EYE MOVEMENTS AND THE HIGHER PSYCHOLOGICAL FUNCTIONS

EYE MOVEMENTS AND THE HIGHER PSYCHOLOGICAL FUNCTIONS

edited by

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In any scientific endeavor,
You must have men who are clever
And men who are nice
As well, like John Weisz.
Without whose support and encouragement
it would have been impossible
to put this book together.

JOHN W. SENDERS

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Preface

This volume represents the edited proceedings of the second symposium on eye movements and behavior sponsored by the U. S. Army Human Engineering Laboratory. The conference was held at the Naval Postgraduate School in Monterey, California on February 6–9, 1977.

This volume is intended to serve as a complementary volume to R. A. Monty and J. W. Senders (Eds.), *Eye Movements and Psychological Processes,* published by Lawrence Erlbaum Associates (1976), rather than as a revision or update of it.

We wish to thank the U. S. Army Human Engineering Laboratory for sponsoring the symposium. In particular, we once again wish to express our deep appreciation to Dr. John D. Weisz, Director of the Human Engineering Laboratory, for his continued encouragement and support. It is to him that we have dedicated this volume.

We are also deeply indebted to Dr. Francis C. Volkmann for organizing and chairing the first session, and to the staff of the Naval Post Graduate School, especially Ms. Ruth Guthrie and Dr. J. Kenneth Arima, who made this one of the smoothest running symposia we have ever witnessed. We are grateful to Ms. Judy Weishampel for keeping the work of the first editor on an even keel and for maintaining liaison among us. Once again, special thanks go to B. Diane Eberly (now operating under the alias of Mrs. B. Diane Barnette), who since the last volume has advanced from the role of secretary to mathematics aide. She, nevertheless, was responsible for handling a myriad of details surrounding planning of the symposium and the resulting publication.

JOHN W. SENDERS
DENNIS F. FISHER
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Introduction

This volume reflects the proceedings of a conference held in February 1977 at the Naval Postgraduate School at Monterey, California, and is the natural successor to an earlier volume of the proceedings of a conference in Princeton, New Jersey entitled *Eye Movements and Psychological Processes* (Monty & Senders, 1976). The earlier conference and book were organized with what we, as organizers and editors, hoped was a logical sequence, beginning with a common base of nomenclature, information, and understanding of the underlying mechanisms of oculomotor control, then progressing through a series of topics relating eye movements to processes that, at least conceptually, advanced from simple to more complex.

To quote from the preface of the earlier volume: "Our purpose was to bring together investigators representing different theoretical positions and methodological approaches to present their recent findings, to debate the theoretical points of view, and to identify and discuss the major research problems." That is, of course, an adequate statement of the purposes of the second conference as well. Parts of the first conference were devoted to search and scanning, to reading, and (Part 7) to eye movements and higher mental processes. The second conference was aimed at providing a greater opportunity for discussing these "higher mental processes." In view of the fact that there were many people at the second conference who had not attended the first or who may not have read the first proceedings, we thought it necessary to have one half day devoted to reviewing topics presented during two whole days at the first meeting.

Part I of this volume is devoted to an intensive review of the underlying processes and psychological functions of eye movements. It includes discussions of the relationships of cortical and subcortical visual areas to eye movements and visual processing associated with them; information about the position of the eye in the head and the perception of visual space; saccades

and visual functioning; and masking. These four papers were essentially didactic in nature. All persons working in the area of eye movements must be aware of the status of knowledge relating to those topics in order to be able to design experiments appropriately and to interpret results accurately. Another session was devoted to methodology and models in order to update information since the earlier conference and published proceedings.

Beginning with the third session, questions of the effects of tasks on eye movements and the effects of eye movements on tasks were addressed. Here, out of necessity, higher mental processes include dealing with particular kinds of application: reading, watching television, flying aircraft, looking for objects, counting things, and the like. Although not all papers presented at the meeting are included in this volume, all were informative and made a contribution to the participants' understanding of the complex relationships between eye movements and behavior. Obviously, behavior and eye movements are the variables which could be compared and correlated. For most of the participants, of course, the behavior was then interpreted in terms of "higher mental processes." It seems appropriate once again to quote from the earlier volume:

