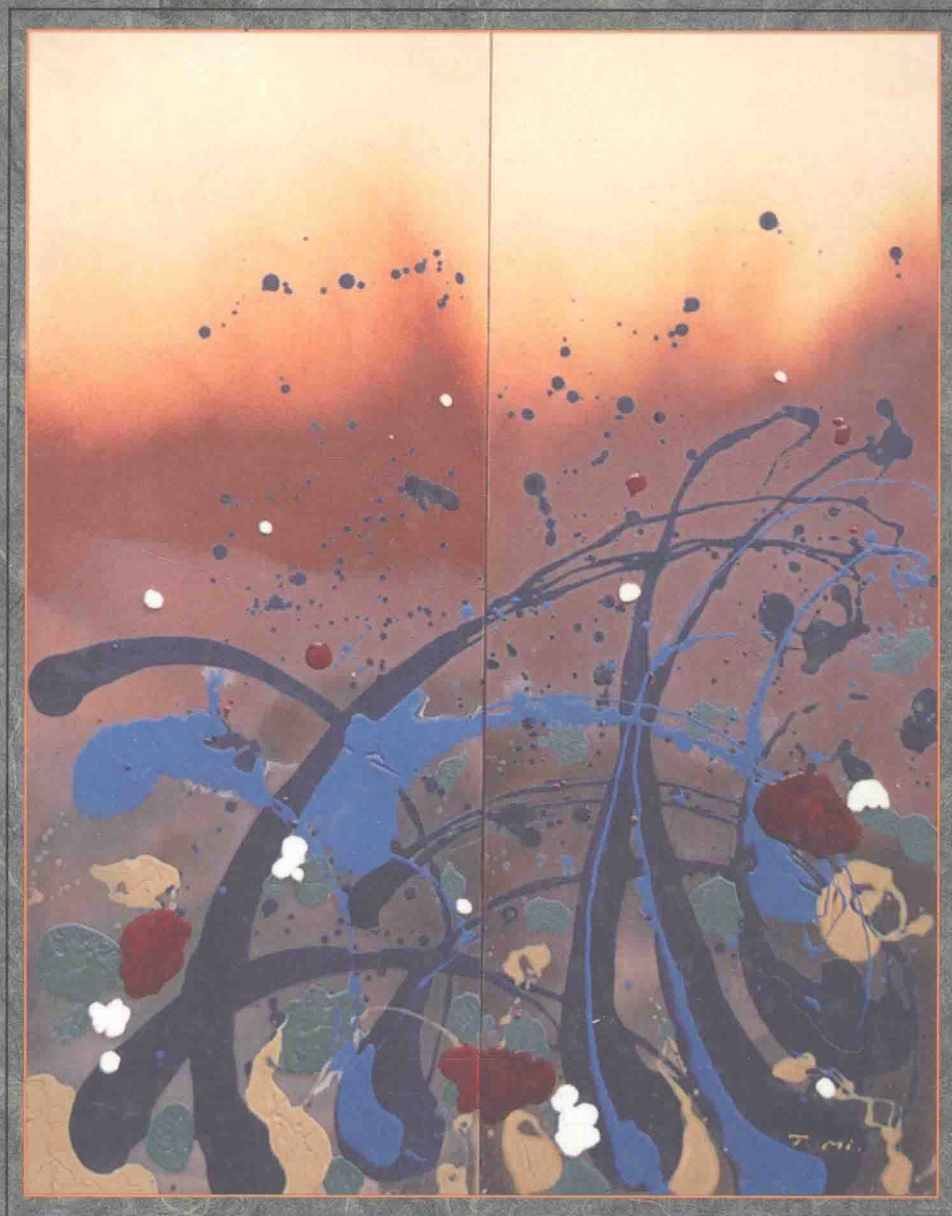


S E C O N D E D I T I O N

COGNITIVE PSYCHOLOGY



KARL HABERLANDT

COGNITIVE PSYCHOLOGY

SECOND EDITION

KARL HABERLANDT

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PREFACE

This book is intended as a text for a basic course in cognitive psychology. Its goal is to convey fundamental information about the excitements and challenges in the study of the human mind. Learning about cognitive psychology involves gaining knowledge of the questions that researchers ask, the theories they propose, and the methods they use. In addition to introducing substantive content about the traditional areas of cognitive psychology—including attention, knowledge representation, memory, comprehension, and reasoning—this book covers significant recent advances in the field and conveys how these advances are made. The impetus for the progress comes from different sources—theory, experimentation, and application—sometimes working in tandem, sometimes not. The text reflects, within the limits of an introductory framework, the inherent appeal of the inquiry into human cognition and of doing science in this discipline.

In the last two decades, there have been fundamental changes in the study of cognition; the most visible of these include:

- The increasing influence of cognitive neuroscience
- The rediscovery of action as an important research issue
- The emergence of the neural network approach
- The renaissance of learning as a focus of research

The contributions of cognitive neurosciences to our understanding of mental processes have been fueled by the introduction of a variety of new methods and the refinement of existing paradigms. Thanks to all of these investigative tools—imaging, electrophysiological, and neuropsychological—new links have been forged between neuroscience and cognitive psychology that have benefited both disciplines. Scientists

can now monitor brain events and much improved temporal and spatial precision and correlate them with behavioral measures, mostly chronometric indices, commonly used by cognitive psychologists. Parallels between neural events and cognitive phenomena are being sought in virtually every domain of cognition, from learning to problem solving.

Actions represent the physical output of the organism to the environment; this includes all uses of the skeletal muscles, from reaching for a specific target to the movements of the eyes. Traditionally, cognitive psychologists have emphasized such input processes as attention and pattern recognition more than output processes. Yet action research has served as one of the catalysts for the rise of cognitive psychology half a century ago. After all, taking account of the action side of cognition gives scientists a fuller understanding of cognition in general. Organisms act and move in order to support cognition, and a multitude of cognitive processes are used in the service of action, even if unconsciously: People adjust movements based on perceptual feedback, and they memorize and plan movements, whether in speaking, exercising, or dancing.

