COGNITION

SEVENTH EDITION

Pearson

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Cognition

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Cognition

Seventh Edition

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Brief Contents

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Preface

The psychology of human memory and cognition is fascinating, dealing with questions and ideas that are inherently interesting: how we think, reason, remember, and use language, to name just a few. When cognitive psychologists talk about research at conventions, they are agitated, intense, and full of energy. However, in contrast to this enthusiasm, undergraduate texts often portray the field as dull, too concerned with the minutiae of experimental method and technical jargon, and not concerned enough with the interesting issues. Without slighting the empirical foundation of the field, we have tried to capture some of the excitement of the area. All professors want their students to understand the material, of course, but we also want you to appreciate cognitive psychology as one of the most interesting and memorable topics of your student career. Several features of the text are designed to accomplish this:

- To engage your interest and understanding, examples of the main points are sprinkled throughout the text. Each of the chapters has a box that asks you to "Prove It." This feature gives you a demonstration project that can be done quickly to illustrate the points being made.
- Mastering the terminology of a new field can be difficult. To help you with the jargon, critical terms are boldfaced in the text and linked to a glossary entry.
- Each major section of a chapter ends with a brief Section Summary. This, along with the glossary terms and other learning guides, should help you check your understanding and memory as you study. Note that some people find it helpful to read the Section Summaries first as a preview of the section's content.
- We try to use a more colloquial style than is customary in the field (or in texts in general). Our students have told us that these features make the text more enjoyable to read. One said, "It's interesting—not like a textbook," which we take as a compliment. Some professors may expect a more formal, detached style, of course. We would rather have you read and remember the material than have you cope with a text selected because of a carefully pedantic style. Besides, you will have plenty of time to deal with boring texts elsewhere.
- Although "how people think" is a topic that is likely to be of basic interest to just about everyone, most of you will not end up being cognitive scientists. So, although the material is written to be useful to people going on to a career some field of cognition, the exposition is also written to give insights to applications outside of formal cognitive science, in careers that more of you are likely to pursue.

New to the Edition

Like the first six editions, this seventh edition is directed primarily toward undergraduates at the junior and senior level, who are probably taking their first basic course in memory and cognition. It has also been used successfully in introductory graduate surveys, especially when first-year students need a more thorough background in memory and cognition. There is much continuity between the sixth edition of *Cognition* and this one: The foundation areas in cognition are still covered thoroughly, as you'll see in the Contents.

But this revision has several new features that you'll want to note:

- There continue to be tremendous increases in the study of memory and cognition with the technologies and perspectives of cognitive neuroscience. This was reflected in prior editions, and this emphasis continues to grow in the seventh edition. The chapter devoted to issues of neuropsychology has been expanded.
- The presentation of the material has been updated to better suit the REVEL platform, and make the learning of the material smoother and better.
- Two new modules have been added to cover issues of cognitive development that were previously allocated to a single module. One of these chapters is on the developmental cognition of infants and children, and the other is on issues of cognitive aging. These are capstone chapters that recapitulate the topics in the text and can be used—or not—as desired by individual instructors wanting to give different flavors or emphases in their course.
- The text has been thoroughly updated, adding and expanding on important topics and developments that are central to the field across a range of topics. As always, there has also been some careful pruning of topics and streamlining of presentation to make room for the new material. Specific example changes include:

  Chapter 1: Updating consideration of issues of the history of cognitive psychology; inclusion of issues of replicability in psychological research; an updating of the themes of cognitive psychology to include the future-oriented nature of much of thought.

  Chapter 2: Continued development of issues and methods of cognitive neuroscience.

Chapter 3: In-depth coverage of issues related to psychophysics; expanded explanation of signal detection theory; consideration of misreading effects.

Chapter 4: Added discussion of local versus global processing; inclusion of discussion of the default mode network; inclusion of a discussion of whether video game playing can improve attention.

Chapter 5: Expanded coverage of Engle's attentional control model; coverage of issues of working memory enhancement attempts.

Chapter 6: Coverage of the story mnemonic is now included; expanded discussion of the process of memory consolidation; discussion of the self-reference effect; inclusion of a discussion of episodic future thinking.

Chapter 7: Expanded discussion of the persistence of knowledge in memory; reorganization of topics on memory in Chapters 6–8.

Chapter 8: Explicit focus on the issues of forgetting; coverage of misinformation acceptance.

Chapter 9: Expanded coverage of the distinctly human nature of language; inclusion of a discussion of prosody.

Chapter 10: Inclusion of the issue of grammatical aspect and cognition; broader consideration of event cognition, including a discussion of how comics are used to study cognition; coverage of the comprehension of idioms and metaphors.

Chapter 11: Expansion of the coverage or heuristics and errors in reasoning; inclusion of coverage of the elimination by aspects heuristic; coverage of issues of decision framing and risky decisions, such as risk aversion for gains and risk seeking for loses; added coverage of decision making as being Bayesian or being governed by principles of quantum theory.

