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Editorial

Color and Space in Perception and Art

Color and space as dimensions of the phenomenal experience are deeply co-dependent with each other and the same can be said for pictorial arts and visual sciences. The motivation behind this special issue was to stimulate reflection regarding the multiple ways in which space, color, perception, and art in all their possible combinations can be studied scientifically.

Space is the medium in which objects are segmented and become visible, while color, also understood as a stroke—a sign that interrupts the homogeneity of the background—is what gives space its shape. When we look around us, the surrounding visual spaces always have color: they can take on a shape and become figural, occupying a position more or less distant from us; they can be partially occluded by other shapes and oriented in many different ways; they can also aggregate or segregate, forming perceptually organized units. The "spaces" thus understood constitute a fundamental part of our phenomenal experience. The rules that determine the segmentation of space in sensory experience have been systematically studied by perceptual psychologists, in particular, by those with a Gestalt orientation. The Danish psychologist Edgard Rubin (1921) was amongst the first to ask himself the problem of what constitutes a phenomenal object, and through systematic studies he identified the factors determining the way in which a figure emerges from the background. Only a few years later, Max Wertheimer (1923), considered the founding father of Gestalt Psychology, introduced the laws of organization in perceptual forms, a series of laws that give rise to the structured and organized phenomenal experience of the world. For example, based on the principle of similarity, other things being equal, objects of similar color will tend to form a perceptual group, just as, based on the principle of spatial proximity, objects close to each other will be experienced as belonging to a perceptual whole.

The principles of perceptual organization are intimately tied to both production and experience of art. In this regard, what Kanizsa writes in Seeing and Thinking (1991) in the paragraph entitled "Experimental phenomenology and pictorial representation" is significant. He states that "…those who draw, besides the mastery of techniques, possesses clear knowledge of the rules according to which the visual system processes the information present in the light. So much so that interpreting pictorial images is a natural ability that does not need to be learned, whereas the ability to produce them does not come naturally and must be formally learned." Kanizsa states that painters grasp how to depict visual objects, scenes, and materials without formal knowledge of visual perception. He

goes on to say that "the perceptual knowledge that is essential in this respect is not concerned with *'pictorial perception per se'* but with visual perception in general the painters strive to discover means by which they can represent visual reality, but, at the same time, they are also investigating the way visual perception works. Each technical discovery is also a contribution to the knowledge of the way the visual system works. Experimental phenomenology and painting complement each other and, instead of being contradictory to each other, they serve as each other's testing ground."

The researchers invited to contribute to this special issue were given the opportunity to interpret the proposed theme of color and space in perception and art in a personal way. To ensure their freedom of interpretation of the proposed theme, we have intentionally avoided requiring any further elaboration and specification from the authors, although this might entail the risk of excessive fragmentation of specific contributions. We have intentionally avoided any further elaboration and specification and to ensure the author's freedom of interpretation of the proposed theme, even at the risk of excessive fragmentation of specific contributions. In the end, the contributions in this thematic issue can be roughly grouped into two broad categories, those that interpreted the theme by placing more emphasis on the artistic component and those that placed more emphasis on the perceptual component. First, we will give a quick overview of the contributions that focused more on the artistic aspects of the topic, and then we will move to the contributions more centered on perception.

Both Wagemans, De Winter, and Linden (this issue) and Koenderink and van Dorn (this issue) highlight the inseparability of the spatial and chromatic structure in the visual arts. They both focus their contributions on how the painters use "essentially a flat surface covered with colours assembled in a certain order" (Denis, 1890, Art et Critique), to evoke a wide range of experiences in those who view the paintings, from the meaningful experiences of depicted objects, scenes, and events to the more aesthetic and abstract experiences of shape, space, and time, "before discursive thoughts kick in" (Koenderink and van Dorn, this issue).