The now classical idea that mental processes, like computer processes, are best expressed as discrete and serial stages provided a very successful framework for cognitive research in the 1960s. However, research innovations in areas from attention to comprehension have sparked interest in parallel models of cognition, especially the neural network models. Such networks consist of many interconnected small processing units that operate in parallel, much like neurons. The neural network approach has called into question conventional mental representations as discrete and symbolic entities and contributed to a renewed interest in learning. Historically, cognitive psychology was unconcerned with learning; instead, researchers emphasized fully

developed mental functions. Changes through learning, however, are at the heart of connectionist networks. Perhaps not coincidentally, information-processing theorists also have increasingly examined the development of expertise through practice and learning.

Innovations tend to engender controversy; the field of cognitive psychology is no exception to this rule. Lively debates continue among cognitive psychologists about the usefulness of the neuroscience methods, the place of action in cognition, and the validity of the neural network approach. Whatever the outcome of the debates, the new frameworks and the ensuing arguments have invigorated the field, leaving no area of cognitive psychology unaffected. Attention, knowledge representation, memory, and problem solving all have a new look as we approach the year 2000. Recent texts in cognitive psychology reflect some of these developments but not their depth and breadth. This book incorporates these formulations in a single source and integrates them with the mainstream topics in cognitive psychology while acknowledging their conceptual and empirical problems.

Cognitive psychology is a basic science; its goal is to illuminate mental representations and processes in their own right. There are, however, many applications of cognitive psychology outside the laboratory. Some of these are supported by basic research; others are not. Illustrative applications of cognitive principles are included throughout this text, such as how to remediate the effects of dyslexia and improve one's long-term retention for mathematics. One chapter of the book discusses applications from four areas in greater detail: cognitive engineering, education, law enforcement, and neuropsychological deficits. Nuts-and-bolts issues such as the design of appliances, methods of enhancing eyewitness testimony, and the rehabilitation of patients with brain damage are also described, as is the great debate on whether such applications are premature.