Chapter 12: Reorganization of problem solving issues to provide a better grounding for students as they progress through the chapter.

Chapter 13: Expanded coverage of issues of emotion and memory consolidation; more in-depth discussion of how choking under pressure can occur.

- As in the first six editions, we have tried to strike a balance between basic, core material and cutting-edge topics. As cognitive psychology continues to evolve, it is important to maintain some continuity with older topics and evidence. Students need to understand how we got here, and instructors cannot be expected to start from scratch each time they teach the course. We've preserved the overall outline and organization of the text, while updating the sections to reflect newer material.

We hope that the balance between classic research and current topics, the style we have adopted, and the standard organization we have used will make the text easy to teach from and easy for students to read and remember. More important, we hope you will find our portrayal of the field of cognitive psychology useful. As always, we are delighted to receive the comments and suggestions of those who use this text, instructors and students alike. You can contact G.A. Radvansky by writing in care of the Department of Psychology, University of Notre Dame, Notre Dame, IN 46556, or e-mail him at gradvans@nd.edu. You can contact Mark Ashcraft by writing in care of the Psychology Department, University of Nevada Las Vegas, 4505 S. Maryland Pkwy, Box 455030, Las Vegas, NV 89154-5030, or e-mail him at mark.ashcraft@unlv.edu.

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- **PowerPoint**—provides a core template of the content covered throughout the text. Can easily be added to to customize for your classroom.
- **Instructor's Manual**—includes in-class discussion questions and research assignments for each chapter.
- **Test Bank**—includes additional questions beyond the REVEL in multiple choice and open-ended—short and essay response—formats.
- **MyTest**—an electronic format of the Test Bank to customize in-class tests or quizzes. Visit: http://www.pearsonhighered.com/mytest.

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Chapter 1
Cognitive Psychology

Learning Objectives

1.1: Analyze the mental processes behind our thoughts

1.2: Differentiate memory and cognition

1.3: Summarize the history of cognitive psychology

1.4: Interpret how planning guides behaviors involved in problem solving

1.5: Compare human information processing to the operations of a computer program

1.6: Explain the mental processes that take place while doing a task

1.7: Describe the themes of cognition

This course is about human memory and cognition; more specifically, the scientific study of it. For the moment, consider memory and cognition to be the mental events and knowledge we use when we recognize an object, remember a name, have an idea, understand a sentence, or solve a problem. In this course, we consider a broad range of subjects, from basic perception to complex decision making, and from seemingly simple mental acts such as recognizing a letter of the alphabet to very complicated acts such as having a conversation. We ask questions such as:

- "How do we read for meaning?"
- "How do we memorize facts?"
- "What does it mean to forget something?"
- "How do we know that we don't know something?"

The unifying theme behind all this is one of the most fascinating and important questions of all time:

How do people think?

We are interested in a scientific approach to memory and thought. This is **cognitive psychology**. One of the central features of modern cognitive psychology is its allegiance to objective, empirical methods of investigation. We are experimentalists, and you will read about this approach in this module. Although we present many studies, we also try to make connections with your everyday experiences and how they are relevant to the discussion of pertinent issues.

Within the boundaries of science, cognitive psychology is asking a wide range of fascinating questions. There has been an explosion of interest in cognition both in and outside psychology proper. Questions that were on the back burner for too long are now active areas of research. For example: "How do we read?" "How do we use language?" The pent-up interest in these questions, unleashed during the **cognitive revolution** of the late 1950s and early 1960s, has yielded tremendous progress. Furthermore, we now acknowledge, seek, and sometimes participate in the important contributions of disciplines such as linguistics, computer science, anthropology, and the neurosciences. This interdisciplinary approach is called **cognitive science**, the scientific study of thought, language, and the brain. In other words, this is the scientific study of the mind.

This course aims to share what has been discovered about human memory and cognition and the insights those discoveries provide about human thought. Human memory—your memory, with its collection of mental processes—is the most highly sophisticated, flexible, and efficient computer available. How does it work? As amazing as electronic computers are, their abilities are primitive compared to what you do routinely in even a single minute of thinking. We have a basic need to understand ourselves, including how our mind works.

This course also aims to describe how cognitive psychology has made these discoveries. You will appreciate this information more if you also understand how one

conducts research and acquires knowledge. Few of you will become cognitive scientists, but presumably most of you are majoring in psychology or a related field. Because the cognitive approach influences many areas of psychology, your understanding of cognitive psychology will enhance your mastery of psychology as a whole. Indeed, cognitive psychology is the core and "the most prominent school of thought" in psychology (Robins, Gosling, & Craik, 1999).

Finally, this course will also illustrate the pervasiveness of cognitive psychology and its impact on fields outside psychology. Cognitive science is a multidisciplinary field. This fusion and cross-pollination of ideas stems from the conviction that researchers in linguistics, artificial intelligence, the neurosciences, economics, and even anthropology can contribute important ideas to psychology and vice versa. Psychology has a long tradition of influencing educational practice, and it is important that it continue to do so. Even fields as diverse as medicine, law, and business use findings from cognitive psychology. For example, a cognitive psychologist named Daniel Kahneman won the Nobel Prize in Economic Sciences in 2002 for his work on decision making. But it should not surprise you that cognitive psychology is relevant to so many other fields. After all, what human activity doesn't involve thought?