Wagemans et al. explore the role of color and pattern in relation to space and time in two interdisciplinary case studies incorporating art history, contemporary art practices, and perceptual psychology. The first case study focuses on Frank Stella, an American painter, sculptor, and printmaker, noted for his work in the areas of minimalism and post-painterly abstraction, and the second focuses on Pieter Vermeersch, an emerging Belgian abstract painter, representing a contemporary trend to break the barriers between artistic disciplines.

Frank Stella's case study explores the perceptual effects of the fluorescent paints used in Stella's paintings. Though Stella himself was well-aware of these effects,

causing the painting to "flip-flop between flatness and illusion," and describe them as a "new way of presenting depth in painting which is more than 2D but less than 3D" (Fried, 1965, cited in Wagemans et al., this issue), they were mostly neglected or brushed aside as being of secondary importance for the total experience of his artworks. Wagemans et al. In this issue created a set of novel stimuli consisting of variations in the presence and placement of the fluorescent colors and investigated perceived spatial depth effects in artists, art historians, and laymen observers. Their findings demonstrate almost instantaneous perceptual impacts and strong interactions between color and pattern in terms of their spatial effects as well as the role of personal factors such as art expertise.

In addition, both Stella and Vermeersch artworks were investigated in a multi-method museum studies combining mobile eye-tracking, questionnaires, rating scales, and semi-structured interviews with participants with different levels of art backgrounds (laypersons, art historians, artists, art lovers) freely moving around the artworks. These studies provide invaluable insights regarding how the visual art explorations unfolds over time before "the full experience of the rich spatiotemporal characteristics emerges and deep questions about space and time might arise."

In their contribution "The Space of Color and the Color of Space," Koenderink and van Doorn masterfully argue that in the visual arts the spatial and chromatic structure of pictures cannot be separated from each other. Through the analysis of several artworks, they demonstrate the power of the phenomenological approach in providing an independent and worthwhile approach to the topic of color and space. Their analyses also highlight the gap between the phenomenological approach and generic vision science, and by drawing attention to this gap, the authors hope to tempt the art academia into formally addressing the same through a rich variety of insights and invitations belonging to the proper phenomenological perspective. Their analyses also highlight the gap between the phenomenological approach and generic vision science which they hope will be tempted to formally address a rich variety of insights and invitations from the phenomenological proper. Such a research program could lead to formal descriptions that would come closer to possible applications in the visual arts and design.

In his stimulating contribution, Soranzo explores the factors contributing to the ambiguous expression in the Lady with Disheveled Hair, a famous portrait attributed to Leonardo. Extending the previous work in which the spatial frequency analysis has been used to investigate the ambiguous expression of Mona Lisa (Livingstone, 2000; Kontsevich & Tyler, 2004) and La Bella Principessa (Soranzo & Newberry, 2015), Soranzo confirms that the Lady with Disheveled Hair exhibits an ambiguous expression, and that this ambiguity is similar to that one observed in the Mona Lisa and La Bella Principessa. Even though the

observed effect is consistent with the role of spatial frequency content in creating expression ambiguity, Soranzo highlights the uniqueness of Leonardo's use of sfumato and argues that the principle of perceptual belongingness as an important phenomenological aspect of Leonardo's work is needed to fully capture the extent of expression ambiguity created by Leonardo in the Lady with Disheveled Hair.

In their contribution, Ruta, Burleigh, and Pepperell focus on the depiction of space in medieval paintings, often regarded as "primitive" compared to the more spatially consistent optical projections prevalent since the discovery of linear perspective. In contrast to this slightly demeaning view of the use of space and scale in medieval paintings, Ruta et al. argue that medieval artists, far from acting in a naïve way in a pre-linear perspective world, used sophisticated techniques for directing the attention of the viewer to a particular figure in a painting and encouraging them to 'see' the depicted space from that figure's point of view. Specifically, Ruta et al. provide experimental evidence that medieval artists used relative scale to manipulate attention and viewer's empathy and suggest that the way artists have depicted space in paintings has an important bearing on how we imagine and perceive visual space.

