Monographic Section: Spatial Vision and Visual Space

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Introduction

The decision to devote this section to Spatial Vision and Visual Space was taken two years ago (October 2004) in Coimbra (Portugal), during the annual meeting of the ISP (International Society for Psychophysics). Three researchers who participated in this meeting (the guest editors) were talking about what is new in the field of visually perceived space. The result is this special section, in which we have attempted to provide researchers and students of psychology with a number of current studies on experimental topics in this field of increasing interest and importance.

Research on visual space has been conducted ever since the beginning of scientific psychology (e.g., von Helmholtz, 1866/1962; Hillebrand, 1902) and it is currently still one of the most active research areas (see, for example, Sedgwick, 1986; De Valois & De Valois, 1988; Indow, 2004; Koenderink, van Doorn, & Lappin, 2000; Morgan, 2003; Wagner, 2006). One of the reasons of such sustained interest can be expressed, simply as follows: if one knows the cognitive operations applied at a given location in physical space to produce a corresponding location in visual space, one could establish the mapping between these spaces. This knowledge could produce advances in various areas of human activities, such as: (a) in robotics, conceiving the visual analysis of the camera's image (PS representation) to produce computerized visual space; (b) in neurosciences, developing man-machine interfaces, allowing us to stimulate some neural circuits (e.g., by transcranial magnetic stimulation), eliciting spatial sensations.

To distinguish between *visual space* and *physical space*, authors usually think the former involves conscious experience while the latter does not. According to Wagner (2006), physical space is objectively defined and it is revealed to us by measuring devices such as rules and protractors. Conversely, visual space is revealed by psychophysical judgments of an observer and it is subjectively defined, that is, its properties may depend critically on certain aspects of the observer (location, viewing conditions, experimental tasks, and so on). The space we see around us is the end product of a long series of physical, physiological, and psychophysical processes (Indow, 2004). Indow and co-workers have described many features of visual space (Indow, 1991, 1997, 1999), claiming that it extends around the self in three directions (azimuth, elevation, and depth); it is veridical in peripersonal space, that is, its structure is isomorphic to that of physical space; it is dynamic, but stable, in spite of the fact that the perceived scene is captured through multiple glances (Carpenter, 1988), it tends to size and distance constancy; and, finally, both (physical space and visual space) have structures whose relationships can be described by a geometry. The visual space geometry derived from the use of psychophysical methods must be something like a computational theory that determines: (a) the inputs to the system (geometrical structure of physical space), (b) the outputs of this processing (visual space and its metric and properties), and (c) the transformation that the visual system applies to those inputs. There is no reason for a perfect correspondence between coordinates for locations in visual space and those in physical space. The magnitude of the difference found specifies the distortion in visual space relative to the structure of physical space.

In this special number of SJP, we present 13 articles related to space perception from three continents (Europe, Asia, and America) and, therefore, an important representation of universities and laboratories of the whole world. Taking into account their content, these articles could be divided into the following three groups: (a) early visual processing, (b) properties of perceived visual space, and (c) relations between space perception and other processes. Let us specify the aspects addressed in each of these three themes.

Early visual processing provides the foundation on which not only the structures that are more specifically related with space perception are based, but also the rest of vision. As is well known (see, for example, DeValois & DeValois, 1988), and, to a great extent, thanks to the influence of the classic works of Campbell and Robson (1968), during the last few decades, the scientific community related to the study of vision has worked on the basis of the notion that processes are carried out in the human retina which are describable by means of Fourier's transformation. Specifically, it was assumed that in the early phases of the visual system's functioning, the light variations contained in the stimulation projected on the retina are analyzed by means of a series of filters that are syntonized with spatial frequency, orientation, etc. This is the conceptual context in which the first two papers of this monographic volume are situated.

Maria Lúcia De Bustamante Simas and Natanael A. Dos Santos assessed the human visual system across responses to contrast for seven angular frequency filters and, thus, attempt to determine whether angular frequency filters exist in the V4 and IT areas of the brain. Interestingly, they discuss the implications of their findings for face recognition, particularly as concerns low angular frequencies.

Vicente Sierra-Vázquez and Ignacio Serrano-Pedraza, starting from the critical-band-masking (CBM) paradigm, attempt to account for the progressive change of threshold curves with the noise mask level and, at the same time, to estimate the bandwidth of visual filters. They measured contrast thresholds of horizontal sinusoidal gratings (0.25-8 c/deg) within a fixed Gaussian window and masked with one-dimensional, static, broadband white noise with each of five power density levels. By assuming a fixed-channel detection model, the best fit was obtained when the octave bandwidth of visual filters decreased as a function of peak spatial frequency.

