 ms. The lines' sequence was followed by a probe line, and the participants had to rotate it to reproduce the target's orientation. The measure of performance was the difference between target's original and reported orientation. A mixture-model analysis revealed a significant effect of SOA on the precision of encoding processes and the rate of reporting the orientation of a non-target item (substitution rate); precision increased, and substitution rate decreased as the SOA increased. However, no significant effect of SOA on guessing rate was found. This pattern of results is different from that found with classical forward and backward masking, suggesting that temporal crowding is not merely 'particularly long' masking effects, but rather involves different processes

Perimetry with a time-varying background luminance

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The temporal dynamics of light adaptation can be investigated by measuring stimulus detection thresholds following a period of adaptation. For foveal photopic vision, contrast detection thresholds are reduced for luminance increment targets when the background is temporally modulated (contrast gain control). The aim of this study was to extend earlier studies to peripheral vision and to determine the influence of stimulus polarity (increment/decrement) and mean background luminance.

We performed perimetry with a minimized testing grid consisting of the fovea and four peripheral test locations (eccentricity ±9°,±9°). Mean background luminance was 120 and 1.2 cd/m2. Perimetry was performed using Goldmann size III stimulus (50 ms) with a +4 -2 dB staircase procedure. Target stimuli (increment/decrement) were presented on a time-varying background whose luminance was sinusoidally modulated (modulation amplitude 60%) at 0 - 30 Hz.

LogCS dropped for background modulation frequencies between 10-20 Hz and increased again at higher frequencies. LogCS was lower for peripheral locations when compared with the fovea but the frequency dependency was similar. No significant effect was visible between polarities. LogCS was considerably reduced when the task was performed at 1.2 cd/m2 and the lowest sensitivity was seen at approximately 3 Hz (compared to 15 Hz at 120 cd/m2).

In conclusion, contrast gain control occurs not only foveally but also peripherally and appears similar for increments and decrements. It occurs also at mesopic luminances, albeit at lower frequencies.

What we like before we know better: Infant preferences in the absence of semantics

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Adults show a strong degree of shared preference for liking judgments of real-world scenes. Yet without shared semantic associations, as in abstract images, preference agreement is markedly reduced (Vessel & Rubin, 2010), suggesting that adult liking is primarily driven by semantic information, not lower-level visual features. What mechanisms underlie development of preference formation in the human visual system? Little is known, despite the central importance of preferential looking studies to theories of cognitive development. Here, we report a novel method to measure preference agreement in young infants. Eye movements of 5-month-old infants were recorded as they viewed a series of pairwise comparisons of real-world and abstract images. Unlike adults, infants showed robust agreement for both real-world and abstract images. Measures of low-level features were significantly associated with infant preferences, whereas content-based measures were associated with adults' preferences for real-world scenes. We conclude that there is a developmental shift in the level of representation that determines liking responses for sensory experiences, from lower-level features to higher-level semantic information and associations, as individuals gain visual experience.

Eye tracking during viewing some famous photos

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Purpose: To examine whether the visual scanning of famous photos changes according to experience in photography. Methods: Photography "professionals and duayens"(33 subjects) , "starters" (1st and 2nd year in photography education, 33 subejcts) and two age and education matched groups without photography education (21 and 33 subjects each) have undergone eye tracking with Tobii X2-60 Eye Tracker during watching five famous/known photographs one after another with a blank slide of 2 seconds duration between photos. The viewing time was 5 seconds for each photo. "Area of interest" and "heat map" of eye tracking in different groups were evaluated and compared. Results: There were statistically significant differences in some aspects of viewing of famous photos. Conclusion: Eye tracking in viewing famous/known photos shows differences due to experience in photography.

Colour associations of the Russian people

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Different cultures make their own associations with colour. The aim of this research is to continue the study of the influence of cultural factors on colour perception and to investigate if there are distinctive patterns in how Russian people subconsciously respond to colour. 70 participants that did not have any known colour defects, were born and lived in Russia were presented 12 pairs of opposites: warm, cold, sorrow, happiness, calm, upset, near, distant, young, old, feminine, masculine, fast, slow, strong, weak, false, true, cheap, expensive, friendly, dangerous, me and others. They were asked to match each word to any colour sample from a chart with 27 selected shades. The colour chart included three shades of every NCS´s elementary colour (Y, R, B, G) and every secondary colour (Y50R, R50B, B50G, G50Y). The first shade was the most brilliant colour (unique hue), the second one was a dark shade, and the third one was a light shade of those eight elementary and secondary colours. In addition to these colours there was also an option for the subjects to choose black, grey or white. The results showed specific colour associations among the Russians especially with the characteristics of feminine and masculine, young and old, friendly and dangerous. The study revealed also differences in the chosen colours related to the subjects' sex, age, experience of colour and religion. The findings can be of interest for professionals and academics working in the remit of visual communication in different cultures.

Objective and subjective complexity-related measures and preferences for neatly organized compositions

Eline Van Geert & Johan Wagemans

KU Leuven

Which factors can predict aesthetic preferences for images of neatly organized compositions, collected on blogs like Things Organized Neatly© (http://thingsorganizedneatly.tumblr.com/)? In this project, we focused on both stimulus and person properties related to order, complexity, and the balance between order and complexity. Participants (N = 415) indicated their preference for one of two simultaneously presented images (100 pairs) and completed some personality questionnaires. In a second (optional) part of the study, participants (N = 84) rated how ordered, complex, soothing, and fascinating they perceived each of 184 images to be. Additionally, some objective statistical measures were calculated on the images (i.e., PHOG-derived measures of self-similarity, complexity, and anisotropy, Fourier slope, and fractal dimension). Amongst others, the proportion of participants that preferred a certain image in a pair related to differences in average fascination ratings between the images. The bigger the difference in average fascination scores was between the images in a pair, the larger the proportion of participants that preferred the most fascinating image in the pair. Subsequently, average fascination ratings for the images could be predicted by the average ratings for order and complexity (Adj–R^2 = .599). Interestingly, subjective ratings of perceived complexity correlated highly with some of the more objective statistical image measures, like fractal dimension ($r = .63$, $p < .0001$) and PHOG complexity ($r = .62$, $p < .0001$). Also, the moderate to high correlations between the different statistical image measures were similar to the correlations found in previous studies for different types of stimuli.

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Statistical regularities modulate attentional capture

Jan Theeuwes & Benchi Wang

The present study investigated whether statistical regularities can bias visual selection. We used the classic additional singleton task in which participants searched for a salient shape singleton while ignoring a color distractor singleton. We presented the color distractor singleton systematically more often in one location than in all other locations. We found that for this high likely location both the amount of attentional capture by distractors and the efficiency of selecting the target were reduced. We observed a spatial gradient from this location as the attentional capture effect scaled with the distance from the high likely location. Whether or not the color of the distractor was repeated from one trial to the next had no effect on capture suggesting that the effect reported here is location-based and not feature-based. We interpret these findings as evidence that these statistical regularities can bias attention such that locations that are high likely to contain a distractor are suppressed relative to all other locations.

An ecological characterisation of face recognition using Game of Thrones

Christel Devue, Annabelle Wride, Catherine Barsics & Gina Grimshaw

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The way in which faces acquire robust representations and become reliably identifiable is not yet understood. Research has either focused on highly familiar faces, where individual exposure is uncontrolled; or used novel faces in unecological tasks that emphasise perceptual discrimination (e.g., Cambridge Face Memory Test). Additionally, there is large heterogeneity in face recognition skills, for which underlying mechanisms are unclear. Importantly, existing tests are usually not challenging for superior recognisers who perform at ceiling, leaving open the question of where their limits lay. We developed a highly challenging task that resolves these issues by exploiting the series Game of Thrones, which introduced numerous unknown actors over the past six seasons. We showed headshots of 90 actors with different exposure levels in the show, mixed with 90 foils, to participants who had watched the entire series. They made familiarity judgments and reported semantic information. To test the robustness of facial representations, we varied the similarity of the actors' headshots to their character's appearance. Recognition rates increased linearly with exposure levels but

interestingly, were affected by similarity throughout. Crucially, scores to the CFMT did not predict hits but only false recognitions of foil; more frequent in poor recognisers than in good ones. Further, poor and superior recognisers committed identification errors to similar extent. We show that face recognition and person identification involve a range of cognitive skills that vary across individuals, and that benchmark tests may not fully capture the intended skills.