Amongst the more perception-centered contributions, Galmonte et al. revisit the role of perceptual belongingness in lightness contrast. Inspired by Agostini and Proffitt's (1993) original findings, they use new displays in which the relative number of inducing and induced elements and their relative spatial position were manipulated. By doing so, they were able to verify how much of the simultaneous lightness contrast relates to perceptual belongingness. They found robust induction effects within perceptually segregated groups even when the number of inducing elements was reduced to one. The induced contrast affected all perceptually unified elements regardless of spatial position of inducing and induced elements.

In his contribution, Gilchrist discusses Gestalt approach as "the original mid-level" theory that rejects the notion and role of both raw sensations and cognitive inference in perception in general and in lightness perception in particular. He argues that the same grouping principles by which objects are segregated from the extended pattern of retinal stimulation, also function to segregate regions of uniform illumination. Lightness values can then be computed by comparing luminance values within each such framework of illumination, with no need for the mysterious and poorly defined concepts of cognitive inference such as "taking the illumination into account."

Todorovic provides systematic phenomenological evidence concerning a somewhat neglected aspect of amodal completion of visually occluded parts of objects, the impression of color of amodally completed surfaces. He investigates this aspect by creating a large number of displays with identical target figures embedded

in systematically varying contexts, to find out which contexts are favorable for amodal completion of color and which are not. He found that, generally, certain arrangements of T- and X-junctions support the impression of amodal completion of color. The same type of effects that are present in displays with geometric, abstract shapes, also appear in displays with recognizable and interpretable outlines.

Along similar lines, Actis-Grosso, Zavagno, and Daneyko investigate the combined role of motion of the occluding surface and lightness contrast in the perception of transparent visual phantoms. They find that the perception of anomalous transparency is perceived only in condition of low contrast and enhanced when the occluding surface is moving. Their results are explained in the theoretical framework of Gestalt theories in perception, suggesting that simultaneous lightness contrast acts as a segregation factor while motion acts as an integration factor.

In a pilot experiment, Parovel et al. explored an intriguing observation made by Zietz and Werner in the 1930s that sounds affect the appearance of color afterimages. Their findings generally support the observations reported by Werner (1934) and Zietz (1931), according to which the colors of the afterimages "disintegrate" at the hearing of a low pitch sound and "concentrate" for a high pitch sound. This relationship is particularly evident with the Yellow stimulus, where the perceived color intensity of its afterimage seems to have a faster negative change with a low pitch sound, and an increase in intensity and duration when perceived simultaneously with a high pitch sound. These data are consistent with the previously reported crossmodal correspondences between pitch/loudness in audition and lightness/brightness in vision.

Plutino, Sarti, Armellin, and Rizzi use models of human color perception to propose an alternative approach to address some longstanding issues concerning color and contrast restoration in film (both photography and cinema). While the common practices in this interdisciplinary domain are of course guided by the subjective criteria of the restorer or the film curator, Plutino et al. present color/tones enhancement based on the Retinex model of color appearance. They use spatial color algorithms to enhance the image tones based on both the pixel chromatic content and spatial arrangement, thus simulating the human visual system.

Finally, Verstegen addresses the issue of inherent expression in perception. He extends Arnheim's Gestalt theory that argues for the generic directness and immediateness of expressive qualities, which is differentiated with further acquaintance. Arnheim also shows how perception can never account for all the power of expressive seeing, and Verstegen explores how these issues are embedded in historical, philosophical, and social contexts.

In conclusion, we would like to express our heartfelt thanks to all the authors whose contributions made this special issue of Gestalt Theory possible. Special thanks also go to the referees who have shown extraordinary helpfulness. Finally, we would like to extend our special thanks to Fabrizio Sors and Mariusz Mela for their assiduous availability, for their great work, and for their heroic patience.

Tiziano Agostini and Branka Spehar

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