1.1: Thinking About Thinking

OBJECTIVE: Analyze the mental processes behind our thoughts

What is going on when we are thinking? What are the cognitive processes that shape our thoughts? The science of cognitive psychology attempts to study not only what we are thinking but also why and how we are thinking it. Memory, perception, emotions, beliefs, reasoning, imagination, and how we acquire knowledge all factor into cognitive processes.

Let's begin to develop a feel for cognitive psychology by considering three examples. For all three, you should read and answer the question, but more important, try to be as aware as possible of the thoughts that cross your mind as you consider the question.

The first question is easy: How many hands did Aristotle have?

Here we are not particularly interested in the correct answer: two. We are more interested in the thoughts you had as you considered the question. Most students report a train of thought something like this: "Dumb question. Of course he had two hands. Wait a minute, why would a professor ask such an obvious question? Maybe Aristotle had only one hand. Nah, I would have heard of it if he had had only one hand—he must have had two."

Table 1.1 Summary of the Intuitive Cognitive Analysis

An informal analysis will uncover some of the thoughts you had. These are tracked below. Bear in mind that Table 1.1 illustrates the intuitive analysis and is not a full description of these processes.

Processes	Topic
Sensory and perceptual	
Focus eyes on print	Visual perception, sensory memory
Encode and recognize printed material	Pattern recognition, reading
Memory and retrieval	
Look up and identify words in memory	Memory retrieval
Retrieve word meanings	Semantic retrieval
Comprehension	
Combine word meanings to yield sentence meaning	Semantic retrieval, comprehension
Evaluate sentence meaning, consider alternative meanings	Comprehension
Judgment and decision	
Retrieve answer to question	Semantic retrieval
Determine reasonableness of question	Comprehension, conversation
Judge speaker's intent and knowledge	Decision making and reasoning
Computational (Question 2)	
Retrieve factual knowledge	Semantic retrieval
Retrieve knowledge of how to divide and execute procedure	Procedural knowledge

First, perceptual processes were used for the written words of the question to focus your eyes on the printed line, then move your focus across the line bit by bit, registering the material into a memory system. Smoothly and rapidly, other processes took the material into memory to identify the letters and words. Of course, few college readers consciously attend to the nuts and bolts of perceiving and identifying words unless the vocabulary is unfamiliar or the print is bad. Yet your lack of awareness does not mean that these processes did not happen. Ask any first-grade teacher about the difficulties children have identifying letters and putting them together into words.

We have encountered two important lessons already. First, mental processes such as reading can occur with little conscious awareness, especially if they are highly practiced. Second, even though these processes can operate very quickly, they are complex. Their complexity makes it even more amazing how efficient, rapid, and seemingly automatic they are.

As you identified the words in the question, you were looking up their meanings and fitting them together to understand the question. Surely, you were not consciously aware of looking up the meaning of *hands* in a mental

dictionary. But just as surely, you did find that entry, along with your general knowledge about the human body.

Now we are getting to the meat of the process. With little effort, we retrieve information from memory that *Aristotle* refers to a human being, a historical figure from the past. Many people know little about Aristotle beyond the fact that he was a Greek philosopher. Yet this seems to be enough, combined with what we know about people in general, to determine that he was probably just like everyone else: He had two hands.

At a final (for now) stage, people report thoughts about the reasonableness of the question. In general, people do not ask obvious questions, at least not of other adults. If they do, it is often for another reason—a trick question, maybe, or sarcasm. So, students report that for a time they decided that maybe the question was not so obvious after all. In other words, they returned to memory to see whether there was some special knowledge about Aristotle that pertains to his hands. The next step is truly fascinating. Most students claim to think to themselves, "No, I would have known about it if he had had only one hand," and decide that it was an obvious question after all. This lack-of-knowledge reasoning is fascinating because so much everyday reasoning is done without benefit of complete knowledge. In an interesting variation, if students are asked, "How many hands did Beethoven have?" their knowledge of Beethoven's musical fame typically leads to the following inference: "Because he was a musician, he played the piano, and he could not possibly have been successful at it with only one hand. Therefore, he must have had two." An occasional student goes even further with, "Two, but he did go deaf before he died."

Now that's interesting! Someone found a connection between the disability implied by the question "How many hands?" and a related idea in memory, Beethoven's deafness. Such an answer shows how people can also consider implications, inferences, and other unstated connections as they reason: The thinking process can consider a great deal of knowledge, and this illustrates the role of prior knowledge in reasoning, where richer knowledge about Beethoven can lead to an inference.

