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The Neuropsychology of Attention

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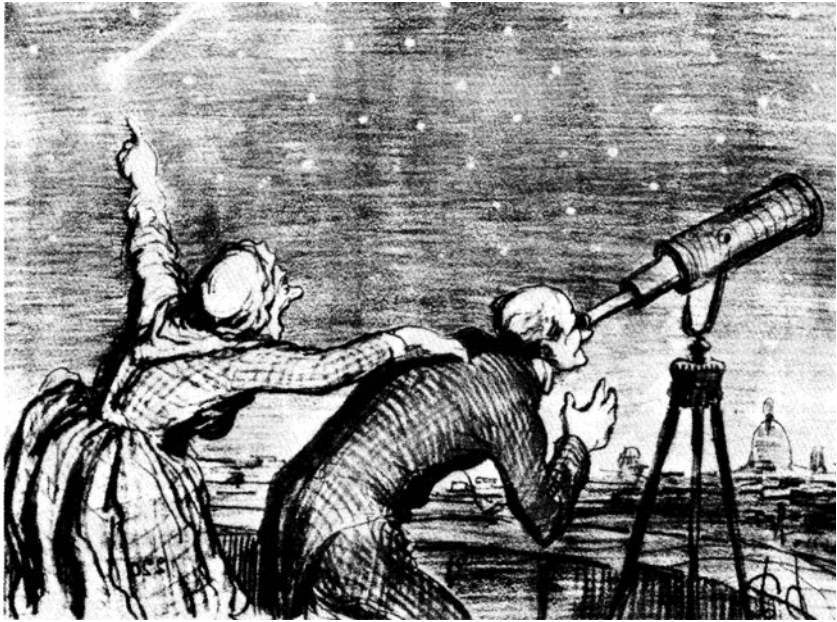
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An unfortunate case of “hemispatial” inattention.

*(“M. Babinet prévenu par sa portière de la visite de la comète.” From *Le Charivari*, 1858, by Honoré Daumier. Babcock Bequest; Courtesy of Museum of Fine Arts, Boston, Massachusetts.)*

Foreword

As you read this, you are probably unaware of how your left foot feels in your shoe. Although your brain was receiving sensory input from this foot, you were not aware of your foot because you were reading and not attending to it. However, this discussion led you to move your attention to your left foot and to become aware of it. When I was a medical student, I saw a patient who was unaware of both the left side of his body and the left side of his environment. Unlike people in normal health, who when instructed can become aware of the left side of the body, this patient could not be made aware of his left arm or the left side of his environment. The patient's defect was so profound that despite being hungry he was unaware of food on the left side of his tray and did not recognize that his left arm belonged to him. This left-sided body and spatial unawareness could not be accounted for by a primary sensory defect.

Although I knew that this man suffered from a large right-hemisphere stroke, I did not know the brain mechanisms that accounted for this profound example of unawareness. It was not until I had almost completed my neurology training in 1969 that I was able to return to this problem. At that time, most neuropsychological research was directed at understanding the language disorders associated with brain disease. There was almost no research on the neuropsychology of awareness and unawareness. Our early research reports on the neuroanatomical basis of neglect were met with open hostility. Not only did the proposal we submitted to the National Institutes of Health go unfunded, but the reviewer stated that if we ever discovered any new and interesting findings, it would certainly be serendipitous. Fortunately, about the same time that we started our research on attentional disorders, other laboratories were also initiating research in this area. For example, in 1970 Kinsbourne explained his hyperactive hemisphere bias hypothesis of neglect to the American Neurological Association.

Since that time, the number of excellent research articles dealing with neglect, awareness, and inattention has increased geometrically. Whereas in the 1960s there were only three groups conducting research on neglect and related disorders, today there are productive research groups throughout the United States. Almost every western European country has a research group performing research in this area and several countries such as England and Italy have multiple groups. In the past several years, investigators in Asian countries have also initiated research in this area and have published many excellent papers.