How do faces and bodies become special? Electrophysiological evidence for the emergence of face- and body-related cortical processing in the first 14 months of life

Helge Gillmeister & Silvia Rigato

University of Essex

There is general consensus that the representation of the human face becomes functionally specialised within the first few months of an infant's life. The literature is divided, however, on the question whether the specialised representation of the remainder of the human body form follows a similarly rapid trajectory or emerges more slowly and in line with domain-general learning mechanisms. Our study investigates visual ERPs in adults (P1 and N170) and infants (P1, N290, P400, and Nc) of three age groups (3.5, 10, and 14 months) to compare the emergence of face- and body-structural encoding. Our findings show that visual ERPs were absent (P1, N290, P400) or smaller (Nc) for bodies than for faces at 3.5 months and peaked later (N290, P400) for bodies than for faces at older ages. Inversion effects for bodies were not reliably found until 14 months (P400 amplitudes). In contrast, inversion effects for faces were present from 3.5 months (N290 latencies). Inverted faces produced an adult-like pattern for P400 at older ages (enhanced P400 amplitudes from 10 months, longer P400 latencies from 14 months), emphasising the role of P400 as the precursor of the adult N170. Importantly, our findings argue that structural encoding of the human body form emerges later in infancy and is qualitatively different from the structural encoding for faces. This is commensurate with infant motor development and the experience of viewing complete body shapes later than faces.

FMRI responses in inferior frontal cortex are associated with prediction error signals in bistable perception

Veith Weilnhammer, Heiner Stuke, Guido Hesselmann, Philipp Sterzer & Katharina Schmack

Charité Universitätsmedizin Berlin

Bistability provides a striking example of the constructive processes involved in visual perception: A constant ambiguous sensory input induces spontaneous transitions between two mutually exclusive perceptual interpretations. However, the mechanisms behind these oscillations, which dissociate conscious perception from sensory stimulation, remain the topic of an active debate. Here, we propose a predictive coding model of bistable perception, which is built on the assumption that bistability arises from an interplay between ambiguous sensory stimulation and dynamic beliefs in the stability of the visual environment. In that, remaining evidence for the currently suppressed percept constitutes a prediction error, which updates the belief in stability and ultimately causes perceptual transitions. We validated our model by perceptual time-course stimulations and formal model comparisons to established models of bistable perception based on adaption and inhibition (Wilson, 2007), noise (Moreno-Bote, 2007) and a combination of adaption and noise (Lehky, 1988). By fitting our model to behavioural data from a fMRI experiment, we inferred on individual model parameters governing the updating of beliefs in perceptual stability and associated prediction error trajectories. The latter were used for model-based fMRI, which revealed a correlation to BOLD time-courses in bilateral inferior frontal gyri and insulae. Taken together, our current work provides theoretical, behavioural and neural evidence for a predictive coding account of bistable perception that posits a crucial role of prediction error signalling in the resolution of perceptual ambiguities.

Holistic and analytic perception of facial expressions: Eye movements

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Lomonosov Moscow State University

The aim of our study was to reveal individual types of eye movement strategies that people use when perceiving facial expressions. We used composite facial expressions to explore the role of holistic/analytic processing in facial expressions. Composite faces were generated from photos of a poser showing one basic emotion in the upper part of the face and another in the lower part. 30 composites were constructed that combined Happiness and Anger in upper or lower face with other 5 basic expressions. 28 participants (12m, 16f) were tested. The stimuli were presented on an LCD-display for 3000ms at a distance of 0,75m. The participants were asked to choose an expression name using the list of seven basic emotions (neutral, sadness, disgust, happiness, fear, anger, surprise). Eye movements were recorded by iView X Hi Speed 1250. The heat maps and scan-paths were analyzed to classify the holistic/analytic strategies of eye movements. Our data showed that approximately 25% of the participants tend to use holistic eye movement strategies having longer fixations in the nose region, while the other 75% show a clear analytic type with the hottest spots on eyes and mouth. Significant gender differences of AOI were revealed: male participants more demonstrated holistic strategies. Also the changes in eye movement strategies were demonstrated in AOI distributions during the first, second and third fixations. The obtained results could be of great importance for developing complex methods of testing the facial expressions during social interactions.

Dwelling, and rescanning, and not only skipping of distractors explain search efficiency differences

Gernot Horstmann

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Prominent models of visual search focus on explaining search efficiency by visual guidance. Visual guidance integrates information from the target template and potential target stimuli to prioritize probable target locations. That some searches are fast whereas other searches are slow is then explained by the ability of the easy target to better guide attention to the target's position. However, other variables might influence search efficiency as well, such as dwelling on distractors, and revisiting distractors. Here we test the relative contributions of dwelling, skipping, rescanning, and the use of visual guidance, in explaining visual search times. In the present experiment, participants have to find an emotional-face target among nine neutral-face non-targets. In different blocks, the target is either more or less similar to the non-targets. Eye-tracking is used to separately measure selection latency, dwelling on distractors, and skipping and revisiting of distractors. As expected, visual search times show a large similarity effect. Similarity also has strong effects on dwelling, skipping, and revisiting (but not on visual guidance). Regression analyses on the trial level further confirm these findings. Overall, the results show that with complex stimuli like faces, target-distractor similarity influences search times primarily via the time the gaze dwells on the non-targets and to a somewhat lesser degree by altering the proportion of revisited non-targets in the course of search. Measures of attentional guidance contributed relatively little to the similarity effect.

Of priming and predictions: Neuroimaging and TMS evidences of the predictive interpretation of priming

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Repeating a stimulus reduces the neural activity, which leads to lower BOLD signal in fMRI experiments. This phenomenon has been recently interpreted in the predictive coding framework and it was argued that stimulus repetitions reduce the predictive error of the system and this is manifested in the lower BOLD signal. However, theoretically the predictive error of a system can also be reduced by related semantic cues/primes as supported by many cross-domain priming experiments with name-picture stimulus pairs. Here we first tested in an fMRI experiment (n=18) if the fusiform and occipital face areas (FFA/OFA) show reduced BOLD signal for faces presented after congruent as compared to incongruent names in a famous/non-famous task. We found, in addition to a strong behavioral advantage of the congruent trials, a significant response reduction in the bilateral FFA and rOFA, suggesting that these areas are playing a role in the computation of prediction errors, based on semantic cues/primes. In a second, TMS experiment (n=14) we found that the stimulation of the right OFA eliminates the behavioral advantage of the congruent cue/prime, suggesting the causal role of the OFA in the estimation of predictive errors and cross-domain priming processes. Overall these results show, for the first time, that the core face-processing areas play a role in cross-domain priming processes and support the idea that priming is related to the reduction of predictive error.

Reinterpreting face aftereffects

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The aftereffects of adaptation to faces have been studied widely, in part to characterize the coding schemes for representing different facial attributes. Often these aftereffects have been interpreted in terms of two alternative models of face processing: 1) a norm-based or opponent code, in which the facial dimension is represented by the relative activity in a pair of broadly tuned mechanisms with opposing sensitivities; or 2) an exemplar code, in which the dimension is sampled by multiple channels narrowly-tuned to different levels of the stimulus. Evidence for or against these alternatives is based on the different patterns of aftereffects they predict (e.g. whether there is adaptation to the norm, and how adaptation increases with stimulus strength). However, these models make many and often implicit assumptions about the channels themselves and how they are combined. We re-evaluated these models to explore how their behavior depends on factors such as the number, selectivity, and read-out of the channels, to clarify the actual differences between these coding schemes and the adaptation effects that are most diagnostic for discriminating between them. We show that the distinction between them has relatively little to do with the number of channels but instead depends critically on how the outputs of the channels are compared and labeled, a difference which in turn depends on how the channel responses are themselves normalized through processes such as divisive normalization. Our analyses suggest that some common tests fail to distinguish norm vs. exemplar coding, and point to more diagnostic criteria.