One other thing to note from this example is that there are different cognitive processes that are all operating at the same time or similar times—perception, attention, memory, language comprehension, and so forth. These processes are also providing input and influencing one another. In essence, cognition is a complex and interactive thing, and it is going to take a lot of time and effort to tease it all apart and understand how it works.

The second question: What is 723 divided by 6?

This question uses your knowledge of arithmetic. Just as with the first question, many of your mental processes happened more or less automatically: identifying the digits, accessing knowledge of arithmetic procedures, and so on. Yet you may be aware of the steps in doing long division: Divide 6 into 7, subtract 6 from 7 to get the first remainder, bring down the 2, then divide 12 by 6, and so on. These steps are mentioned at the bottom of Table 1.1, "Computational," which includes your knowledge of how to do long division. Cognitive psychology is also interested in your mental processing of arithmetic problems and knowledge you acquired in school, not just the kind of reasoning you used in the Aristotle question.

The third question: Does a robin have wings?

Most adults have little to say about their train of thought when answering this question. Many people insist, "I just knew the answer was yes." The informal analysis for Question 1 showed how much of cognition occurs below awareness. The assertion that "I just knew it" is not useful, however certain you are that no other thoughts occurred. You had to read the words, find their meanings in memory, check the relevant facts, and make your decision as in the previous examples. Each of these steps is a mental act, the very substance of cognitive psychology. Furthermore, each step takes some amount of time to complete.

Question 3 takes adults about one second to answer. However, the question "Does a robin have feet?" takes a little longer, around 1.2 to 1.3 seconds. Even small time differences can give us a wealth of information about cognition and memory. The difference in Question 3 is that most of the mental processes do not require much conscious activity; the question seems to be processed automatically. Because such automatic processes are so pervasive, we are particularly interested in understanding them.

WRITING PROMPT

Studying Human Cognition

How can we approach the study of human cognition and thought in a way that does not bias us with our preconceptions?

The response entered here will appear in the performance dashboard and can be viewed by your instructor.

Submit

1.2: Memory and Cognition Defined

OBJECTIVE: Differentiate memory and cognition

To better understand the topic of this title, we need to be more explicit about the terms we use. Just what do we

Understanding the Terms Memory and Cognition

Now that you have an idea of the topics under cognitive psychology, we need more formal definitions of the terms *memory* and *cognition*.

Interactive

Memory | Cognition

The term *cognition* is a much richer term. In Ulrich Neisser's landmark book *Cognitive Psychology* (1967), he stated that cognition "refers to all the processes by which the sensory input is transformed, reduced, elaborated, stored, recovered, and used . . . [including] such terms as sensation, perception, imagery, retention, recall, problem solving, and thinking" (p. 4).

For the present, we use the following definition: *Cognition* is the collection of mental processes and activities used in perceiving, remembering, thinking, and understanding, as well as the act of using those processes.

Cognitive psychology is largely, though not exclusively, interested in what might be everyday, ordinary mental processes. These processes are entirely commonplace—not simple, by any means, but certainly routine. Our definition should not include only "normal" mental activities, however. Although cognitive psychology generally does not deal with psychologically "abnormal" states, such as schizophrenia, such "non-normal" processes, although unusual or rare, may enrich our science.

mean when we use the terms **memory** and **cognition**? In this section, we will address these two concepts.

Most cognitive research deals with the sense modalities of vision and hearing and focuses heavily on language. Some people may be concerned that the reliance on seemingly sterile experimental techniques and methods, techniques that ask simple questions, may yield overly simple-minded views about cognition. This reflects a concern that cognitive research lacks **ecological validity**, or generalizability to the real-world situations in which people think and act (e.g., Neisser, 1976). To some this criticism is sensible, and it is definitely true that the findings derived from work in cognitive psychology should, in some way, find value and applicability in the real world, even if that value may be several steps removed from the original study. A primary reason that cognitive psychologists often do not try to do studies that have an immediate and direct implication for real-world activities is the glaring fact that cognition is complex, even when using artificially simple tasks. At our current level of sophistication, we would be quickly overwhelmed if tasks were very complex or if we tried to investigate the full range of a behavior in all its detail and nuance. In this stage of investigation, it is reasonable for scientists to take an approach called **reductionism**, attempting to understand complex events by breaking them down into their components. An artificially simple situation can reveal an otherwise obscure process. Once the basic processes and components of cognition are understood, then better accounts of how they work together can be put forward. The greater goal is for scientists to eventually put the pieces back together and deal with the larger events as wholes.

WRITING PROMPT

Studying Memory and Cognition

What aspects of human experience fall under the categories of memory and cognition? Are there limits to the scientific study of these concepts?

The response entered here will appear in the performance dashboard and can be viewed by your instructor.

