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CHAPTER

1

Cognitive Psychology

An Introduction

What a piece of work is man. How noble in reason! How infinite in faculty! In form and moving how express and admirable! In action how like an angel! In apprehension, how like a god! (Act 2, scene 2)[1]

SHAKESPEARE'S *Hamlet*

One difficulty in the psychological sciences lies in the familiarity of the phenomena with which they deal. A certain intellectual effort is required to see how such phenomena can pose serious problems or call for intricate explanatory theories. One is inclined to take them for granted as necessary or somehow "natural."

CHOMSKY, 1968, p. 24

[1]Unlike Shakespeare, modern writers have been sensitized to the sexist bias implied by the use of *man, he,* and so on in a generic sense. We have attempted to avoid such usage whenever possible, or to alternate between *he* and *she* on a section-by-section basis.

This book is about human memory and cognition, and specifically about the scientific study of human memory and cognition. Let's start with a quick definition of terms and return later for the more formal definitions. 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 book, we consider a broad range of subjects, from basic perception through complex decision making, from seemingly simple mental acts such as recognizing a letter of the alphabet to very complicated acts such as participating in a conversation. We will 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?

Note that we are interested in an empirical, scientific approach to human memory and thought. This places us in the branch of modern psychology called cognitive psychology. The discipline of psychology has largely accepted the empirical, scientific approach to the study of mind and behavior. Thus one of the central features of modern cognitive psychology is its allegiance to objective, empirical methods of investigation. We are experimentalists, and this is the approach you will read about in this book. However, while we do present a lot of studies, we also try to make connections with your everyday experiences and how these experiences may be relevant to the issues being discussed.

Within the boundaries of objective scientific methods, cognitive psychology is asking an enormous range of fascinating questions. Since the beginnings of modern cognitive psychology about 50 years ago, there has been an explosion of interest in cognition and in the cognitive approach to human behavior and thought both in and outside of psychology proper. These questions that were on the back burner for too long—such as "How do we read?" or "How do we use language?"—are now active areas of research. The pent-up interest in these questions, unleashed during the cognitive revolution of the late 1950s, has yielded tremendous progress. Furthermore, we now acknowledge, seek, and sometimes participate in the important contributions of disciplines such as linguistics, computer science, and the neurosciences. This interdisciplinary approach, this joining of diverse forces, is called **cognitive science**, *the scientific study of thought, language, the brain—in short, the scientific study of the mind.*

The most basic aim of this book is to tell you what has been discovered about human memory and cognitive processes and to share the conclusions and insights about the particularly human activity called thought. Human memory—your memory, with its collection of mental processes—is the most highly sophisticated, flexible, and efficient computer available today. How does it work? As amazing as electronic computers are, their capabilities are primitive compared with what you do routinely in even a single minute's worth of thinking. The need to understand ourselves is basic, and this includes an understanding of how our minds work.

Another aim of this book is to describe how cognitive psychology has made these discoveries. You'll understand and better appreciate the information in this book if you also understand how research is done, how new knowledge is acquired in the scientific pursuit of cognition. Few of you will become cognitive scientists yourselves, but presumably most of you have decided to major in psychology or a related field. Because

the cognitive approach has come to influence many areas in modern psychology—indeed, the evidence suggests that cognitive psychology is at the core and remains "the most prominent school" of thought in modern psychology (Robins, Gosling, & Craik, 1999)—your mastery of psychology as a whole will be enhanced by an understanding of cognitive psychology.

A final aim of this book is to illustrate the pervasiveness of cognitive psychology and its impact on other fields outside psychology proper. As you read a moment ago, cognitive science is a multidisciplinary field. This fusion and cross pollination of disciplines and ideas represents 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 the potential for cognitive psychology to continue these contributions is both obvious and important. Even fields as diverse as medicine, law, and business are incorporating findings from cognitive psychology—for example, a cognitive psychologist named Kahneman won the Nobel Prize in Economics in 2003 for his work on decision making (see Chapter 11 for a full account of Kahneman's work, and Kahneman, 2003b, for a first-person description of the collaborative work that led to the Nobel). But it should not be surprising that cognitive psychology is relevant to so many other fields. After all, what human activity doesn't involve thought?