Brain activity from stimuli that are not perceived: Visual mismatch negativity during binocular rivalry suppression

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Predictive coding explains visual perception as the result of an interaction between bottom-up sensory input and top-down generative models at each level of the visual hierarchy. Evidence for this comes from the visual mismatch negativity (vMMN): a more negative event-related potential (ERP) for rare, unpredictable, visual stimuli—deviants, than for frequent, predictable, visual stimuli—standards. We studied whether vMMN occurs in the absence of visual consciousness. To manipulate visual consciousness, we used binocular rivalry, the perceptual alternation between two dissimilar images presented one to each eye. To elicit vMMN during binocular rivalry, we compared ERPs to standards comprising a horizontal grating to one eye and a vertical grating

to the other eye with deviants comprising the same gratings but with decreased luminance of one of them. Because of binocular rivalry, deviants presented to the dominant eye were perceived whereas deviants presented to the suppressed eye were not. We found that the vMMN was maximal at about 250 ms after stimulus onset for both sorts of deviants, with perceived deviants eliciting a bigger vMMN than not-perceived deviants. This shows that visual consciousness enhances the processing underlying vMMN, presumably because visual consciousness increases the precision of the prediction-error by modulation of synaptic gain. We conclude that generative models of visual perception are tested, even when visual input for those models is not perceived.

Screening for visual field defects by quantifying the spatio-temporal properties of eye-movements

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Perimetry – the quantitative evaluation of the visual field – is a diagnostic technique fundamental to ophthalmology. Standard perimetry requires the patient to maintain stable fixation for prolonged periods of time and to respond by pressing a button. This causes both discomfort to many patients and limits the clinically assessable population. Here, we propose a new rapid technique to screen for the presence of a visual field defect based on eye-tracking that largely overcomes these issues. Our straightforward continuous tracking task reduces the amount of time required down to 1-2 min, down from the 10 min required by most standard techniques. We hypothesized that different visual field defects would systematically alter the spatio-temporal properties of eye-movements, which could be used in subsequent classification. We tested this hypothesis in 35 visually healthy observers while (gaze-contingently) simulating visual field defects that replicate the typical scotomas of three ophthalmologic disorders: glaucoma, AMD, and hemianopia. We quantified the spatio-temporal properties of the eye-movement using cross-correlogram analysis (Mulligan et al. 2001). The test was performed at two levels of contrast, and in a smooth-pursuit and a saccadic tracking variant. Our results indicate that in most of the conditions tested, there is a significant difference (* $p < 0.01$, one tail permutation test) between the controls and the simulated VFDs. Cluster analysis could clearly separate the control and simulated VFDs conditions. Our results, although preliminary, shows that this technique can be successfully applied as a screening test for (simulated) visual field defects.

Human eye movements display target features during search

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The time needed to find a target during visual search is influenced by target features and the visual scene in which the target is embedded. This led to a number of highly sophisticated models that aim to predict search time. The influence of target features on eye movements, however, has not been investigated as thoroughly. In our study, participants searched natural scenes for 6 artificial targets with different spatial frequencies in eight sessions. High spatial frequency targets led to shorter fixation durations and smaller saccade amplitudes than low spatial frequency targets. The effect was present during the first session without training, persisted throughout all sessions and disappeared when the target was not specified in advance. Interestingly, fixation durations for low spatial frequency targets were only prolonged before saccades that changed direction compared to the previous saccade. If a saccade was directed in the same direction, fixation durations and successive saccade amplitudes did not differ. In addition, fixation durations and saccade amplitudes were shortest for saccades in the same direction in all conditions. Our results demonstrate that eye movement behavior is strongly affected by the visibility of search targets in the periphery. Low spatial frequency targets can be detected further into the periphery but need more time for identification. Direction specificity of our effects suggests a default scanning mechanism that moves gaze forward in the same direction as the previous saccade. However, likely target locations compete with this default strategy. In summary, eye movements provide details about cognitive processes during search.

Face experts? Assessing passport-matching performance in police officers and novices

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Due to both evolutionary processes and extensive day-by-day exposure, the human cognitive system has developed highly specialized face processing abilities. Therefore, humans are considered to be "face experts," in that they accomplish face recognition quite effortlessly. While this may be true for familiar face recognition, the identification of unfamiliar faces has often been shown to be remarkably poor. Paradoxically, the standard procedure of identity verification in security-related contexts is still the mere visual match between a passport photograph and the alleged holder's face by security personnel. In an experimental passport-matching scenario, we investigated whether professional experience in passport checks leads to the acquisition of expertise for unfamiliar faces and an enhanced face matching ability. We compared passport-matching performance in a sample of 96 officers of the German Federal Police with that of 48 passport-matching novices. Police officers significantly outperformed novices, but nevertheless failed to detect a strikingly high ratio of fraudulent passports. Moreover, we assessed the effects of manipulating specific facial features (paraphernalia like glasses and jewelry, distinctive features like moles and scars, and hairstyle) on passport-matching performance. Especially manipulations of hairstyle lead to an increased acceptance of fraudulent passports. These results suggest that passport checks are not a reliable procedure for identity verification, even if conducted by experienced professionals. Consequently, we argue that labelling humans as "face experts" is not only inappropriate considering poor performance usually found in unfamiliar face matching studies, but it might also promote an unjustified confidence in society concerning the reliability of passport checks.

Top-down effects modulate rapid saccadic reaction times to personally familiar faces

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Several studies have investigated the fastest speed at which visual categorization of visual objects can occur. Specifically, manual Go/No-go paradigms have addressed the speed required for face or animal detection, and familiarity decisions. Saccadic reaction time (SRT) paradigms have been developed to provide a more precise description of the lower bound of processing speed. Typically, subjects perform a saccadic choice decision between two parafoveally presented stimuli towards a predefined target category. According to a recent study (Visconti di Oleggio Castello & Gobbini, 2015) rapid saccades towards personally familiar (PF) faces can be performed within 180ms. However, this study used an extremely small number of PF stimuli, which moreover differed between subjects. Here, we sought to determine the extent to which processing speed measured by SRTs is influenced by decisional space across two SRT familiarity-decision tasks differing in target predictability: the number of PF identities (Departmental members) presented was either 3 or 7. Participants performed saccades towards the same PF target identities, which were presented with a well-matched unfamiliar distractor on each trial. Our findings indicate performance modulation through target predictability: when confronted with fewer identities subjects perform more accurately and/or faster. This stresses the importance of considering task constraints and procedural aspects in SRT paradigms when attempting to determine processing speed using forced-choice decisions. These findings contradict SRT modulation that has been previously attributed to personal familiarity (Visconti di Oleggio Castello & Gobbini, 2015), which can instead be accounted for by stimulus predictability.

When predictive coding impedes perception

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Introduction: The information available to our senses is restricted and to varying degrees ambiguous. Our perceptual system needs memorized concepts and predictions in order to resolve current ambiguities and anticipate the "perceptual future" (predictive coding). We recently identified two ERP components, reflecting the ambiguity of both a currently and a previously perceived stimulus. In the present study we tested whether these ERPs are also sensitive to the ambiguity of a highly predictive upcoming visual stimulus. Methods: We presented ambiguous Necker lattices and disambiguated lattice variants in pairs and varied ambiguity of the first (S1) and second (S2) stimulus in four separate conditions. Participants indicated their percept of S1, and identical or changed percepts of S2 compared to S1. EEG traces and reaction times to both S1 and S2 were selectively sorted with respect to the ambiguities of S1 and S2 and averaged. Results: The ERP amplitudes to stimulus S1 reflect the ambiguity of both the current stimulus S1 and the upcoming S2. In particular, we found smallest amplitudes, when both S1 and S2 were ambiguous, largest amplitudes, when both stimuli were unambiguous, and intermediate amplitudes in case of different ambiguity levels. Further, reaction times to an unambiguous S1 increase, if S2 is predicted to be ambiguous. Discussion: Our results show that the ERP response to a highly unambiguous visual stimulus is reduced by the anticipation of an upcoming ambiguous stimulus. Longer reaction times in this situation may indicate that the perceptual present is altered by the anticipation of the future.