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1.3: An Introductory History of Cognitive Psychology

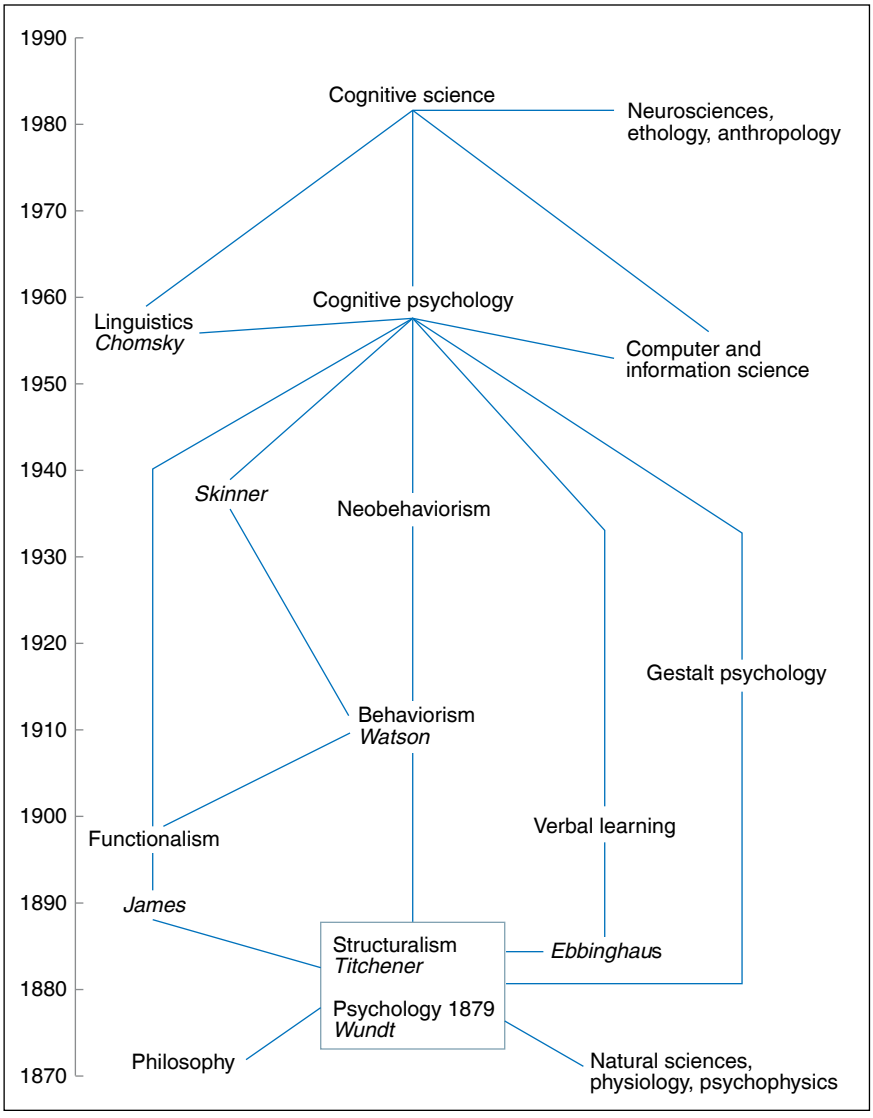
OBJECTIVE: Summarize the history of cognitive psychology

Let's now turn to cognitive psychology's history and development (for an excellent history of cognitive psychology, see Mandler, 2007). Figure 1.1 summarizes the main patterns of influence that produced cognitive psychology and cognitive science, along with approximate dates.

To a remarkable extent, the bulk of the scientific work on memory and cognition is quite recent, although some elements, and many experimental tasks, appeared even in the earliest years of psychology. However, interest in memory and cognition—thinking—is as old as recorded history. Aristotle, born in 384 B.C., considered the basic principles of memory and proposed a theory in his treatise *De Memoria* (*Concerning Memory*; see Hothersall, 1984). Even a casual reading of ancient works such as Homer's *Iliad* or *Odyssey* reveals that people have always wondered how the mind works and how to improve it (in Plato's *Phaedrus*, Socrates fretted that the invention of written language would weaken reliance on memory and understanding, just as modern parents worry about the Internet). Philosophers of every age have considered the nature of thought. Descartes even decided that the proof of human existence is our awareness of our own thought: *Cogito ergo sum*, "I think, therefore I am" (Descartes, 1637/1972, p. 52).

The critical events at the founding of psychology, in the mid- to late 1800s, converged most strongly on one man, Wilhelm Wundt, and on one place, Leipzig, Germany. In 1879, Wundt established the first laboratory for psychological experiments that had a lasting impact, at the University of Leipzig. Yet Wundt's was not the first psychology laboratory. For example, Ferdinand Ueberwasser founded a psychology laboratory in 1783. However, for various reasons, it did not have a lasting or widespread impact (Schwarz & Pfister, 2016). Also, several people had already been doing psychological research, but did not fully identify themselves as psychologists, but more as physiologists and the like (e.g., Weber's and Fechner's work in psychophysics, Helmholtz's studies of the speed of neural impulses, and Broca's and Wernicke's identification of linguistic brain regions). American psychologist William James even established an early laboratory in 1875,

Figure 1.1 The Main Patterns of Influence That Produced Cognitive Psychology and Cognitive Science



although apparently he used it more for classroom demonstrations than for genuine experiments. Still, the consensus is that 1879 is the beginning of the discipline of psychology, separate from philosophy and physiology.