> Now we are concerned with the question of what people do with eye movements.
>
> It is an important question. We spend our time, as Steinman has pointed out, sometimes voluntarily selecting places in the visual field to look at, and at other times allowing a process to go on that one is nearly unaware of, in which the eye successively fixates different parts of an apparently nicely stabilized visual field. From these "looks" we continually reconstruct, renew, and refresh some internal map of what is "out there."
>
> There has been continuing study over the last 25 years of how people look at dynamical things, for example, dials on an aircraft instruments panel [when one is flying], or faces if one is engaged in conversation or lecturing. They change when one is not looking at them; sometimes they change while one is looking at them. Certain rules can be established relating the content of dynamic displays to the distribution of visual attention across these displays.
>
> Another aspect of the visual world is the static aspect. We look at a landscape and things mostly stay where they are. Trees don't get up and walk around; paintings and cast-iron eagles, in particular, tend to stay exactly as they have been. Yet the eye does come back from time to time to look once again at a piece of the visual field which it has just recently visited and from which it has departed. A very interesting problem is that of the relationship between the content and structure of a [static] visual field, and the way in which one distributes visual attention over that field.

And further:

> The possibility of keeping physical records as aids to memory by the use of spatially organized materials must have occurred very early to ancient man. The

particular ways in which these materials are specially organized, however, has varied through all possible arrangements. Languages may be written from left to right or right to left and top to bottom or bottom to top, in vertical lines and in horizontal lines, and there is no particular reason to assume that any one way of organizing material is better than any other. However, some serial arrangement in one sense or another must be imposed if the written material is to be interpreted correctly. The degree, however, to which positional structure within sentences is important depends upon the degree to which the language is inflected. English is a highly positional language in which the meanings of sentences are determined both by the words within the sentence and by the positions they hold relative to the other words. This is not necessarily true of all languages.

Even more interesting, of course, is the higher mental process involved in the extraction of meaning from written language. Much of the work in this area is related to the hypothetical internal representation of the material that is read and the relationship of that material to the eye movements made during the reading as well as subsequent to it, as was the case for some of the chapters in the earlier volume. Virtually all the chapters beyond the first set in this volume imply that there is "a strong direct link between the way in which the eye moves and the fact of its moving at all, and the kind of perceptual and memory structure which is being used by the observer to store and organize information."

Where it has made a contribution to the reader's understanding of the content of a paper, we have preserved the discussion with only a few deletions. In some cases, the points raised during the discussions were as important to those present as the paper itself. Although all the papers presented at this meeting had been prepared in advance, unlike those of the first meeting, we have attempted to preserve, through the discussions, the spirit of intense involvement and serious give-and-take that pervaded the whole meeting. We hope that the chapters and comments presented here will encourage subsequent research efforts using eye movements, so that the state of the art and understanding of the processes are continually advanced.

* * * * *

WARREN H. TEICHNER, 1921-1978

Just before this book went to press, the editors learned of the death of Warren H. Teichner, who was a participant in the symposium and a contributor to this volume. We were saddened to lose a good friend and colleague who had contributed so much to Experimental and Engineering Psychology.

Contents

Part I

BASIC PROCESSES

I.1

The Visual Substrate of Eye Movements

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The visual system is continually bombarded with stimuli. Not all of these stimuli are of equal significance; some are ignored whereas others elicit a shift of attention and an eye movement. The visual processing preceding such a movement requires analysis of the visual stimulus in terms of three questions: where is it, what is it, and is it behaviorally significant? Recent work has attempted to analyze several cortical and subcortical visual areas in order to determine their contributions to the visual processing preceding eye movements. We will discuss these questions with reference to the superior colliculus, the striate cortex (area 17), the posterior parietal cortex (area 7), and the frontal visual area (area 8, "the frontal eye fields") of the rhesus monkey.

SUPERIOR COLLICULUS

The cells in the superficial grey and optic layers of the monkey superior colliculus respond to visual stimuli (Cynader & Berman, 1972; Goldberg & Wurtz, 1972a; Humphrey, 1968; Schiller & Koerner, 1971). Unlike cells in striate cortex (Hubel & Wiesel, 1968; Wurtz, 1969a), visual cells in the superior colliculus are not sensitive to the shape or orientation of stimuli. Instead, these respond to the onset of small spots of light within their receptive field, and also to stimuli moving over a wide range of directions and stimulus velocities (Goldberg & Wurtz, 1972a) as shown in Fig. 1. They have large receptive fields, and receptive field size increases with depth in the colliculus (Goldberg & Wurtz, 1972a; Humphrey, 1968). It is highly unlikely that cells in the colliculus can provide much qualitative information about visual stimuli, although ensembles of collicular neurons