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Sheldon M. Ebenholtz
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Oculomotor Systems and Perception

Understanding visual experience has long challenged the best of human minds, from the Ancient Greeks' interest in optics to the study of visual perception by contemporary psychologists and neuroscientists. Today's scientific study of perception seeks to understand the nature of our experience in terms of the underlying mechanisms by which it occurs.

This text is the first to emphasize the role of oculomotor systems in perception. Oculomotor systems that regulate eye movements play an important role in accounting for certain qualities of visual experience. These systems are implicated in a wide array of perceptual topics, from apparent size, depth, and distance to apparent slant and vertical orientation. The text begins with a brief introduction to the basic characteristics of such oculomotor systems as those controlling vergence, pursuit, the vestibulo-ocular response, and saccadic eye movements. Also introduced are fundamental concepts in physiological optics. Next explored are mechanisms of perception, with a particular focus on eye movements, and the remarkably diverse implications of oculomotor research, which extend to motion sickness and life in space orbit. Insights into dysfunctional vision are offered as well.

Oculomotor Systems and Perception complements standard texts on visual perception, yet may be read independently by those with a modest background in vision science.

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This work is dedicated to my dear wife, Jean, whose energy and enthusiasm never once veered toward entropy, and for whose support I shall always be grateful; and to my remarkable son, Keith, who taught me fathering and the law.

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I think a teacher's role should be limited to clearly showing his pupil the goal that a science sets itself and to pointing out all possible means at his disposal for reaching it. But a teacher should then leave his pupil free to move about in his own way and, according to his own nature, to reach his goal, only coming to his aid if he sees that he is going astray. I believe, in a word, that the true scientific method confines the mind without suffocating it, leaves it as far as possible face to face with itself, and guides it, while respecting the creative originality and the spontaneity which are its most precious qualities.

—Claude Bernard (1865/1957)
*An Introduction to the Study
of Experimental Medicine*

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Foreword

This work is intended to complement a standard text on visual perception with knowledge of the essential features of oculomotor systems and their bearing on visual perception. These issues, however, have useful implications for students in a number of disciplines such as psychology, biomedical engineering, human factors, optometry, ophthalmology, and artificial intelligence. Accordingly, the work is structured to be complete in itself and may be read on its own. Students not trained in optics or the vision-health disciplines also may find useful the Appendix on common visual anomalies as well as Chapter 2 on central concepts of physiological optics.

I have tried, throughout, to be mindful of historical and philosophy of science issues so that the myriad facts associated with the intersection of perception and eye movement systems may derive extended meaning by being seen in an appropriately broad context. My hope, of course, is that in so doing, reading the text proves to be both a useful and an enjoyable intellectual exercise.

S. M. E.
Goodyear, AZ

Preface

The theme of this book developed gradually as my teaching of perception evolved in courses and seminars, first at Connecticut College, in New London, and later at that remarkable research institution, the University of Wisconsin, Madison. My belief in the importance of the search for underlying mechanism in the explication of psychological phenomena, however, began still earlier at the New School for Social Research with my teachers Irvin Rock, Hans Wallach, Solomon Asch, and Mary Henle, and my peer group, Bill Epstein, Lloyd Kaufman, Martin Lindauer, and Carl Zuckerman. It was a wonderfully stimulating zeitgeist where phenomenology met the firm constraints of empiricism and where the democratic ethos worked its way into the classrooms so that challenges to current ideology were expected and encouraged.

Hopefully this attitude was not lost on my past graduate students, many of whom, like Judith Callan, Paul Dubois, S. K. Fisher, Ken Paap, and Wayne Shebilske, contributed to the empirical corpus of evidence that has helped to solidify the view that oculomotor systems underlie various aspects of perception, and thereby provide a theoretical alternative or at least a necessary complement to cognitive and computational explanations. And to all of my former students, including Tim Babler, Terry Benzschawel, Karl Citek, Changmin Duan, Gerry Glaser, Gordon Redding, Martin Steinbach, Mike Streibel, and John Utrie, who have distinguished themselves in all manner of endeavor, I wish to express my genuine appreciation for their curiosity, and above all for their commitment to learn the ways of truth seeking in science.

To Karl Citek, S. K. Fisher, Gerry Glaser, Wayne Shebilske, and Bob Welch, I am especially grateful for their helpful comments on various portions of this work.

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A note of appreciation also must be expressed in connection with our scientific agencies and foundations, NIH, NIMH, and NSF. I am grateful not just for having survived many of their peer reviews, but for the positive role these government agencies have played in stimulating the commerce of science by providing the palpable means by which ideas may enter the public domain initially as testable hypotheses and ultimately providing the facts of our discipline.

Special mention is reserved for my colleagues Mal Cohen, Dick Held, Bob Kennedy, Len Matin, and Bob Welch, who over the years have provided both collegiality and much insight. Always remarkably stimulating and productive were my several extended visits to Mal's lab at the NASA–Ames Research Center, and to Bob Kennedy's lab in Orlando and to his utterly unique Pensacola–Ariola conferences in Pensacola Beach. A debt of gratitude also is owed to my colleagues and friends Marcia Ozier and Bruce Earhard, whose nomination led to my appointment as a Killam Senior Fellow during 1971–1972 at Dalhousie University in Nova Scotia. The idea that a change in the oculomotor vergence resting level was the mechanism underlying so-called distance adaptation was germinated during that remarkable year.

I am also pleased to take the opportunity of this public forum to thank the many colleagues who, over the years, shared their enthusiasm for new contributions to knowledge at various conferences, and at meetings of the Psychonomic Society and the Association for Research in Vision and Ophthalmology. Many of them grew into an extended family that nurtured mutual respect and valued scientific accomplishment. Finally, I offer a special note of appreciation, for the many opportunities to share time with Herschel and Eileen Leibowitz, and for their enduring legacy of civility and creativity.