THINKING ABOUT THINKING

Let's begin to develop an intuitive feel for our topic by considering some examples, coming back later to improve our quick definitions of the terms *memory* and *cognition.* For all three examples that follow, you should read the question and come up with the answer, but more importantly you should try to be as aware as possible of the thoughts that cross your mind as you consider the question. The first question is easy:

1. *How many hands did Aristotle have?*

For such a ridiculously easy question, of course we are not particularly interested in the correct answer, "two." We are quite interested, however, in the thoughts you had as you considered the question. Most students report a train of thoughts 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."

A bit of informal cognitive analysis will uncover some of the different thoughts you have while arriving at your answer. Keep track of the analysis with the list in Table 1-1; as you read the later questions, refer to Table 1-1 to see which processes and steps apply to all the questions and what new ones should be added. Bear in mind that Table 1-1 merely illustrates the intuitive analysis; it is no substitute for the full description of these processes and steps found later in the book.

First, although you were no doubt unaware of it, a large group of perceptual processes were brought into play to deal with the written words of the question. Highly overlearned visual processes focused your eyes on the printed line, then moved your focus across the line bit by bit, registering the printed material into some kind of

TABLE 1-1 Summary of the Intuitive Cognitive Analysis

Processes	Topic and Chapter
Sensory and perceptual	
Focus eyes on print	Visual perception, sensory memory: Chapter 3
Encode and recognize printed material	Pattern recognition, reading: Chapters 3 and 10
Memory and retrieval	
Look up and identify words in memory	Memory retrieval: Chapters 5–8
Retrieve word meanings	
Comprehension	
Combine word meanings to yield sentence meaning	Semantic retrieval, comprehension: Chapters 7–10
Evaluate sentence meaning, consider alternative meanings	Comprehension: Chapters 9 and 10
Judgment and decision	
Retrieve answer to question	Semantic retrieval: Chapters 8 and 9
Determine reasonableness of question	Comprehension, conversation: Chapters 9 and 10
Judge speaker's intent and knowledge	Decision making and reasoning: Chapter 11
Computational (Question 2)	
Retrieve fact knowledge	Semantic retrieval: Chapter 7
Retrieve knowledge of how to divide and execute procedure	Procedural knowledge: Chapters 6, 11, and 12

memory system. Smoothly and rapidly, another set of processes looked up the encoded material in memory and identified the letters and words. Of course, few if any readers of a college text pay conscious attention to the nuts and bolts of perceiving and identifying words unless the vocabulary is unfamiliar or the printing is faint. Yet your lack of awareness of these stages does not mean they didn't happen; ask any first-grade teacher about the difficulties children have in learning to identify letters and their sounds and putting these components together into words.

We have encountered two important lessons already. First, mental processes can occur with little conscious awareness. This is especially true of processes that have received a great deal of practice, such as reading skills. Second, even though these processes can operate very quickly, they are quite complex, involving difficult motor, perceptual, and mental acts. Their complexity makes it even more amazing how efficient, rapid, and seemingly automatic they are.

As you identified the individual words in the first question, you were also accessing or looking up the meanings of those words and then fitting those meanings together to understand the question. Surely you weren't consciously aware of looking up the meaning of the word *hands* in a mental dictionary. But just as surely, you did search for and find that entry in memory, stored together with all your other general knowledge about the human body. A few students insist that they wondered whether the question might be referring to a different Aristotle—maybe Aristotle Onassis—because a question about the philosopher Aristotle's hands seems so odd.

Now we are getting to the meat of the process. With little effort, we retrieve the information from memory that the word *Aristotle* refers to a human being, a historical figure from the distant 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 to be true of people in general, to determine that he was probably just like everyone else: He had two hands. Those who consider Aristotle Onassis seem to reach the same stage as well. Even though they may know a few facts about this more contemporary person (Greek shipping magnate, married Jacqueline Kennedy), they probably find no specific information in memory about the number of hands he had, so they make the default assumption that it was two. Think of how differently you would have understood the question if it had been "How many hands does Aristotle have?" Tipped off by the present tense, would you have searched your memory for a still-living person named Aristotle? Would you have explicitly asked yourself whether Aristotle Onassis was dead, or would you have tried to find some unusual, maybe metaphorical way of interpreting the question?