Currently, there are so many excellent research articles being published that, despite being an avid reader, I have difficulty keeping abreast of all of the advances related to the

neuropsychology of attention. That is why I was so pleased that Dr. Cohen decided to write a book that summarized many of these advances. Dr. Cohen's book does more than summarize advances in the neuropsychology of attention. A summary would only describe the pieces of the puzzle; this book helps to put the puzzle together. Although the entire puzzle remains to be solved, only when the pieces are put together can one see what areas remain to be explored. Therefore, this book is more than a summary: it is a synthesis.

There are many methods by which one may study attention and attentional disorders. Physiologists have studied attention using single-cell recording, evoked potentials, and most recently neurophysiological imaging; cognitive psychologists have developed information processing models; and neuropsychologists and behavioral neurologists have attempted to fractionate behavior, test brain processing models, and discover the brain structures that support these modular functions. Cohen and his coauthors do a superb job of integrating the cognitive, physiological, and anatomical approaches to attention and attentional disorders.

The Neuropsychology of Attention is rather unique in its emphasis, as it is one of the few books in the field of neuropsychology that deals exclusively with the topic of attention. Not only does the book consider neuropsychological findings regarding the mechanisms underlying attention; it frames current knowledge regarding the neuropsychology of attention in the context of theoretical and empirical information regarding attention derived from other scientific disciplines. The book concludes with a consideration of neurobehavioral constraints on attention imposed by temporal and spatial dynamics, information processing speed, memory-attentional interactions, and the characteristics of neural systems. Cohen develops a unified theoretical framework and a comprehensive taxonomy for the neuropsychological analysis of attention that is a synthesis of this knowledge. This synthesis enables readers to obtain a better understanding of what has been accomplished in the field of attention and attentional disorders and allows readers to see what must be done in the future.

Kenneth M. Heilman

Gainesville, Florida

Preface

At the beginning of this project, I was struck by several paradoxes regarding the study of attentional phenomena within neuropsychology. On one hand, the concept of attention has been central to the historical development of psychology. Attention was considered a fundamental and inescapable aspect of human experience by Wilhelm Wundt, William James, and the other founders of modern psychology. On the other hand, for much of the 20th century, psychologists tried desperately to avoid acknowledging the need for an attentional construct. Because attention has an intangible quality and cannot be specified as a unitary process, many behavioral scientists considered the construct of attention theoretically incoherent. Some of their concerns regarding the nature of attentional phenomena were clearly justified. It is also apparent, however, that explanations of behavior and cognition that fail to account for attentional phenomena cannot fully capture human experience.

Recently, there has been a shift in zeitgeist, and attention has received more favorable treatment within the cognitive neurosciences. Humans cannot handle an infinite amount of simultaneous information. Therefore, cognitive processes must exist that direct our focus to information that is important, and that permit the selection of stimuli and responses from the large universe of alternatives. Regardless of whether one advocates the existence of a discrete attentional process, it is necessary to account for the occurrence of those phenomena that we normally label as aspects of attention. Consideration of the mechanisms underlying the selection of information and the control of stimulus and response processes is critical if we hope to understand human cognitive experience.

The necessity of studying the mechanisms underlying attentional phenomena is particularly evident within neuropsychology. Patients with brain disorders frequently do not perform at optimal levels, even when task variables are held constant. They may fail to detect an object in the environment, even though it can be demonstrated that they have adequate perceptual capability. Reference to performance deficits stemming from attentional dysfunction is common in clinical neuropsychology, though historically, few systematic approaches have been developed for assessing attention. Recently, this situation has begun to change, as greater effort has been expended in both developing methodologies for evaluating attention and understanding the brain mechanisms underlying attentional control and selection. Yet there continues to be a lack of coherence among concepts, models, and theories of attention, or the methodological approaches to the study of attentional phenomena.

This text attempts to provide a more systematic and integrated theoretical framework for the neuropsychology of attention. To accomplish this goal, it was first necessary to consider a large quantity of theoretical and empirical information regarding the phenomenology of attention for the many disciplines within psychology and the neurosciences. Because historically there has been relatively little exchange among these different disciplines, it was important to establish the features common to all approaches to the study of attention. Unless there is consistency in the constructs used to characterize attention, a scientific analysis of attentional phenomena is impossible. With the establishment of a coherent conceptual framework, it is more feasible to consider the neural mechanisms underlying attentional processes. Information regarding the cognitive, behavioral, and neural bases of attention can then be more systematically applied to neuropsychological studies of brain dysfunction.