Crowding, visual span and reading speed in adults with dyslexia

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Excessive crowding may be a determinant factor of reduced reading speed in dyslexia ("crowding hypothesis" hereafter). Although controversial, this hypothesis implicitly relies on one main causal link: excessive crowding induces a smaller visual span (VS) which in turn induces reduced performance in eye-mediated reading. The VS in reading is the number of letters, arranged horizontally, that can be recognized reliably without moving the eyes and without any linguistic context. However, clear evidence supporting the link between VS and reading speed for dyslexics and non-dyslexics is still missing. Here we investigated this issue with dyslexic and skilled adult readers who were matched in non-verbal IQ, vocabulary knowledge, chronological age, gender and educational level but differed in reading level. In both groups of 28 participants, reading speed was assessed through sentence reading. Adaptive staircase procedures were used to estimate participants' VS using trigrams of letters presented for 100 ms at different locations across the horizontal meridian (while observers had to fixate a central dot). Participants had to report the middle letter of trigrams. Results show that both groups differ in two clear-cut ways: skilled readers have a significantly higher reading speed (by about 50 words/min) and a larger VS (by about 2 letters) than dyslexic readers. However, a mediation analysis shows that the group difference in reading speed is not mediated by VS. In conclusion, the controversial "crowding hypothesis" in dyslexia still needs an explicit causal link between crowding and reading speed in order to offer a testable and coherent model.

Neural timeline of contextual guidance facilitating visual search in natural scenes

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Visual search and subsequent eye movements in real world are extremely critical and can be modulated by contextual guidance. So far the underlying neural mechanism behind contextual guidance of visual search remains largely unexplored. We used multivariate pattern classifiers to predict coarse contextual location from single electroencephalogram (EEG) trial during visual search for objects in natural scenes. Seventeen naive observers searched for random targets specified by cues (500ms duration) presented prior to natural images (100ms). Target absent images used for analysis were chosen such that a single contextually relevant

location (left/right) was consistent with the sought target. Our results demonstrate that contextual locations in natural scenes can be predicted reliably from neural activity when observers were searching for targets and the prediction rate improved significantly post 400 ms stimulus onset. The pattern classifier failed to predict the expected location using the same stimuli in a separate control EEG study when contextual information was made inconsequential. Lateral occipital complex (LOC) and intraparietal sulcus (IPS) were previously shown to contribute towards contextual guidance in natural scenes but their exact role in facilitating the visual search remained unclear. Using a source localization analysis of the event related potential (ERP), we could further explore the spatiotemporal dynamics to understand the neural timeline of contextual guidance. Our source localization analysis suggests that scene information is passed on from LOC via IPS to the fronto parietal network which then directs the LOC and IPS to focus on the contextually relevant locations.

Critical features of face recognition in humans and machines

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A fundamental question in the study of face recognition is which facial features determine the identity of a face. Previously, we discovered that replacing a subset of facial features, which included the hair, eye-shape and color, eyebrow-thickness, and lip-thickness, modified the identity of a face (i.e., critical), whereas changing other features including face-proportion, nose, eye-distance or skin-color did not change the identity of a face (i.e., non-critical). We also showed that these critical features, unlike non-critical features, are those that remain invariant under changes in face appearance. These findings were based on similarity rating of unfamiliar faces. Here we show that the same features are also critical for familiar face recognition: Replacing these critical features in celebrity faces resulted in failure to recognize them, while replacing non-critical features had smaller effect on recognition. Discovering these critical features allowed us to examine whether the same features are also used in machine face recognition. In particular, deep neural networks (DNNs) have recently reached human-level face recognition, but it is uknown to which high-level facial features the algorithm is sensitive. To that end, we used OpenFace, a DNN that was trained on unconstrained faces, to obtain similarity scores between an original face and the same face in which critical or non-critical features were replaced. We found that, similar to humans, the DNN was more sensitive to critical than non-critical features. We conclude that humans and DNNs are sensitive to a subset of features that are invariant to within-person changes in appearance.

Unravelling the neural coding of idiosyncratic fixation strategies for faces

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When engaging in face recognition people visually sample some facial features more than others and these idiosyncratic strategies do not impact on performance. However, it is still unknown whether a relationship exists between the way people visually explore faces and the neural responses to the fixated facial features. More precisely, it remains to be clarified whether the processing of the preferred fixated facial features drive specific neural responses. To address this question, we first recorded the oculomotor behaviour of participants while they performed an old-new face recognition task and determined which facial features were fixated the most by each observer. Independently, we recorded, in the same subjects, the electrophysiological responses to faces by means of both fast-periodic oddball stimulation (FPOS) and event-related potentials (ERPs), while varying the fixation location across nine equidistant points covering all the inner facial features. The responses generated by FPOS were considered in the frequency domain and allowed us to reveal clear modulations of early neural responses by the fixated facial feature, which were unrelated to the idiosyncratic fixation biases. However, a relationship emerged from the ERPs study between the most fixated facial features and the P300 electrophysiological component. The higher the bias of the fixations toward one feature, the greater the P300 amplitude when processing faces at this fixation location. Our data show that idiosyncratic eye movement strategies are directly coupled with the later neural decisional signatures of face processing, which most probably require re-entrant fine-tuned information from the face network.

Expressive faces confuse identity recognition

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We explored the effect of facial expressiveness on recognition. We created two packs of cards from images selected from our own database of highly variable, naturalistic facial images. Each pack contained an equal number of face images of two unfamiliar identities. While one pack depicted neutral faces, the other contained faces varying in expressiveness. Importantly, for each card in the neutral pack there was a corresponding card in the expressive pack that came from the same movie segment; therefore variables such as lighting were constant within image pairs, while expressiveness differed. In two experiments, participants sorted the card packs into piles, one for each perceived identity. Consistent with other studies using this paradigm, the perceived number of identities was higher than the veridical two. However we found a clear difference between the expressive and neutral sorting tasks when we measured the internal accuracy of the identity piles. When the task was performed with expressive faces, identity piles were significantly more likely to contain cards of both identities, indicating that the two had been confused. This finding uniquely demonstrates that variability of expressions, over and above other sources of variation, give rise to these errors of identity confusion. This shows that expressions are not factored out when we make decisions about identity of unfamiliar faces. These results support face-processing models that permit both invariant and changeable facial information to be drawn upon for identity decisions.

Decoding the contents of visual awareness from unstimulated regions of early retinotopic cortex

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During bistable perception, observers experience alternations between two mutually exclusive interpretations of a constant ambiguous input. This phenomenon is often explained by framing perception as an inferential process generating and testing hypotheses about the causes of sensory stimulation. Predictive coding accounts of perceptual inference propose that predictions encoded at higher sensory processing levels are compared against sensory input signals at lower levels. According to this idea, the currently dominant state in bistable perception establishes an implicit prediction that is fed back from higher to lower hierarchical levels and stabilizes perception. We reasoned that information about the currently dominant percept should thus be present in early retinotopic visual areas. To dissociate feedback from feedforward signals, we tested whether the dominant percept could be decoded from retinotopic regions representing unstimulated parts of the visual field. We used bistable plaid motion stimuli that covered three quadrants of the visual field while one quadrant remained unstimulated. Human subjects underwent functional magnetic resonance imaging (fMRI) while they viewed the bistable stimuli and reported spontaneous perceptual alternations. Retinotopic mapping was performed to delineate stimulated and unstimulated regions within areas V1-V3. Using multivoxel pattern analysis we could decode perceptual states as reported by the participants with above-chance accuracy from fMRI signal patterns in stimulated quadrants in V1-V3 and, importantly, also from unstimulated regions within these areas. These findings indicate that early visual cortex receives feedback from higher-level brain areas that encode the alternating perceptual contents in bistable perception, thus supporting a predictive coding account of perceptual inference.