The 15 chapters of this book have been written independently; instructors may vary the order in

which to cover the chapters, depending on student interest and the nature of the course. The chapters reflect the diverse aspects of cognitive psychology and approaches common in the discipline. Most chapters describe the interplay of theory and experimentation typical of experimental science. Other chapters cover computational issues, and still others emphasize conceptual analysis, reflecting the approaches of such related disciplines as linguistics. In several chapters, a historical approach is taken in the belief that the genesis of a framework highlights the significance of newer developments.

The study of the richness of the human mind and of mental processes is as fascinating as it is demanding. This book was written for the reader who is prepared to meet the challenge this subject offers. Doing so will open new perspectives on the rich panorama of the mind and kindle a lasting interest in the cognitive sciences.

ACKNOWLEDGMENTS

My work in cognitive psychology, including this book, is the result of years of study and research in the field. I am very fortunate for having received inspiration and support from teachers, colleagues, and students too numerous to list. I am grateful to my teachers for stirring my curiosity about the human mind, to my colleagues for sustaining that curiosity, and to my students for questioning assumptions that I held to be self-evident.

The first edition of this book benefited greatly from the suggestions of distinguished reviewers, including Robert Bjork (University of California, Los Angeles), Ira Fischler (University of Florida), Barry Hughes (University of Illinois), William Mackavey (Boston University), Michael O'Boyle (Iowa State University), Janet Proctor (Purdue University), Jeanne Scholl (Boston College), Michael Smith (Texas A&M University), and Steven Smith (Texas A&M University). My work on the second edition was greatly aided by Stephen Buggie (University of New Mexico-Gallup), Jann Cupp (Tennessee Technical University), Larry Z. Daily (George Mason

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PREVIEW OF CHAPTERS

PREVIEW

Cognitive psychology involves the experimental study of human information processing in its many manifestations such as attention, recognition, action, learning, memory, language processing, problem solving, and reasoning. Information processing is based on what we know; consequently, cognitive psychology investigates knowledge structures and the processes that operate on those structures. Cognitive psychology is rooted in experimental psychology; however, its questions about knowledge are older than psychology itself and date back to philosophy: What are the sources of human knowledge? How is knowledge represented in the mind? and What are the mental processes that make use of the representations? Cognitive psychology has been influenced by several traditions in psychology, including psychophysics, structuralism, behaviorism, Gestalt psychology, and the forerunners of the information-processing approach in mental chronometry and human factors research. This introductory chapter traces these antecedents, noting the legacy of each as well as their differences from the cognitive perspective.

The chapter also describes the influence of linguistics and computer science on cognitive psychology. Linguistics has stimulated research on knowledge structures underlying language use and other cognitive skills. The computer has provided both a metaphor for theories of human information processing and a powerful tool for data collection and analysis. The chapter concludes with an examination of basic assumptions, issues, and methods in the study of cognition. Advances in cognitive psychology are

characterized by debate; at issue are specific mechanisms underlying performance in cognitive tasks, the nature of mental representations and cognitive processes, the relation of the field to other disciplines, and the implication of basic research for applications in the real world.

INTRODUCTION

Your mind is constantly working even when you are unaware of it. When you remember an errand, write a message, or simply answer a question, your mind is active. Most of the time our mental processes are routine; they help us navigate through the environment, solve problems, and carry on conversations. Consider the intricate mental processes that occur in a speaker's and listener's mind during a conversation. The speaker has some thoughts she wishes to communicate; she expresses them in words and sentences. Without having to worry about it, she uses her articulatory system, facial muscles, lungs, and vocal cords to produce a comprehensible utterance. Do you know any mechanical device that works so flawlessly every time you use it? Where do thoughts come from? How do you find the words to capture thoughts? What mechanism translates a word into an utterance? What sort of knowledge must a speaker have to organize words into a comprehensible sentence?