1.3.1: Anticipations of Psychology

Aristotle, for two reasons, is one of the first historical figures to advocate an empirically based, natural science approach. First, although he was certainly not the only great thinker to insist on observation as the basis for all science, he was the first to express this—a position known as **empiricism**. Second, Aristotle's inquiry into the nature of thought led him to a reasonably objective explanation of how learning and memory take place. The basic principles of association he identified have figured prominently in many psychological theories. Equally important was Aristotle's insistence that the mind is a "blank slate" at birth, a ***tabula rasa***, or clean sheet of paper (Watson, 1968). The idea is that experience, rather than inborn factors, "writes" a record onto the blank sheet.

There have been many fits and starts in the study of memory over time since Aristotle. For example, St. Augustine, in Chapter 10 of his *Confessions*, presented a quite modern account of memory. Most other anticipations of psychology date from the Renaissance and later periods and are largely developments in scientific methods and approaches. By the mid-1800s, more observational or empirical methods were adopted. By the time psychology appeared, the general procedures of scientific inquiry were well developed. Given the progress in scientific fields such as physics, biology, and medicine by the mid-1800s, it is not surprising that the early psychologists thought the time was ripe for a science of the mind.

1.3.2: Early Psychology

Four early psychologists are of particular interest for cognitive psychology. These early psychologists from the late 19th and early 20th centuries worked to develop scientific methods for studying thought and behavior, which had not been explicitly or emphatically done before.

WILHELM WUNDT To a large extent, the early psychologists were students of Wilhelm Wundt (1832–1920) (Benjamin, Durkin, Link, Vestal, & Acord, 1992). Beginning in 1875, Wundt directed more than 200 doctoral theses on psychological topics (Leahey, 2000). Wundt continually updated his book *Principles of Physiological Psychology*, reporting new results from his laboratory. He also founded the first psychology journal, *Philosophical Studies* (neither of these titles matches its modern connotations). Unfortunately, Wundt's later interests went largely unrecognized until recently (Leahey, 2000). His work on language, child psychology, and other applied topics foreshadowed some modern insights but was rejected or ignored at the time.

Wilhelm Wundt

In terms of psychology, Wundt believed that the study of psychology was "of conscious processes and immediate experience"—what today we consider areas of sensation, perception, and attention. To study these, in addition to extensive use of response time measures, Wundt used the method of *Selbst-Beobachtung*. Translated literally as "self-observation," this generally is known as **introspection**, a method in which one looks carefully inward, reporting on inner sensations and experiences. Wundt intended this to be a careful, reliable, and scientific method in which the observers (who were also the participants) needed a great deal of training to report only the elements of experience that were immediate and conscious. Reports in which memory intruded were to be excluded.

EDWARD TITCHENER For American psychology in Wundt's tradition, the most important figure was Edward Titchener, an Englishman who came to Cornell University in 1892. Working with Wundt convinced Titchener that psychology's progress depended critically on introspection. Topics such as mental illness and educational and social psychology (including Wundt's broader interests) were "impure" because they could not be studied this way. Titchener insisted on rigorous training for his introspectors, who had to avoid "the stimulus error" of describing the physical stimulus rather than the mental experience of it. Moreover, Titchener made himself the final authority on whether introspection reports were correct or not. By these means, Titchener attempted to study the structure of the conscious mind: the sensations, images, and feelings that, for Titchener, were the very elements of the mind's structure. He called this **structuralism**, an early movement or

school of psychological thought (see Figure 1.1). Such a system was destined for difficulties. For example, it is unscientific for one person, Titchener, to be the ultimate authority to validate observations. As other researchers used introspective methods, differences and contradictory results began to crop up, producing disputes that hastened the decline of Titchener's once-powerful structuralism.

HERMANN VON EBBINGHAUS In contrast to Titchener's structuralism, there was the theoretically modest but eventually more influential work of Hermann von Ebbinghaus. Ebbinghaus was a contemporary of Wundt's in Germany, although he never studied with Wundt in person. Ebbinghaus's achievements in studying memory and forgetting are all the more impressive because he worked outside the establishment of the time. Historical accounts suggest that Ebbinghaus read Wundt's book, decided that a study of the mind by objective methods was possible, and set about the task of figuring out how to do it.

