COGNITION • THIRD EDITION

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About the Author

Stephen K. Reed is currently professor of psychology and a member of the Center for Research in Mathematics and Science Education at San Diego State University. He has also taught at Florida Atlantic University (1980–1988) and at Case Western Reserve University (1971–1980).

After receiving his B.S. in psychology from the University of Wisconsin in 1966 and his Ph.D. in psychology from the University of California, Los Angeles, in 1970, Dr. Reed worked as an N.I.H. postdoctoral fellow at the Laboratory of Experimental Psychology at the University of Sussex, Brighton, England.

His research on problem solving, carried out in part through grants from NIMH, the National Science Foundation, and the Air Force Office of Scientific Research, has been extensively published in numerous journals including *Memory and Cognition; The Journal of Experimental Psychology: Learning, Memory, and Cognition;* and *Cognition and Instruction.* He is the author of numerous articles and books, including *Psychological Processes in Pattern Recognition* (Academic Press, 1973).

Preface

The most exciting development in the field of cognitive psychology is not a particular theory or experimental finding but a general trend. Cognitive psychologists have demonstrated an increasing interest in studying complex, real-world tasks and are making significant progress in understanding how people perform on these tasks. I hope that one result of this trend will be that undergraduates discover the direct relevance of cognitive psychology to many of their daily activities. A course about cognition should be useful not only to psychology students but also to those who have selected other fields of study.

In this book I have attempted to place a greater emphasis on the application of cognitive psychology than is typically found in an undergraduate text. The study of reading, for example, is discussed in the chapters on pattern recognition, attention, language, and text comprehension. Efficient learning strategies are major topics in the chapters on long-term memory and visual imagery. The chapter on classroom problem solving shows how the study of problem solving is currently being extended to include the kinds of problems students encounter in their courses. The chapter on language discusses how the implications of sentences influence legal testimony and advertising, and the chapter on decision making includes a section on medical decision making. In order to help students relate the study of cognition to popular articles they are likely to read, I have included many magazine and newspaper clippings on such contemporary topics as measuring brain activity during dreaming and determining the value of a human life in order to justify life-saving decisions.

In presenting this material, I have attempted to avoid overwhelming students with more information than they need. The chapters are each about 25 pages long and include a summary. They cover a wide range of topics, and instructors should be able to expand on whatever topics interest them. The 14 chapters are divided into three parts: Information-Processing Stages, Representation and Organization of Knowledge, and Complex Cognitive

Skills. The first part consists of an introductory chapter followed by chapters on pattern recognition, attention, short-term memory, and long-term memory. The chapters describe what occurs during the different information-processing stages and how the stages interact. The second part contains chapters on levels of processing, visual images, categorization, and semantic organization. The first two chapters in this part describe qualitatively different memory codes, and the next two chapters discuss the organization of knowledge in long-term memory. The final part consists of chapters on language, comprehension and memory for text, problem solving, classroom problem solving, and decision making. The discussion of these complex cognitive skills is often related to ideas presented earlier in the book.

The organization of a book on cognition should reflect what we actually know about cognition. Research suggests that a hierarchy is a particularly effective way to organize knowledge (see Chapter 9). Recall is facilitated when information is partitioned into categories, which are further partitioned into smaller categories. Hierarchical organization seems to be particularly effective when the number of partitions varies from two to five. I deliberately selected such a structure for this book in the hope that the material would thereby be more accessible to students.

The third edition retains the same organization as the first and second editions. I had two objectives in revising the book: I wanted to make it more readable by making the figures easier to interpret, by clarifying some points that needed clarifying, and by eliminating material that may have been too advanced for an undergraduate course. Also, I wanted to report on some of the new research that had been done since the publication of the second edition.

Examples of new material include an expanded discussion of parallel processing in pattern recognition, the role of attention in thought suppression, metacognitive activities in memory, and the distinction between direct and indirect tests of memory—and their relation to semantic, episodic, and procedural memory. Part II, on the representation and organization of knowledge, now contains material on transfer-appropriate processing, neurological impairment, developmental changes in using defining features, and the construction of semantic networks as a study technique. Additions to the third section, on complex cognitive skills, include an expanded discussion of interpreting ambiguous sentences and noun phrases, forming mental models during text comprehension, using prior (schema-based) knowledge during problem solving, and training decision-making strategies.