By whatever mechanism, a speaker generates an utterance. Physically, an utterance is a pattern of sound waves that travel through the air; the sound waves enter the listener's ear, pass ossicles and membranes, and arrive at the auditory receptors in the basilar membrane. The sound energy is transformed into impulses that travel along neurons and axons into higher centers in the brain, and eventually, by some process, the listener is able to piece sounds, words, and sentences together. He knows what the words mean and what his friend is talking about. What mechanism was engaged to transform the sound waves into a neural impulse and the latter into a recognizable

word? For that matter, how did the listener retrieve the meanings of words and understand the relation between words expressed in the sentences the speaker uttered? These are among the questions cognitive psychologists seek to answer.

Curiosity and questions are at the root of cognitive psychology, as in any other science. Cognitive psychologists wonder how the mind works in such contexts as communication, recognition, and remembering. There are also practical questions like the following: Why is math so difficult? Why do we forget names of people so quickly? How should we study a foreign language to maximize knowledge and retention? How should word-processing systems be designed to facilitate learning and use? Is speed reading efficient in terms of comprehension and retention? and Could rearranging the controls on the dashboard of cars help us avoid accidents? Cognitive psychology seeks to answer questions like these, whether they are general or specific, theoretical or practical. To develop a definition of cognitive psychology, we will consider cognitive processes in three practical contexts: eyewitness testimony, air traffic control, and composing a paper.

— The testimony of eyewitnesses who were present at the scenes of accidents and crimes is essential in our legal system. The judgment of law enforcement officers, attorneys, and juries depends on eyewitness testimony, which in turn depends on perception and memory. Often an incident, whether it is a crime or an accident, tends to be fleeting; the witness sees a suspect from the side, at a distance, or in the dark. Perceptions also

depend on the witness's state of mind; frequently the witness is scared and tries to hide or get away, so impressions are formed in a hurry. When the witness later recounts the events, her memory may have dimmed or changed. In addition, the manner in which she is questioned may bias the witness to report selected or inaccurate information. Each of these aspects of eyewitness testimony—perceiving an incident, remembering it, and reporting it—involves cognitive processes (see Loftus, 1979).

— Air traffic controllers guide airplanes in landing and departure. They use a wide range of sophisticated equipment in their work, including radar, audio and video monitors, and computers. The performance of these operators is based on cognitive processes. The operator observes the displays and panels and interprets the data. Different aircraft produce different images on the radar screen. At a certain critical distance from the control station, voice contact between the tower and the aircraft is established. The controller coordinates visual input from several sources, including the radar screen and panels that show the altitude and distance of several planes relative to the tower and to each other. The operator also coordinates verbal information—for example, on the amount of fuel left in the plane, the space on the runways and in air corridors, and so on. A lapse of attention to any aspect of the operator's job can cause very serious trouble.

— Assume you are given a topic for a brief term paper, such as tuition increases at universities. Composing a paper is a cognitive activity, although quite different from giving eyewitness testimony or observing and coordinating information in a control tower. The writer must come up with ideas and organize and express them in lucid form. You, the writer, must satisfy several goals simultaneously: You must choose the correct words, form grammatically correct sentences, compose an interesting essay, and be persuasive. No wonder writing is difficult!

Performance in each of these three situations depends on the interplay between numerous men-

tal activities, including attention, interpretation, understanding, coordination, problem solving, and decision making. These activities represent instances of information processing: We acquire information, transform it, and produce some information as output. Cognitive psychology is the field that studies these processes and the knowledge structures on which they are based. Our working definition expresses this substantive goal; it also identifies the experiment as the principal method of cognitive psychology. Though mental structures and processes are not directly observable, they manifest themselves in performance as investigated in controlled experiments. Based on performance of subjects in experiments, cognitive psychologists draw inferences about knowledge structures and mental processes. Here, then, is the definition of cognitive psychology followed by a summary of major cognitive functions.

Cognitive psychology involves the experimental study of human information processing in its many manifestations such as attention, pattern recognition, learning, memory, language processing, problem solving, and reasoning. Information processing is based on what we know; consequently, cognitive psychology investigates knowledge structures and the processes that operate on those structures.