Hermann von Ebbinghaus

Lacking a formal laboratory and in an academic position with an absence of sufficiently like-minded colleagues, Ebbinghaus had to rely on his own resources, even to the extent that he alone served as a subject in his research. Ebbinghaus's aim was to study memory in a "pure" form. To do this, he needed materials that had no preexisting associations, so he constructed lists of *nonsense syllables*, consonant–vowel–consonant (CVC) trigrams that, by definition, had no meaning. Ebbinghaus would learn a list (e.g., of 16 items) to a criterion of mastery (e.g., two perfect recitations), then set the list aside. Later, he would relearn the same list, noting how many fewer trials he needed to relearn it. His measure of learning was the "savings score," the number (or proportion) of trials that had been saved in memory between the first and second sessions. His savings measure of memory is based on the idea that if information is stored in memory, even in a form that is not strongly consciously available, it can still ease the relearning of that material. This is in contrast to modern memory researchers who place a greater emphasis on methods such as recall and recognition, and miss some of the potential advantages of the savings method. Using his savings method, Ebbinghaus was able to study retention and forgetting of memories as a function of time, degree of learning or overlearning, and even the effect of nonsense versus meaningful material (he compared forgetting curves for nonsense syllables and meaningful poetry).

Ebbinghaus's work, described in his 1885 book, gained wide acclaim as a model of scientific inquiry into memory. For instance, Titchener praised Ebbinghaus's work as the most significant progress since Aristotle (cited in Hall, 1971). It is difficult to point to another psychologist of his day whose contributions or methods continue to be used. The field of verbal learning owes a great deal to Ebbinghaus. The Ebbinghaus tradition, depicted in Figure 1.1, is one of the strongest influences on cognitive psychology.

WILLIAM JAMES American philosopher and psychologist William James, a contemporary of Wundt, Titchener, and Ebbinghaus's, provided at Harvard an alternative to Titchener's rigid system. His approach, influenced by the writings of Darwin, was **functionalism**, in which the functions of consciousness, rather than its structure, were of interest. Thus, James asked questions such as "How does the mind function?" and "How does it adapt to new circumstances?"

James's informal analyses led to some useful observations. For example, he suggested that memory consists of two parts: an immediately available memory that we are currently aware of and a larger memory that is the

William James

repository for past experience. The idea of memory being divided into parts, based on different functions, is popular today. Indeed, the first serious models of human cognition included the two kinds of memory James discussed in 1890.

Probably because of his personal distaste for experimentation and his broad interests, James did not do much actual research. However, his far-reaching ideas were more influential than any of Titchener's work, as evidenced by his classic 1890 book *Principles of Psychology*. James's influence on the psychology of memory and cognition was delayed, however, for it was John B. Watson, in 1913, who solidified a new direction in American psychology away from both the structuralist and functionalist approaches. This new direction was behaviorism.

1.3.3: Behaviorism

Not all of American psychology from 1910 through the 1950s was behaviorist. The fields of clinical, educational, and social psychology, to name a few, continued in their own development in parallel to behaviorism. Furthermore, there were changes within behaviorism that smoothed the transition to cognitive psychology. This was a kind of neobehaviorism with some unobservable, mediating variables. Nonetheless, it was still a behaviorist environment.

Most people who take introductory psychology know of John B. Watson, the early behaviorist who stated in his 1913 "manifesto" that observable, quantifiable behavior was the proper topic of psychology, not the fuzzy and unscientific concepts of thought, mind, and consciousness. Attempts to understand the "un-observables" of the mind were inherently unscientific, in his view, and he pointed to the unresolved debates in structuralism as evidence. Thus, psychology was redefined as the scientific study of observable behavior, the program of **behaviorism**. There was no room for mental processes because they were not observable behaviors.

Why did such a radical redefinition of psychology's interests have such broad appeal? Part of this was a result of the work that Pavlov and others were doing on conditioning and learning. Here was a scientific approach that was going somewhere compared to the endless debates in structuralism. Furthermore, the measurement and quantification of behaviorism mirrored successful sciences such as physics. Modeling psychology on the methods of these sciences might help it become more scientific (Leahey, 2000, calls this mentality "physics envy"). One of behaviorism's greatest legacies is the emphasis on methodological rigor and observables, traditions that continue to be in force to this day.

During the behaviorist era, there were a few psychologists who pursued cognitive topics—Bartlett of Great Britain, for example—but most American experimental psychology focused on observable, learned behaviors, especially in animals (but see Dewsbury, 2000, for a history of research on animal cognition during the behaviorist era). Even the strongly cognitive approach of Tolman—whose article "Cognitive Maps in Rats and Men" (1948), a molar (as opposed to molecular) approach to behaviorism, is still worth reading—included much of the behaviorist tradition:

- Concern with the learning of new behaviors
- Animal studies
- Interpretation based closely on observable stimuli

Gestalt psychology, which immigrated to the United States in the 1930s (Mandler & Mandler, 1969), always maintained an interest in human perception, thought, and problem solving but never captured the imaginations of many American experimentalists.

Thus, the behaviorist view dominated American experimental psychology until the 1940s, when B. F. Skinner emerged as a vocal, even extreme, advocate. In keeping with Watson's earlier sentiments, Skinner also argued that mental events such as thinking have no place in the science of psychology—not that they are not real, but that they are unobservable and hence unnecessary to a scientific explanation of behavior.