With these goals in mind, this text provides a synthesis of theories, concepts, and experimental findings regarding the neuropsychology of attention. The book is divided into three parts. Part I reviews the basic concepts necessary to neuropsychological considerations of attention. Several broad domains of theoretical and experimental information of relevance to the study of attention are addressed: (1) information-processing models; (2) alternative nonsensory models; (3) behavioral theories of attention; and (4) psychophysiological and neurophysiological evidence regarding the nature and mechanisms of attention. There has been little previous integration of attentional concepts developed from these different domains, although this is not altogether surprising when one considers the different scientific and philosophical perspectives that each represents. An attempt is made to present the strengths and weaknesses of each of these approaches, and to develop a more unified conceptual framework regarding the cognitive, behavioral, and neural mechanisms of attention. At the end of Part I, a theoretical framework of attention is presented that is applied to subsequent discussions of the neuropsychology of attention.

In Part II, this theoretical attentional framework is considered with regard to neuropsychological disturbances of attention. Consideration of the effect of brain damage on attention provides an important means of assessing the role of particular neural structures in mediating attention. The discussion here is not meant to be an exhaustive review of all neuropsychological data pertaining to attentional dysfunction in neurological and psychiatric disorders. Instead, the reader is introduced to several different neuropsychological perspectives on attention. In the first two chapters, the neuroanatomical systems involved in attentional control are discussed with consideration of the effect of localized lesions. Because there are extensive experimental data from studies of animal behavior, these chapters consider both human and laboratory animal studies of attention. The two subsequent chapters of Part II discuss how specific neurological diseases and psychiatric disorders affect attention. This discussion is followed by a consideration of the neuropsychological assessment of attention; covering both neuropsychological and more traditional psychological methods of evaluating attentional dysfunction. Experimental methods developed from information-processing approaches are also described. The final chapter of Part II describes several important neuropsychological models of attention. These models are distinguished from those described in Part I in that they are derived largely from studies of the effects of lesions on human attention. At the end of this chapter, a comprehensive neuropsychological taxonomy of attention is proposed.

Attention is determined by the interactive influence of multiple neural systems in response to incoming information from the environment. Characterization of the neuro-behavioral bases of attention requires that the neural, behavioral, and physical parameters underlying attentional processes be specified. Part III departs from clinical neuropsychology to consider factors that must be examined if one hopes to specify the neuropsychologi-

cal parameters underlying attention. These factors place constraints on human attention. We begin with a discussion of the relationship among consciousness, self-awareness, and attention. We then consider structural constraints on attention, including (1) processing speed; (2) memory–attention interactions; (3) the temporal dynamics of attention; (4) the spatial representation of attention; and (5) constraints imposed by the characteristics of neural systems. These five structural factors influence the capacity of humans to perform attentional operations. We also discuss computational methods and their application to the study of attention. This chapter is not meant to be an exhaustive review of current neural computational theories; rather, it is a consideration of the utility of this approach for neuropsychology. These computational models provide a formal theoretical system for the analysis of specific theories of attention and provide a test for the attentional processes within a neuropsychological framework. In the final chapter, a theoretical synthesis of the cognitive, behavioral, and neural mechanisms underlying the phenomena of attention is provided, and our neuropsychological taxonomy of attention is reexamined in light of this synthesis.

In the past few years, we have witnessed explosive growth in the field of cognitive neuroscience, including an increased interest in the neural bases of attention. In fact, I have been impressed by the increased level of interest in the neuropsychology of attention, and by the efforts of many investigators to establish a clearer foundation for attentional research. In the future, we will undoubtedly see even greater cohesiveness of the concepts and methods used in the study of attention. I hope that this text will facilitate these efforts.

Ronald A. Cohen

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I also thank Michael Feuerstein who helped initiate this project and Eliot Werner who helped to make this book a reality. Special thanks go to Sue Woolford and the editorial staff at Plenum Publishing who brought the book to fruition.

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