I wrote the first edition of this book while spending a sabbatical year at the University of California at Berkeley. I am grateful to Case Western Reserve University and the Group in Science and Mathematics Education at Berkeley for providing financial support during that year. The Group in Science and Mathematics Education also furnished me with a stimulating environment, and the Institute of Human Learning provided an excellent library.

Shortly after arriving at Berkeley, I had the good fortune to meet C. Deborah Laughton, a psychology editor at Brooks/Cole. She expressed confidence in the book long before it was deserved and, with the assistance of an excellent staff at Brooks/Cole, helped in the development of the text. The development was also facilitated by a number of first-rate reviewers. For their insightful comments, I would like to thank Ian M. Begg of McMaster University, Bruce K. Britton of the University of Georgia, Dennis Egan of Bell Laboratories, Judith P. Goggin of the University of Texas at El Paso, Richard A. Griggs of the University of Florida, David T. Hakes of the University of Texas at Austin, Kenji Hakuta of Yale University, Robert Haygood of Arizona State University, Stephen M. Kosslyn of Harvard University, Stephen E. Palmer of the University of California at Berkeley, Stan Parkinson of Arizona State University, John W. Payne of Duke University, John Pittenger of the University of Arkansas at Little Rock, Peter Polson of the University of Colorado, James R. Pomerantz of the State University of New York at Buffalo, Eleanor Rosch of the University of California at Berkeley, and Robert E. Till of Eastern Illinois University.

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I   INFORMATION-PROCESSING STAGES

1 Introduction

Cognitive psychology refers to all processes by which the sensory input is transformed, reduced, elaborated, stored, recovered, and used.

ULRIC NEISSER (1967)

COGNITION IS USUALLY defined simply as the acquisition of knowledge. However, the acquisition and use of knowledge involve many mental skills. If you glanced at the table of contents at the beginning of this book, you saw a list of some of these skills. Psychologists who study cognition are interested in pattern recognition, attention, memory, visual imagery, language, problem solving, and decision making.

The purpose of this book is to provide an overview of the field of cognitive psychology. The book summarizes experimental research in cognitive psychology, discusses the major theories in the field, and attempts to relate the research and theories to cognitive tasks that people encounter in their daily lives—for example, reading, driving, studying, judging advertising claims, evaluating legal testimony, solving problems in the classroom, and making medical decisions.

Neisser's definition of cognitive psychology quoted on the preceding page reflects how psychologists study cognition. Let me repeat it for emphasis: "Cognitive psychology refers to all processes by which the sensory input is transformed, reduced, elaborated, stored, recovered, and used."

This definition has several important implications. The reference to a sensory input implies that cognition begins with our contact with the external world. Transformation of the sensory input means that our representation of the world is not a passive registration of our physical surroundings but an active construction that may involve both reduction and elaboration. We can attend to only a small part of the physical stimulation that surrounds us, and only a small part of what we attend to can be remembered. Reduction occurs when information is lost. Elaboration occurs when we add to the sensory input. For example, when you meet a friend, you may recall many shared experiences.

The storage and the recovery of information are, of course, concerned with memory. The distinction between storage and recovery implies that the storage of information does not guarantee recovery. A good example of this distinction is the "tip of the tongue" phenomenon. Sometimes we can almost, but not quite, retrieve a word to express a particular thought or meaning. Our later recall of the word proves that the earlier failure was one of retrieval rather than one of storage. The word was stored in memory; it was simply hard to get it back out.

The last part of Neisser's definition is perhaps the most important. After information has been perceived, stored, and recovered, it must be put to good use—for example, to make decisions or to solve problems. We will learn more about problem solving and decision making in Part 3, after we review the progress that has been made in understanding perception and memory.

THE INFORMATION-PROCESSING APPROACH

The fact that cognitive psychology is often called *human information processing* reflects the predominant approach to the subject used by cognitive

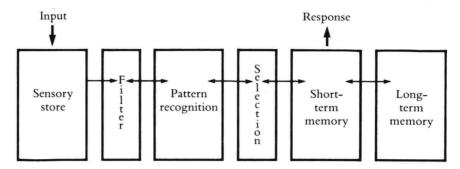Input   Response

FIGURE 1.1   Stages of an information-processing model.

psychologists. The acquisition, storage, retrieval, and use of information involve a number of separate stages, and the information-processing approach attempts to identify what happens during these stages (Haber, 1969).