Cognitive load effects on social looking in an authentic context

Evan Risko & Alan Kingstone

Much work in social attention focuses on looking behavior in contexts which are arguably minimally social (e.g., looking at a schematic face, looking at a picture of a social scene). This limits the extent to which we can generalize results to authentic social contexts. The dual function of gaze framework (Risko, Richardson & Kingstone, 2016) attempts to provide a perspective from which attention within an authentic social context can be understood. According to this framework, the eyes are driven by both the need to acquire information and social norms guiding appropriate looking behavior. One hypothesis is that implementing the latter is a controlled process limited by available resources. We begin to examine this idea in the present investigation in a large sample (> 100 participants) mobile eye tracking experiment. Participants walked a pre-determined path and confederates walked past them. Critically, in one condition participants walked while also performing an n-back task and in another condition participants simply walked (and listened to the n-back stimuli without performing the task). This allowed us to assess whether cognitive load influenced looking behavior (to the confederates) in an authentic social context. Results demonstrate that social looking in this context is modulated by load (i.e., the pattern of gaze to the confederate changes as a function of condition). We will discuss these results in the context of the dual function of gaze framework.

Practice with visual search in simulated hemianopia does not lead to the development of optimal search strategies.

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We previously found that healthy participants with simulated hemianopia fail to adopt efficient eye movement strategies during visual search. One possible explanation is that participants were not exposed to the deficit for long enough. Here visual information in one hemifield was removed, while participants searched for a line tilted 45° to the right among lines of varying degree of tilt. Participants completed testing sessions over five consecutive days, and received monetary payment for improvements in performance. Additionally, in the first and last session, participants were tested on their ability to spot the target using their peripheral vision, and to report objects embedded in images of natural scenes under simulated hemianopia conditions. We found search performance improvements on the main task, but these improvements were mainly associated with better peripheral vision rather than improved search strategies. Even after five days of training, saccades were directed to the sighted field under conditions where little or no new information about the target location would be gained by doing so. However, more eye movements were directed into the blind field in the first compared to the last session in the object naming task, leading to slightly better performance in the object naming task. This modest improvement was not observed over the same period, in a control group who did not undergo training. Together these results suggest that both extensive training and explicit instructions might be necessary to optimize search performance.

Understanding viewpoint generalization in the human face-processing network: From neurons to voxels and back again

Fernando M. Ramírez

Electrophysiological measurements from macaques have shown that the anatomical location of distinct face-selective cortical patches is associated with a specific functional identity (Freiwald and Tsao, 2010). While neurons in the middle face patches (ML, middle lateral, and MF, middle fundus) were unimodally tuned to a single preferred orientation, neurons in the anterior lateral face patch (AL) were bimodally tuned to mirror-symmetrically oriented faces—e.g., the left and right profiles of a face. Recently, studies combining fMRI and multivariate pattern analysis (MVPA) methods including representational similarity analysis (RSA) aimed to describe

the form of tuning of neural populations in the human face-processing network. Conclusions across studies diverged, however, in all core face-selective areas. Here, we investigated the impact of choice of pattern dissimilarity measure in RSA by analyzing population responses of single-neurons recorded in macaques (data: Freiwald and Tsao, 2010). We used re-sampling to simulate the impact of the fMRI measurement process on inferences regarding neural coding. Depending on the level of pooling of single-cell responses, using Euclidean distances led to incompatible inferences regarding the underlying form of tuning in MF and AL. Such inconsistencies were not observed when relying on angular distances. Moreover, similar to recent observations in the human fusiform face area with fMRI, average spike-rates in macaques revealed stronger responses to frontally viewed faces in ML/MF, but not in AL. These findings suggest a unified interpretation of otherwise inconsistent conclusions regarding viewpoint generalization in humans, and generally bear on the interpretation of MVPA analyses of large-scale signals.

Simulating foraging in the wild using an iPad

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Traditional search tasks have taught us much about vision and attention. Recently, several groups have begun to use multiple-target search to explore more complex and temporally extended "foraging" behaviour. In our previous work we developed a 2D dot cancellation app inspired by classic animal foraging studies. Participants typically selected targets at random from two available categories when items were distinguished by a single feature (colour), but tended to use long "runs" from the same category during conjunction (colour and shape) conditions. In the current work, we asked whether this feature/conjunction manipulation would modulate behaviour in a situation more closely resembling foraging in the wild. We present a new experimental app where participants play the role of a squirrel foraging within a 3D model of a city park. Target and distractor items were acorns and walnuts of different colours and we used the same feature/conjunction manipulation as before. In Experiment 1 participants used a virtual joystick to navigate, collecting items by virtually touching them. Target and distractor items were equally numerous. In Experiment 2 navigation was via whole-body rotations of the iPad, more closely mirroring natural exploration. In the conjunction condition we also reduced the target/distractor ratio to 30/70 to further increase search difficulty. In contrast to our previous work, target selection from the two categories remained completely random in all conditions. Thus, in a simulated complex environment, with more real-world task demands and search dynamics, we find no influence of the feature/conjunction manipulation.

Lack of free choice reveals the cost of multiple-target search within and across feature dimensions

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It is debated whether people can actively search for more than one object at a time or whether search is limited to only one item. Using a gaze-contingent eye-tracking paradigm, we indicate a critical role for cognitive control. We instructed participants to simultaneously look for two target objects presented among distractors. In one condition, both targets were available, giving the observer free choice on what to look for. In other conditions, only one of the two targets was available, so that the choice was imposed. Reliable switch costs only emerged when targets were imposed, but not when target choice was free, suggesting that active search is limited to a single item. In a follow-up experiment, we investigated whether this limitation holds irrespective of whether the objects are defined within or across feature dimensions. We presented colored shapes to participants and instructed them to either look for two colors, two shapes (within-dimension condition), or for one color and one shape (across-dimension condition). In both the within-dimension and the across-dimension search, switch costs only emerged when target availability was limited, suggesting a general limitation of active search. These results are consistent with models of visual selection in which only one attentional template actively drives selection. Currently, we are exploring whether this limitation can be bypassed by storing the target features as an integrated object, which could serve as a single template. This tests the hypothesis that the template would not be limited to a single feature, but to a single object.

Mapping fast and automatic visual categorization of faces in the human ventral occipito-temporal cortex with intracerebral recordings

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The neural basis of human visual categorization remains poorly understood, essentially because of difficulties in measuring this fast and automatic process inside the human brain with direct recordings of neural activity. We extend the findings of a recent study (Jonas et al., 2016) by reporting local neurophysiological activity from a total of about 4000 contact electrodes implanted in the ventral occipito-temporal cortex (VOTC) of a large group of temporal epileptic patients (N=60). The experimental paradigm taps into fast and automatic visual processes by presenting variable natural object images at a rapid fixed rate (6 images per second: 6 Hz), with natural images of faces interleaved every 5th stimulus (1.2 Hz). High signal-to-noise ratio face-selective responses are objectively (i.e., at the face stimulation frequency) identified across the whole VOTC, revealing a wide distribution of activity but with regional peaks. The lateral section of the right middle fusiform gyrus shows the largest face-selective

response by far, supporting indirect measures of neural activity obtained with fMRI. Three novel regions with large face-selective responses are disclosed in the ventral anterior temporal lobe, a region that is undersampled in fMRI due to magnetic susceptibility artifacts. A high proportion of contacts responding only to faces (i.e., "face-exclusive" responses) are found in these regions, suggesting that they contain populations of neurons fully dedicated to the visual category of faces. These observations provide original evidence for hemispheric and regional specialization of visual category-selectivity in the human brain with direct measures of brain activity.

Stable visual search strategies within but not between visual search paradigms

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Different people use different strategies when searching for a target. For example, when searching for a target in an array of distractors that are homogeneous on one side, and heterogeneous on the other, the optimal strategy is to search the heterogeneous part of the array (were the target present in the homogeneous side of the array, you would already have detected it). While a small number of observers search such displays optimally, many do not, and some are outperformed by random models [Nowakowska, Clarke & Hunt, 2017, Proc. Royal Soc. B]. A striking range of individual differences in search behaviour was recently reported using two other tasks [Irons & Leber 2016, AP&P; [Kristjánsson et al, 2014, PLoS One]. This leads us to the question of whether an individual's performance in one specific search paradigm tells us anything about how they will perform in another. We tested observers in the three paradigms mentioned above over two sessions. Even though the test-retest reliability of the tasks used by Nowakowska et al (2017) and Irons and Leber (2016) is reasonably high, the results show that an observer's performance and strategy in one task does not predict their behaviour in the other two. These results suggest search strategies are context-specific, and caution should be taken when trying to generalise results between tasks.

