Visual Coding

INTRODUCTION

This feature issue of JOSA A commemorates the life and career of Russell L. De Valois, who passed away following a car accident in September, 2003. De Valois is widely recognized as one of the most important and influential vision scientists of the 20th century. Early in his career he pioneered the study of the neural mechanisms of human color vision by measuring the color responses of cells in the primate lateral geniculate nucleus (LGN), the thalamic relay between the retina and visual cortex. His work revealed that individual neurons received antagonistic inputs from different classes of cone photoreceptors and consequently gave excitatory responses to some wavelengths while producing inhibitory responses to others (as would have been expected from Ewald Hering's observations of color appearance). This result provided a clear physiological foundation for the theory of color opponency, ending more than a century of controversy at the center of color science, while at the same time exposing many new questions about the nature of color coding. De Valois' discovery of the mechanism of opponency within single postreceptoral cells remains a cornerstone of modern theories of human color vision. A classic account of this work—and one that is still widely cited—was published in JOSA in 1966.[1] According to his coauthor Gerald Jacobs, De Valois chose to publish in JOSA rather than a physiology journal because he wanted to bring the work to the attention of both neuroscientists and psychologists. The paper compares properties of human color perception to the population responses of color opponent cells in the LGN. As such, it represents one of the earliest examples of an attempt to explicitly define the neural underpinnings of human perception, a goal that is now at the heart of the emerging field of cognitive neuroscience. De Valois was also the first person ever to recognize and emphasize the importance of using an animal model that matches the behavior of humans if one's ultimate goal is to explain the behavior of human observers. In a series of important psychophysical studies, he complemented his physiological work by showing that behaviorally the color vision of macaques and humans is very similar.

In the 1970s De Valois began a second major line of inquiry by exploring how spatial information is represented in primary visual cortex. These studies played a central role in characterizing the stimulus selectivity of cortical cells. They remain highly influential in showing that the cells are more accurately described as localized, spatial-frequency-selective filters than as simple bar or edge detectors. In a further series of experiments, he used functional anatomical techniques to reveal how cells with different response properties are organized within the cortex. Much of this work and its theoretical implications were laid out in the classic book he wrote with Karen De Valois in 1988.[2] The book, part of the Oxford Psychology Series, is particularly notable for synthesizing research on spatial vision from both behavioral and physiological perspectives and thus again illustrates the interest throughout his career in accounting for perception in terms of the underlying behavior of neurons.

In more recent work he returned to analyses of the mechanisms of color vision. His early recordings showed that cells in the LGN do not combine the cone signals in the exact ways predicted by measures of color appearance. This suggests that still further transformations of color information occur in the cortex, and the nature of these transformations is currently one of the most actively pursued questions in color science. In his own work on this question, he combined theoretical models with empirical measurements from both psychophysics and single-cell recording to once again help reveal the neural bases of color. In his final work he also pursued a novel theory of motion encoding in visual cortex.

De Valois was born in 1926 in Ames, Iowa, but grew up in South India, where his parents were missionaries. He returned to the U.S. to attend Oberlin College and then the University of Michigan, where he received his Ph.D. in Physiological Psychology in 1948. After a period on the faculty of the psychology department at Indiana University, he moved in 1968 to the University of California, Berkeley, where he was a professor of psychology, neuroscience, vision science and optometry. De Valois was a member of the National Academy of Sciences and received some of the most prestigious awards offered by a diverse array of scientific societies, including the Warren Medal of the Society of Experimental Psychologists, the Distinguished Scientific Contribution Award of the American Psychological Association, and the Prentice Medal of the American Academy of Optometry. He was a Fellow of the Society of Experimental Psychologists, a Fulbright Fellow, a William James Fellow of the American Psychological Society, and a Fellow of the American Association for the Advancement of Science.

It is fitting that an issue commemorating De Valois should appear in JOSA A. De Valois was a Fellow of the Optical Society of America and in 1988 received the Society's Tillyer Medal for distinguished work in vision science. The OSA Vision and Color Division had selected De Valois to deliver the Robert M. Boynton Lecture at the Fall Vision Meeting in Tucson in October 2003, where two symposia were organized in his honor. Plans for the feature grew out of these symposia, and many of the speakers there have contributed papers to this issue, along with many other former students and colleagues.

While designed as a tribute focused on topics related to De Valois' work, we hope that the papers in the issue will also serve to provide a timely snapshot of some of the critical questions at the center of current research on the early stages of coding in the visual system and how both new and established approaches are being used to answer them. Despite five decades of intensive study since De Valois' initial recordings, many fundamental mysteries remain about the mechanisms of color and form percep-

Fig. 1. Russell L. De Valois (1926–2003).

tion. An invited review by Peter Lennie and J. Anthony Movshon evaluates our present understanding of the neural bases of color and form processing in early visual pathways. The remaining papers span a variety of topics on the encoding of color, spatial, and temporal information in the visual system. This broad range appropriately reflects De Valois' own broad interests; what unites and connects the papers is the common goal of revealing the processes shaping visual perception and a common recognition of how De Valois' contributions helped shape this pursuit.

We are very grateful to Stephen Burns, the Editor of JOSA A, for first suggesting this feature issue and to both Steve and Karen De Valois for their advice and support. Our thanks also to the JOSA A staff for their help and patience. We would also like to express our sincere thanks to the contributors, and especially to Peter Lennie and Tony Movshon for their invited review. Finally and foremost, on behalf of many we thank Russ De Valois for inspiring and guiding our own work on the mechanisms of visual coding.

REFERENCES

1. De Valois *et al.*, "Analysis of response patterns of LGN cells," J. Opt. Soc. Am. **56**, 966–977 (1966).
2. R. L. De Valois and K. De Valois, *Spatial Vision* (Oxford U. Press, 1988).

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