Figure 1.1 identifies the stages that researchers most commonly include in information-processing models. They are arranged in temporal order; however, since information flows in both directions, as indicated by the two-headed arrows, an earlier stage can be influenced by information in a later stage. For example, in order to recognize a pattern in the pattern recognition stage, we need to store information about patterns in long-term memory.

A brief consideration of the model in Figure 1.1 will give you a superficial account of the stages, each of which will be elaborated in later chapters. The *sensory store* provides a brief storage for information in its original sensory form. Presumably, a sensory store exists for each of the senses, although the visual and auditory stores have been the most widely studied. The sensory store extends the amount of time that a person has to recognize a pattern. If a visual pattern is flashed on a screen for 5 msec (5 milliseconds, or 5/1000 of a second), the observer has more time than 5 msec to identify it if the visual information can be briefly maintained in a sensory store. Although the sensory store for vision lasts only about one-quarter of a second (250 msec), this is much longer than the 5-msec exposure.

The information in the sensory store is lost at the end of this time unless it can be described during the *pattern recognition* stage. Most of the patterns we encounter are familiar, and recognition consists in classifying a pattern as a cat, the letter *a*, the word *ball*, and so on. When we recognize a familiar pattern, we are using information that we have previously stored in memory. If the description does not match a description of a familiar pattern, the observer may want to store the new description in memory.

The relation between pattern recognition and attention has been a topic of much debate. Some theorists have claimed that we can recognize only one pattern at a time. They argue that attention acts as a filter that determines which patterns will be recognized when many patterns arrive simultaneously. Other theorists have argued that simultaneous patterns can all be recognized but that only some of the recognized patterns will be remembered whereas

others are immediately forgotten. The latter view states that attention controls which patterns will be selected into memory. Since the most popular current view is that both theories are correct, depending on the circumstances, attention is represented in Figure 1.1 by both the *filter* and the *selection* stages. The filter limits the amount of information that can be recognized at one time, and the selection limits the amount of material that can be entered into memory.

Memory is represented in Figure 1.1 by *short-term* and *long-term* memory. We use short-term memory (STM), for example, to remember a telephone number as we are dialing it. STM is limited in both the amount of information it can hold (capacity) and the length of time it can hold the information (duration). Most adults can remember a seven-digit number, but they find it very difficult to remember a ten-digit number, such as an unfamiliar area code in addition to the telephone number. The limited duration of STM is illustrated by the fact that we may quickly forget the number if we don't repeat it to ourselves by using verbal rehearsal. Long-term memory (LTM) has neither of the two limitations of STM. It has no limitations on the amount of information it can hold, and forgetting occurs relatively slowly, if at all.

The "higher" cognitive skills, such as decision making and problem solving, do not have a stage in our information-processing model. However, they depend greatly on the other stages. For example, pattern recognition skills are important in playing chess, a very demanding intellectual task. The limited capacity of STM is a major determinant of performance on tasks that require complex decision making or problem solving. The role of problem solving in learning new information is receiving increasing emphasis as cognitive psychologists discover more about the active nature of learning. Specifying the interactions among perception, memory, and thought is one of the challenges that confront cognitive psychologists.

THE BEGINNING OF COGNITIVE PSYCHOLOGY

It is difficult to pinpoint the exact beginning of any field of study, and cognitive psychologists would likely offer a wide variety of dates if asked when cognitive psychology began. William James's *Principles of Psychology*, published in 1890, included chapters on attention, memory, imagery, and reasoning. Wolfgang Kohler's *The Mentality of Apes*, published in 1925, investigated processes that occur in complex thinking. He and other Gestalt psychologists emphasized structural understanding—the ability to understand how all the parts of a problem fit together. F. C. Bartlett's book *Remembering: A Study in Experimental and Social Psychology*, published in 1932, contained a theory of memory for stories that is very consistent with current views. We could find other important articles or books that would seem modern but did not cause a major shift toward the way cognitive psychology is currently studied.