Fast periodic visual stimulation (FPVS) identifies highly reliable EEG markers of discrimination between genuine and posed facial expressions

Amy Dawel[1], Paige Mewton[2], Elinor McKone[1], Milena Dzhelyova[3], Bruno Rossion[3] & Deborah Apthorp[2]

[1]Australian National University, and ARC Centre of Excellence in Cognition and its Disorders; [2]Australian National University; [3]University of Louvain

In everyday social interactions, we make judgments about whether others' facial expressions are a genuine reflection of their underlying emotional state, or whether they are posing or pretending the expression for other reasons (e.g., as part of social communication). Here, we provide the first EEG data showing evidence of neural discrimination between genuine and posed facial expressions, using images depicting sad expressions. In our Fast Periodic Visual Stimulation (FPVS) paradigm, we presented genuine sad expressions as "oddball" stimuli within a rapid "baseline" stream of posed sad expressions, and vice versa. Our key outcome measure was EEG responses to the oddball stimuli, which are indicative of discrimination between the oddball and baseline stimulus categories. Results showed significant oddball responses to both genuine-in-posed and posed-in-genuine oddballs in Exp 1 (n = 18), and this result was replicated in Exp 2 (n = 16). Critically, oddball responses were significantly stronger: (1) over right-hemisphere occipito-temporal electrodes (e.g., T6), corresponding with face-perception areas, compared to the equivalent left-hemisphere electrodes (e.g., T5; Exp 1 & 2); and (2) when faces were upright compared to inverted (Exp 2). Further, oddball responses were highly reliable even at the individual participant level. Overall, our novel findings show evidence of discrimination between genuine and posed facial expressions in brain regions associated with face perception, which are not attributable to low level artefacts. The high reliability of these EEG markers makes them suitable for investigating individual differences in perception of emotional genuineness (e.g., in schizophrenia, or autism spectrum disorder).

Thursday August 31st Symposia presentations

How is binocular disparity information used for depth perception?

Julie Harris

University of St. Andrews

What is the purpose of binocular vision in humans? Most experts agree that it is used as a source of information about depth and shape. Binocular vision allows us to obtain a measure of the tiny differences between each eye's view of the world, called binocular disparity. Our visual systems are exquisitely sensitive to binocular disparity, allowing us to detect depth differences as small as 1mm, 1m away. A major focus in understanding binocular vision, has therefore been to explain how depth from binocular disparity can be extracted by the visual system. Yet this is not the whole story, it is also important to determine how binocular disparity contributes to perceived depth. Evidence suggests that the depth perceived is biased by other aspects of scene configuration, and potentially by the pattern of disparity itself. Thus the brain does not have access to a point for point disparity map. I will review some of this evidence in this talk, and discuss some of the constraints these data place on the potential utility of binocular disparity information for depth perception in natural vision.

Sensory Integration in Visual Cortex Develops Late in Childhood

Tessa M. Dekker, Hiroshi Ban, Bauke Van den Velde, Marty Sereno, Andrew Welchman & Marko Nardini

University College London

Only by age 10 years do children start combining multiple sensory cues to minimise perceptual uncertainty. This might be due to slow development of the neural mechanisms that

fuse sensory information. Alternatively, fused representations may be computed before age 10 years, but the ability to use this information to the benefit of perception is still developing. To distinguish between these possibilities, we combined behavioural psychophysics, retinotopic mapping, and pattern classification fMRI (Ban et al. 2012). In a sample of 100 children aged 6-13 years we measured visual depth psychophysical discrimination thresholds and established that adult-like fusion of motion-parallax and disparity cues to depth develops between ages 10-11 years. In a subset of 27 children aged 8-13 years, we then tested for sensory fusion of these cues across the retinotopically-organised cortex. In older children who showed adult-like cue integration behaviour (>10.5 years), there was clear evidence of sensory fusion in visual area V3B, which also combines depth cues in the mature brain. In contrast, we found no evidence for sensory fusion in the visual cortex of younger children whose depth perception did not benefit from multiple cues (< 10.5 years). These findings could not be explained by age-differences in body movement, differences in vergence, or overall signal quality. These results suggests that the perceptual shift between ages 10-11 years occurs because the neural computations that give rise to fused depth representations in V3B only develop by this age.

Stereopsis from oriented lines

Pascal Mamassian & Anna Ptukha

Laboratoire des systèmes perceptifs, Département d'études cognitives, École normale supérieure, PSL Research University, CNRS, 75005 Paris, France

When a vertical line is presented in front of or behind fixation, horizontal disparities are generated in the projected images of the two eyes. When the line is slanted about a horizontal axis, orientation disparities are generated between the projected images in addition to the horizontal disparities. There is a large and tormented literature on orientation disparities that questions their usefulness (Bridge et al., 2001, Vis Neurosci), their existence at the neural level (Blakemore et al., 1972, J Physiol; Bridge & Cumming, 2001, J Neurosci), and their actual use to estimate slant (Ninio, 1985, Perception; Cagenello & Rogers, 1993, Vision Res). After a brief review of this literature, a novel aspect of orientation disparities is presented. Observers viewed a long tilted line (40 deg from vertical), either to the right or left of fixation (0.15 deg eccentricity), and had to judge whether the line appeared in front of or behind fixation. In addition to horizontal disparities (from -0.6 to 0.6 arcmin), orientation disparities were added between the left and right images (from -7 to 7 deg). Surprisingly, even though orientation disparities should only introduce a slant of the line, they produced a systematic depth bias. In addition, depth judgments were most precise for a particular combination of horizontal and orientation disparities that seem to be consistent with the line lying in a vertical plane passing through fixation. These results add to the literature on the interactions between orientation and horizontal disparities for depth perception (Farell, 2006, J Neurosci).

What are the local computations that support depth?

Jenny Read[1], Sid Henriksen[1], Dan Butts[2] & Bruce Cumming[3]

[1]Newcastle University; [2]University of Maryland; [3]NIH

Primate stereopsis is remarkably precise and can break camouflage, revealing structures that are monocularly invisible. This ability depends on matching up the two eyes' images, a process which begins with disparity-sensitive neurons in primary visual cortex, V1. The currently accepted model of these neurons is a 3-layer linear/nonlinear neural network. The weights from the input layer to the hidden layer represent binocular simple-cell receptive fields. These simple cells then converge onto a single V1 complex cell.

With the right parameters, this model can reproduce many general properties of V1 neurons, notably their attenuated responses to anticorrelated images. Here, contrast is inverted in one eye, meaning there are many false local matches but no global depth. However, attempts to fit these models to V1 neurons using spike-triggered covariance have not shown this attenuation. Thus it is unclear whether this model really describes how V1 works.

We have used a new machine learning approach to train models on correlated, uncorrelated and anti-correlated random-line patterns with a range of disparities. Despite being given only raw images – not disparity or correlation – as input, the model predicts disparity tuning curves well for all three correlations. This shows for the first time that these models can describe individual V1 neurons. However, many neurons show very high activity for one preferred disparity, which the models cannot capture. This suggests that the real puzzle of V1 neurons may not be how they attenuate their response to false matches, but how they boost their signal for one preferred disparity.

Ocular Dominance Plasticity in V1 of adult humans

Concetta Morrone

University of Pisa

Binocular rivalry is a sensitive method to study ocular dominance and to monitor variation of eye balance that can occur after abnormal visual experience. We have shown that short-term monocular deprivation unexpectedly boosts the deprived eye in adults (homeostatic plasticity), resulting in a strong dominance of visual perception of the deprived eye during binocular rivalry (Lunghi et al, Current Biology 2011). The increase in eye dominance caused by short-term monocular deprivation correlates with the decrease in resting GABA (measured by 7-Tesla Magnetic Resonance Spectroscopy) in occipital cortex, suggesting a critical role for GABAergic inhibition in triggering visual plasticity (Lunghi et al, Current Biology, 2015). In addition, GABA measured during stimulation of individual eyes, but not during binocular stimulation, correlates negatively with the ocular dominance changes induced by deprivation, suggesting an overall reduction of inter-ocular suppression after deprivation. Bold measurements of ocular dominance in V1 at 7T corroborate these results showing an increase of the activity and a broadening of stimulus selectivity for spatial frequency of only the deprived eye after short-term monocular deprivation (Binda et al, VSS 2017). Reduction of stimulus selectivity of individual

neurons is usually associated with a decrease on inhibition. All these results indicate that ocular dominance is strongly linked to the GABAergic inhibitory intra-cortical mechanisms, and that these mechanisms retain a high level of plasticity in adult primary visual cortex.