Attention plays a role in the perception of stimuli and when we face an overload of information. *Recognition* is the process by which a person interprets a stimulus, whether simple or complex. *Learning* refers to the acquisition of knowledge, and *memory* involves its retention and use. *Language processing* includes producing and understanding language. *Problem solving* refers to the achievement of a goal with a set of constraints, and *reasoning* subsumes mental activities that result in beliefs and judgments.

Cognitive psychology developed within the tradition of experimental psychology. Its development was influenced, however, in important ways by advances in other disciplines, including neuroscience, computer science, and linguistics. Neuroscience investigates the neural bases of cognition. Computer science is concerned with information processing

in computers and provides computer models used for the study of cognition. Linguistics is the study of the structure of language, which is one of the most remarkable manifestations of the human mind. This chapter will sketch the contributions of philosophy, experimental psychology, linguistics, and computer science to cognitive psychology. The final section is devoted to basic assumptions of cognitive psychology, to issues studied and to methods used in the field. Chapter 2 is devoted to neuroscience and the potential it offers for understanding cognitive processes.

PHILOSOPHY

Our interest in human knowledge—what it is, where it came from, and how it is used—is as old as humankind itself. Philosophers have pondered questions about the nature of human knowledge for centuries. Plato (427–347 B.C.) is widely credited for his inquiry into the sources of knowledge. Most of his writings are devoted to different kinds of knowledge, and the certainty and origin of knowledge. His writings are in dialogue form, with Socrates as the discussion leader. Socrates elicits knowledge from his listeners without telling them the answers explicitly. According to Socrates, having knowledge is a kind of consciousness raising; the teacher makes the student aware of what he already knows. Following Plato, there were many other thinkers who pondered the nature of knowledge and its categories. We will briefly consider the contributions of three philosophers of the seventeenth and eighteenth centuries whose impact on cognitive psychology is still felt: René Descartes, David Hume, and Immanuel Kant. Each was concerned with the nature of human knowledge but offered a different view. Descartes was a rationalist; Hume an empiricist, and Kant combined these two approaches.

René Descartes

Descartes (1596–1650) lived toward the end of the Renaissance, a period of great intellectual ferment and growth. He investigated a broad scope

of subjects that included physics, geometry, physiology, and languages. After giving much thought to the sources of knowledge, he came to believe that human reason, the product of the mind, was unique. It provided insights more certain than those gained from the senses. Think, for example, of the laws of arithmetic and geometry; consider Pythagoras's theorem illustrated in Figure 1.1. The theorem states that the square of the length of the hypotenuse, h , of a right triangle equals the sum of the squares of the lengths of the other two sides, a and b . Pythagoras's theorem is true for any such triangle.

Regularities like these were thought to be pure, and not subject to the illusions and errors of the senses; they had the status of laws. Beginning with Aristotle, philosophers studied illusions, including tactile, optical, and auditory illusions. The Mueller-Lyer illusion in Figure 1.2 was widely studied. The upper line in Figure 1.2 appears longer; the two lines are, however, exactly the same length. Philosophers following Descartes

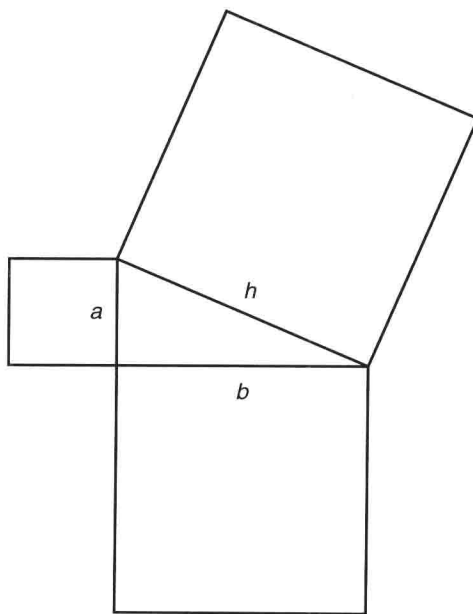


FIGURE 1.1 Right triangle with sides a , b , and h . Pythagoras's theorem states that $h^2 = a^2 + b^2$.