The second group of articles focuses on the study of the main characteristics of spatial vision (its structure and degree of fit with physical space, the development of space perception with age), as well as the possible formal equivalence between two classic conceptual instruments of this area: Emmert's law and the size-distance invariance hypothesis.

Toshio Watanabe investigated the geometrical structures of depth, both indirectly perceived from photographic and stereoscopic spaces compared with directly observed objects in a photograph in order to express the mapping function between photographic and physical spaces in terms of the exponent of the power law. The results revealed that photographic space is more anisotropic than visual space (hyperbolic) whereas the geometrical structure of stereoscopic space is similar to that of visual space.

J. Antonio Aznar-Casanova, Elton H. Matsushima, Nilton Ribeiro-Filho, and José A. Da Silva compared the accuracy in exocentric distance estimates and examined the structure of visual space in three environments: near frontoparallel plane, a small virtual space, and a large three-dimensional outdoor open field. With this aim, they used two different psychophysical methods, namely, fitting data to the power law and multidimensional scaling (MDS).

José A. Da Silva, Elton H. Matsushima, J. Antonio Aznar-Casanova, and Nilton P. Ribeiro-Filho verified the constancy law in a natural environment by using very large physical distances. Children and adults, of ages that varied from 5 to 7, 7 to 9, 9 to 11, and 11 to 13 years, participated in an experiment performing distance estimates, and the psychophysical method of fractionation (bisection) was used. The authors analyzed the exponent of the power function relating physical distance to perceived distance, and the relative errors for each physical distance.

Mariko Imamura and Sachio Nakamizo attempted to verify empirically the formal equivalence between the Emmert's law and the size-distance invariance hypothesis. They measured both the perceived size and distance of afterimages and real objects with the same proximal size. The participants reproduced the apparent sizes of the afterimages and real objects using the reproduction method and estimated the apparent distances using the magnitude estimation method. Results showed that the function of apparent distance fitted a linear function, and the slopes for the afterimages and the real objects were equivalent.

The third and last group of articles focuses on the relations between spatial perception and other areas of cognition, as it is unnecessary to remind readers that spatial vision does not comprise a discrete area of human cognition but instead is related to many other aspects of cognition. This relation is bidirectional, so that spatial perception influences and is influenced by other processes. Among the processes considered herein are included color perception, memory, movement, and action control.

The paper of Julio Lillo and Humberto Moreira is a clear example of how spatial perception can influence another psychological process, in this case, color perception. More specifically, the authors show how the conceptions of the anchoring theory (the notion that the perceived spatial planes determine the perception of lightness, see Gilchrist et al., 1999) can be extended to explain color perception also and, therefore, how the same stimulation can produce the perception of different colors as a function of the framework in which it is perceived.

Alessandra Ackel Rodrigues and Susi Lippi Marques evaluated the accuracy of mental representations and the strategies adopted to acquire and retain visuo-spatial information of a configuration as a function of two types of instructions. They found that, under intentional instructions, judgments seemed to be based on strategies related to the position of the stimulus, whereas judgments under incidental instructions were based on strategies related to the name of the stimulus.

Harald Frenz and Markus Lappe present an investigation in the fields of the *movement perception* / *distance perception* interaction, discovered in a previous work (2005). Specifically, these authors noted that human observers can obtain information about the distance between objects from the optic flow, although with a high degree of underestimation. The data provided in this monographic volume led the authors to conclude that this underestimation cannot be explained by the characteristics of perception in static environments.

The last articles in this monographic volume can be considered a series, as they all focus on the same topic: to determine whether perceived distance to a target can be influenced by the energy expenditure associated with an action and they provide an exciting example of scientific debate. The series starts with an experimental work in which Jeffrey J. Hutchison and Jack M. Loomis attempt to replicate, with negative results, the results obtained by Dennis Proffitt, Jeanine Stefanucci, Tom Banton, and William Epstein (2003). These latter authors expound, in the second paper of the series, their comments on the failed result of Hutchison and Loomis, thus initiating a debate that continues in the next two papers of the series.

The articles of this monographic volume clearly reveal that interest in the study of spatial perception is currently as strong as in the past and, obviously, it produces a large variety of complementary approaches. Each article of this special section has been greatly improved by the suggestions of the anonymous reviewers. Undoubtedly, their hard work improved the clarity, accuracy, and rigor of all the articles and we thank them for their helpful efforts.

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