Neural signals dynamics for the perception of stereo depth in primates

Kristine Krug, Dante Wasmuht, Nela Cicmil & Andrew Parker

University of Oxford

Our rich experience of the 3-dimensional visual world depends directly on neural signals in different areas of visual cortex. For instance, electrical micro-stimulation experiments in Rhesus monkeys have demonstrated how the perceptual appearance of 3D structure-from-figures is controlled by neural circuits in extra-striate visual area V5/MT (Krug et al., 2013). Here, the focal introduction of an artificial electrical signal changes the reported percept of a visual stimulus in line with the functional selectivity for binocular disparity and depth of the stimulated neurons. While this result underlines the principle of sparse coding, of course, visual stimulation activates neurons beyond the immediate range of the stimulating electrode. Interrogating the time-course and interneuronal interactions of neuronal signals contributing to 3D perception reveals dynamic changes specifically associated with the emergence of a robust 3D percept. When comparing neuronal signals in V5/MT for correlated binocular disparities, which result in a 3D percept, and anticorrelated disparities, which do not, we find that correlated disparities result in lower variance-to-mean ratios. This suggests a reduction in noise when the correspondence problem has a unique solution. In related experiments, we found that three-dimensional structure-from-motion figures result in higher interneuronal correlations with neighbouring V5/MT neurons than random motion stimuli. In both experiments, the changes emerge over time-courses of 100s of milliseconds – the neural signature of a top-down signals acting on visual structures. V5/MT neurons may be part of a recurrent network with attractor dynamics that is stabilised when a 3D percept is formed.

Intrinsic cone signals evoked with photostimulation

Gereon Hüttmann, Hendrik Spahr, Clara Pfäffle, Helge Sudkamp, Gesa Franke & Dierck Hillmann

University of Lübeck

Imaging of retinal function in vivo promises new diagnostic possibilities and insights into vision processes. Different changes of optical properties of retinal tissue can be related to the vision process. These intrinsic optical signals (IOSs) are changes in light scattering, absorption, or birefringence and they occur with time constants from milliseconds to seconds. Unfortunately, the observed signals are weak and difficult to measure in humans. Even with optical coherence tomography (OCT), which allows imaging of single retinal layer with micrometer axial resolution, measured changes of scattering signals after stimulation were extremely noisy and difficult to interpret. By evaluating the phase of the OCT signal, we reliably measured human retinal photoreceptor function after optical stimulation. We observed first a slight decrease of less than 10 nm and then an increase of the optical path length in the photoreceptor outer segments, which we even could assign to single cones after computational aberration correction. Temporal resolution and signal quality were high enough to exactly quantify the observed changes. With 150 nm/s, the slope of the main signal, which continued after stimulation, was not dependent on the strength of the stimulation. Only the maximum value of the optical path length changes increased with stimulation intensity and duration. The observed IOSs returned to baseline within seconds. Our results are corroborated by the recent observation of an elongation of rod outer segments in mice after high light exposures (up to 10% bleach of rhodopsin), which was attributed to osmotic swelling after the activation of the G-protein.

Cell-resolved retinal imaging and function testing

Rigmor C. Baraas, Hilde R. Pedersen & Stuart J. Gilson

University College of Southeast Norway

Spatial acuity measures are associated with the ability to see fine detail; the functional resolving capacity of the human eye. In clinical settings, it is a measure of visual function typically made with high contrast achromatic stimuli, even if we know that such measures are less meaningful when assessing retinal integrity. Acuity for coloured stimuli, which isolate a single cone type, may provide a more useful measure. Here, we were interested in understanding the degree of correlation between the photoreceptor mosaic, cone density and different measures of acuity using cone isolating stimuli. Healthy participants with normal vision were enrolled in the study. Colour vision was examined with a battery of tests including anomaloscopy and computerized discrimination tests. High-resolution retinal images were obtained of cone outer- and inner-segments in the macular region, using an adaptive optics scanning light ophthalmoscope that allowed for simultaneous confocal and split-detection imaging. Perceptual tasks such as spot detection acuity, Vernier acuity and single letter acuity was measured at different retinal eccentricities for L-cone isolating stimuli of different levels of cone contrast. Observers were corrected to best visual acuity and performed the tasks monocularly with natural pupils. The results emphasise the role of phenotypic variation in the cone and rod mosaic and its limit on visual perception under natural viewing conditions.

Vision at its sensitivity limit: linking retinal circuit function with behavior

Lina Smeds, Daisuke Takeshita, Tuomas Turunen, Jussi Tiihonen & Petri Ala-Laurila

Aalto University

Correlating neural circuit function with behavior is a pivotal goal in neuroscience. However, experimental evidence for this has until now been mostly missing due to the complexity of neural circuits and the challenges of quantifying complex behavior. We now measure for the first time quantal signals originating only from several tens of photons by electrophysiology through the neural circuits of the retina and correlate the retinal output signals with precisely quantified behavioral decisions using a novel tracking technology of the head and body positions of freely-moving mice. We show that

behavioral relies on information from the retinal On pathway, carried by increases in spiking, even when information from the Off pathway, carried by decreases in spiking, would allow higher sensitivity. The results have several fundamental consequences for understanding how the brain integrates information across parallel information streams as well as for understanding the limits of sensory signal processing.

Variability in threshold and summation among human cone photoreceptors

Wolf M Harmening, Kady S Bruce, William S Tuten, Austin Roorda & Lawrence C Sincich

University of Alabama at Birmingham

Human psychophysical thresholds have been studied in many ways, yet variation in cone functional weighting and cone signal integration have not been directly examined in vivo. Using an adaptive optics scanning laser ophthalmoscope (AOSLO) equipped with multiwavelength imaging and stimulation capabilities, we delivered cone-sized stimuli to individual photoreceptors in 7 human subjects. Perceptual increment thresholds for 543 nm light were measured from single cones and cone pairs using a staircase method of threshold estimation. In 42 of 99 pairs, individual thresholds differed between cones ($p < 0.05$), and differences in threshold smaller than 15% were detectable. To explain the source of observed variability in cone threshold, we examined several factors that could lead to threshold differences. We found that thresholds were consistent when measured over multiple testing days, that there is no relationship between cone reflectivity in AOSLO images and perceptual threshold ($n = 494$ tests; $p = 0.19$), and that systematic stimulus delivery errors did not explain variation (average error = 0.2 arcmin; $R^2 = 8\times10^{-5}$). Individual cones in pairs were stimulated simultaneously and analyzed with respect to their signal summation. Lower thresholds were always observed, with 17 of 99 pairs manifesting linear summation, and 42 pairs integrating signals according to a two-detector model. The style of signal integration was not correlated with the eccentricity of the tested cones, but was related to inter-cone distance (15 of 17 linear pairs were located within 1.5 cone spacings of one another), suggesting bipolar cells as mediating cone signal summation.

A virtual microscope for retinal bipolar cells: Reconstructing the bipolar cell layer by analyzing ganglion cell responses to light

Tim Gollisch

University Medical Center Göttingen

Retinal ganglion cells are the output cells of the retinal neural network at the back of the eye. They pool their excitatory signals from about a dozen different types of presynaptic bipolar cells. Seeing the layouts of these bipolar cell types in the retina and their functional connectivity to ganglion cells would be a great boon for understanding how visual information flows through and is processed by the retina. Here, I will discuss recent methodological advances that allow us to computationally reconstruct the layout of bipolar cells by recording the activity of ganglion cells under visual stimulation. In particular, we have developed a technique to identify functional subunits inside a ganglion cell's receptive field by analyzing the statistical structure of those stimuli that successfully triggered action potentials in the ganglion cell. By simultaneously recording light-evoked activity from ganglion cells and bipolar cells in the salamander retina, we have shown that the identified subunits correspond to the receptive fields of presynaptic bipolar cells. Applying this method to large-scale multi-electrode recordings of ganglion cells thus lets us reconstruct the layout of entire populations of bipolar cells in a piece of retina. This allows us to infer the functional connections of the reconstructed bipolar cells to ganglion cells, build network models of stimulus encoding, and analyze the sharing of bipolar cell inputs by different types of ganglion cells.

