Visual perceptual learning of task-irrelevant feature of the stimulus: preliminary results

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Human and nonhuman animal brains are able to adapt rapidly and continually to the surrounding environment, also by becoming increasingly sensitive to important and frequently encountered stimuli. This process - known as perceptual learning (PL) - is considered a manifestation of neural plasticity [1]. In the visual domain, PL can lead to permanently improved performance in the adult neural system [2]. Focused attention, awareness, and task-relevance were thought to be necessary for PL [3,4]: e.g., the ability of participants to discriminate line orientation does not improve when participants attend to the brightness rather than orientation of the line [3]. In other words, a *Feature of the Stimulus* (FoS) on which participants perform a task is learned, while a task-irrelevant FoS is not learned. This view has been challenged by the discovery of task-irrelevant PL: Watanabe *et al.* showed that PL can occur for unattended, subthreshold, and task-irrelevant stimuli [5,6]. However, in the latter studies the relevant stimulus features were unconscious whereas this was not the case in the former studies. Potentially, task-irrelevant PL needs subthreshold stimuli [7,8]. Here, we tried to reconcile this question. Our experiment lasted 8 days and it was divided into 3 main stages: pre-test (day 1), training (from day 2 to day 7) and post-test (day 8). During pre- and post-test participants performed a 3-dot Vernier task (i.e., judging whether the middle dot is offset to the left or to the right of the imaginary vertical line that connects the outer dots) and a 3-dot bisection task (i.e. judging whether the middle dot is closer to the upper or to the lower dot). During training participants performed a luminance discrimination task on the same 3-dot stimulus. The task-irrelevant FoS manipulated during training was the position of the middle dot, which could be left/right offset of an amount below participants' discrimination threshold measured during pre-test (Experimental Group), or aligned with the outer dots (Control Group). This type of training was designed under the assumption that: (1) the prolonged exposure to the subthreshold left/right offset (Experimental Group) might improve performance in the 3-dot Vernier task and not in the 3-dot bisection task; (2) the exposure to no offset (Control Group) might have no effect on performance improvement in both tasks, because no offset is presented during training. In the Experimental Group, the results have shown a performance improvement in the 3-dot Vernier task (performance improvement between pre- and post-test - paired one sample tTest: p = 0.001), but not in the 3-dot bisection task (paired one sample tTest: p = 0.192). In the Control Group, the discrimination threshold did not change between pre- and post-test in the 3-dot Vernier task (paired one sample tTest: p = 0.984). Unexpectedly, we found in the control group a performance improvement in the 3-dot bisection task (paired one sample tTest: p = 0.024), despite no up/down offset was presented during the training stage. One way to explain this result is to hypothesize that other factors might have produced an "illusory up/down offset", like the difference in luminance between the dots during the training stage. The difference in luminance between the 3 dots might have produced a condition in which

the middle dot was grouped with the upper or the lower dot, and therefore perceived closer to one of the outer dots. However, when we tested this hypothesis in a second experiment (i.e., we tested participants in a zero offset bisection task using a 3-dot stimulus with luminance differences), the pattern of data was congruent with an equidistant perceived position of the middle dot from the outer dots. Further research is needed, but our preliminary results suggest that PL can occur as a result of mere exposure to a subthreshold and task-irrelevant FoS. The present findings add new evidence in support of task-irrelevant PL, which seems to occur not only when two different stimuli are used during test and training as in [5], but also when the same stimulus is used in both stages.

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