1.3.4: Emerging Cognition

It is often difficult to determine precisely when historical change takes place. Still, many psychologists favor the idea that a cognitive revolution occurred in the mid- to late 1950s, with a relatively abrupt change in research activities, interests, scientific beliefs, and a definitive break from behaviorism (Baars, 1986). Because of the nature and scope of these changes, some see the current approach as a revolution that rejected behaviorism and replaced it with cognitive psychology. However, some historians claim that this was not a true scientific revolution but merely "rapid, evolutionary change" (see Leahey, 1992). In either case, the years from 1945 through 1960 were a period of rapid reform in experimental psychology. The challenges to neobehaviorism came both from within its own ranks and from outside, prodding psychologists to move in a new direction.

WORLD WAR II Lachman, Lachman, and Butterfield (1979) made a point about the growing dissatisfaction among the neobehaviorists. They noted that many academic psychologists were involved with the U.S. war effort during World War II. Psychologists accustomed to studying animal learning in the laboratory were "put to work on the practical problems of making war . . . trying to understand problems of perception, judgment, thinking, and decision making" (p. 56). Many of these problems arose because of soldiers' difficulties with sophisticated technical devices: skilled pilots who crashed their aircraft, radar and sonar operators who failed to detect or misidentified enemy blips, and so on.

Tasks, such as the vigilance needed for air traffic control, require cognitive processes at a fundamental level.

Lachman et al. (1979) were very direct in their description of this situation:

> Where could psychologists turn for concepts and methods to help them solve such problems? Certainly not to the academic laboratories of the day. The behavior of animals in mazes and Skinner boxes shed little light on the performance of airplane pilots and sonar operators. The kind of learning studied with nonsense syllables contributed little to psychologists trying to teach people how to operate complex machines accurately. In fact, learning was not the central problem during the war. Most problems arose after the tasks had already been learned, when normally skillful performance broke down. The focus was on performance rather than learning; and this left academic psychologists poorly prepared. (pp. 56–57)

As Bruner, Goodnow, and Austin (1956) put it, the "impeccable peripheralism" of stimulus–response (S–R) behaviorism became painfully obvious in the face of such practical concerns.

To deal with practical concerns, wartime psychologists were forced to think about human behavior very differently from how they had been up until that point. The concepts of attention and vigilance, for instance, were important to understand sonar operators' performance. Experiments on the practical and theoretical aspects of vigilance began (see especially Broadbent, 1958). Decision making was a necessary part of this performance too, and from this came such developments as signal detection theory. These wartime psychologists rubbed shoulders with professionals from different fields—those in communications engineering, for instance—from whom they gained new outlooks and perspectives on human behavior. Thus, these psychologists returned to their laboratories after the war determined to broaden their own research interests and those of psychology as well.

VERBAL LEARNING **Verbal learning** was the branch of experimental psychology that dealt with humans as they learned verbal material composed of letters, nonsense syllables, or words. The groundbreaking research by Ebbinghaus started the verbal learning tradition, which derives its name from the behaviorist context in which it found itself. Thus, verbal learning was defined as the use of verbal materials in various learning paradigms. Throughout the 1920s and 1930s there was a large body of verbal learning research, with well-established methods and procedures. Tasks such as serial learning, paired-associate learning, and, to an extent, free recall were the accepted methods.

Proponents of verbal learning were similar to the behaviorists. For example, they agreed on the need to use objective methods. There also was widespread acceptance of the central role of learning, conceived as a process of forming new associations, much like the learning of new associations by a rat in a Skinner box. From this perspective, a theoretical framework was built that used a number of concepts that are accepted today. For example, a great deal of verbal learning was oriented around accounts of interference among related but competing newly learned items.

The more moderate view in verbal learning circles made it easy for people to accept cognitive psychology in the 1950s and 1960s: There were many indications that an adequate psychology of learning and memory needed more than just observable behaviors. For instance, the presence of meaningfulness in "nonsense" syllables had been acknowledged early on: Glaze (1928) titled his paper "The Association Value of Nonsense Syllables" (and apparently did so with a straight face). At first, such irksome associations were controlled for in experiments to avoid contamination of the results. Later, it became apparent that the memory processes that yielded those associations were more interesting.

In this tradition, Bousfield (1953; Bousfield & Sedgewick, 1944) reported that, with free recall, words that were associated with one another (e.g., *car* and *truck*) tended to cluster together, even though they were arranged randomly in a study list. There were clear implications that existing memory associations led to the reorganization. Such evidence of processes occurring between the stimulus and the response—in other words, mental processes—led proponents of verbal learning to propose a variety of mental operations such as rehearsal, organization, storage, and retrieval.

The verbal learning tradition led to the derivation and refinement of laboratory tasks for learning and memory. Its advocates borrowed from Ebbinghaus's example of careful attention to rigorous methodology to develop tasks that measured the outcomes of mental processes in valid and useful ways. Some of these tasks were more closely associated with behaviorism, such as the paired-associate learning task that lent itself to tests of S–R associations in direct ways.