Color sensations elicited by individual cones

Ramkumar Sabesan

University of Washington

The visual system reconstructs fine spatial detail and rich color experience from a paucity of wavelength and intensity signals originating in the cone mosaic. To understand the role of the early visual system in decoding luminance and color, we recorded hue percepts upon targeting individual, spectrally identified, human cones near the fovea. Two distinct populations of cones were observed: a smaller group predominantly signaled chromatic percepts while a second larger group was associated with achromatic percepts. Within those cones that drove color, 'red' and 'green' sensations were associated with L- and M-cones respectively while both cone types led to achromatic percepts. A given cone's sensation was dominated by just one of these specific perceptual categories (achromatic or color) and remained consistent over time. The relationship between the cones' immediate spectral neighborhood (non-opponent or opponent) and the resulting percepts departed from models of single-cone-centered foveal midget ganglion cells. These results are consistent with the notion of a parallel high-resolution achromatic channel and a lower resolution color system, the characteristics of which emerge as early as the photoreceptor synapse. The implications of these results in relation to contemporary models of neural circuitry mediating color and spatial vision will be discussed.

Figure-ground organization and the emergence of proto-objects in the visual cortex

RüDiger Von Der HeyDt

Johns Hopkins Univ

Image understanding is often conceived as a hierarchical process with many levels where complexity and invariance of object selectivity gradually increase with level in the hierarchy. In contrast, neurophysiological studies have shown that figure-ground organization and border ownership coding, which imply understanding of the object structure of an image, occur at levels as low as V1 and V2 of the visual cortex. This cannot be the result of back-projections from object recognition centers in the inferotemporal cortex, because border-ownership signals appear around 70 ms after stimulus onset, well before shape selective responses emerge

in inferotemporal cortex. Ultra-fast border-ownership signals have been found not only for simple figure displays, but also for complex natural scenes. This talk will review the hypothesis that the brain uses dedicated grouping mechanisms early on to link elementary features to larger entities called "proto-objects." This process is pre-attentive and does not rely on object recognition. The proposed mechanism consists of grouping cells that sum distributed feature signals with fixed templates and, by feedback, enhance the same feature signals. With this circuit, the system can enhance many feature signals by top-down activating a single grouping cell. The shapes and sizes of the grouping templates and the rise and persistence of grouping cell activity define "objectness" akin to the Gestalt laws of perception. The proto-object structures serve to individuate objects and track their identity across movements and eye movements, as well as to select objects attentively.

Solving border ownership: insights from V4 responses to isolated and occluded shapes

Anitha Pasupathy

Univ of Washington

I will describe how the problem of border ownership may be solved in the primate brain on the basis of a series of our neurophysiological results in macaque area V4. First, responses of many V4 neurons encode shape parts in an object-centered reference frame. Second, responses of many other neurons are sensitive to the area of the visual stimulus. Third, V4 responses are exquisitely position invariant—response magnitude may change as a function of position but shape tuning remains consistent. Fourth, when one shape is partially occluded by a second shape, neurons in macaque V4 show suppressed encoding of accidental contours formed at the T-junctions between occluded and occluding object boundaries. This influence of local image cues on encoding are often observed within 60 ms of stimulus onset. On the basis of these results, I will argue that area V4 shifts the stimulus representation from an encoding of local orientation, contrasts and spatial frequency, to encoding of objects by collections of contours and regions. One advantage of this object-based encoding scheme is that it offers a more general explanation of major V4 properties, such as boundary curvature tuning, in a way that implicitly solves the border ownership problem.

Using feedback to segregate the visual scene: excitation and suppression of responses in V1 through border-ownership tuned cells in higher visual areas.

Matthew Self

Netherlands Institute for Neuroscience, Amsterdam, The Netherlands

The responses of cells in V1 are higher on regions perceived as figures compared to those on backgrounds, an effect known as figure-ground modulation (FGM). This enhanced firing on figures is thought to be due to feedback from higher visual areas. I will present laminar recordings from V1 showing that feedback targets particular layers causing an early enhancement on figures and a later suppression of the entire background. This effect is dependent on the activity of NMDA receptors and the spatial pattern of excitation and inhibition are remarkably spatially precise and can be used to predict the behavior of animals performing shape discrimination tasks.

To understand the source of this modulation I will discuss a new model of FGM in which connections between a higher visual area (V4) and V1 are governed by the border-ownership (BO) preferences of cells in V4. I propose that BO cells send feedback to V1 in the direction of their preferred side of figure while suppressing activity on the non-preferred side. This connection scheme can reproduce the spatial patterns of FGM observed in V1. The model predicts that cells in V4 will be more strongly connected to V1 cells with RFs located on their preferred side of ownership. We confirmed this prediction using measurements of noise correlations from simultaneous recordings from V1 and V4. We suggest that FGM may arise through interactions between BO tuned cells in higher visual areas and cells in V1 leading to labeling of the surfaces of figures with enhanced firing-rates.

Neural mechanism of long-range interaction is the key to link figure-ground, shape and illusory surface perception

Naoki Kogo

Figure-ground segregation is an emergent property of vision reflecting global configurations. Computation of border-ownership signals indicating the figural side of boundary is assumed to underlie the phenomenon. Although border ownership can only be derived from the global image context, it is unknown how border-ownership signals (BOSs) reflect the global configurations of the image. In previous computational models, algorithms were implemented to give a "convexity bias" to the models' response. However, counter examples, such as the ones with holes, indicate that convexity is not a satisfactory condition and that the long-range consistency of surface properties also plays the key role. I will present a neuro-computational model in which long-range facilitatory interactions of BOSs occur only if they satisfy the following conditions. 1. Their geometrical relationship fits to convexity of a shape. 2. The surface properties at the location of BOSs are consistent. The model shows unprecedented robust responses to complex figures without the necessity of T-junction detectors. I will then introduce the key hypotheses of the symposium. 1. In visual system, border-ownership computation is mediated by "grouping cells" with circular structure of receptive field that group the consistent border-ownership signals. 2. The collective signals of the grouping cells constitute "medial axis" like signals which are thought to play an important role in shape detection. 3. Completion phenomena in illusory surface perception (e.g. the Kanisza triangle) emerge through the dynamics of the border-ownership computation. These hypotheses lead to an integrated view of computational mechanisms of perceptual organization.

Thinking about seeing

Brian Rogers

University of Oxford

The purpose of our controversy symposium is consider and discuss the most fundamental question in the field of perception - what is it that we are trying to explain? According to Koffka, the answer is "Why do things look as they do?" i.e. how can we account for our perceptual experiences - and the majority of publications in our field, and the presentations at this conference, have attempted to do just that. But does appearance matter and what is its causative status? Others, notably James Gibson, have argued that the underlying purpose of perception is to guide action - "Perceiving is an achievement of the individual, not an appearance in the theatre of his consciousness". If this view is correct then what might be the role of subjective experiences - our qualia? There are also significant differences between researchers as to what constitutes the appropriate level of explanation in the field of perception. For example, some might argue that single cell recordings and brain images provide objective and definitive answers to questions about perception and these will eventually supercede what we have learned from traditional psychophysical and behavioural methods? To try to find some answers to these and other questions, we have brought together four distinguished vision scientists—Jan Koenderink (KU Leuven), Alan Gilchrist (Rutgers University), Susana Martinez-Conde (State University of New York), and Dejan Todorovic (University of Belgrade)—with quite different backgrounds, mentors and approaches to the study of perception to debate and answer questions from the chair and from the audience.

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