At a final (for now) stage, people report a set of thoughts and judgments that involve the reasonableness of the question, similar in many respects to the interpretations of remarks in a conversation. In general, people do not ask obvious questions, at least not of other adults. If they do, however, it is often for another reason—a trick question, maybe, or sarcasm. Consequently, students report that for a time they decided that maybe the question wasn't so obvious after all. In other words, there was a return to memory to see whether there was some special knowledge about Aristotle that pertains to his hands. The next step is truly fascinating. The majority of students claim to have thought to themselves, "No, I would have known about it if he had had only one hand," and they decide that indeed it was an obvious question after all.

This lack-of-knowledge reasoning process is a fascinating topic because so much of our everyday reasoning is done without benefit of complete knowledge. In an interesting variation, we have asked students, "How many hands did Beethoven have?" Knowing of Beethoven's musical fame typically leads to the following inference: "Because he was a musician, he probably played the piano, and he could not possibly have been very successful at it with only one hand; therefore he must have had two." An occasional student goes even further with the intriguing answer, "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 shred of evidence in memory, Beethoven's deafness. Such an answer shows how people can also consider implications, inferences, and other unstated connections as they reason and make decisions: It shows what a great deal of knowledge can be considered even for a simple question. The answer also illustrates the role of prior knowledge in such reasoning, where the richer body of information about Beethoven can lead to a more specific inference than was possible for the Aristotle question.

Although this informal analysis does not exhaust the discussion of cognitive processes in reading, memory retrieval, or comprehension, it does orient you to some of the important features of cognitive psychology and its subject matter. Let's continue with the other questions to see what else is in store for you in this book.

IN DEPTH

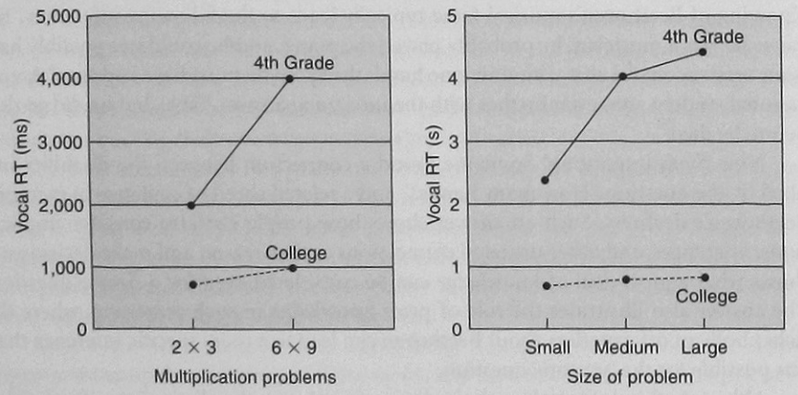
Interpreting Graphs

If you're good at interpreting data presented in graphs, do not bother with the rest of this box; just study the figures. Some students struggle with graphed material, not understanding what is being shown as well as their professors think. Because you will encounter a lot of graphed data in this book, you need to understand what you are looking at and what it means. Take a moment to go through these simple graphs to see how they are put together and what to pay attention to when you interpret the data.

The figure in this box is a simple graph of response time data, the time it takes to respond to an item. We almost always abbreviate response time as RT, and it is usually measured in milliseconds (ms), thousandths of a second (because thought occurs so fast). In the figure, the label on the *y*-axis says "Vocal RT"; in other words, these people were making vocal responses (speaking), and the researchers measured the time between the onset of a simple multiplication problem and the vocal response. The numbers on the *y*-axis show you the range of RTs that were observed. The dependent variable is always the measure of performance we collect in the experiment—here it is vocal RT—and it always goes on the *y*-axis.

The *x*-axis in the left panel is labeled "Multiplication problems," and we've plotted just two problems, 2×3 and 6×9. It is customary to show a more general variable than this on the *x*-axis, as shown in the right panel. There you see a point for a whole set of small multiplication problems, from 2×3 up to 4×5; a set of medium-size problems such as 2×7 and 8×3; and a set of large problems, such as 6×8 and 9×7. So the *x*-axis label in the right panel says "Size of problem." A general rule for the proportions of a graph is that the length of the *x*-axis is slightly shorter than the height of the *y*-axis; a 3 to 4 (or maybe a 4 to 5) ratio is about right, so that if the height of the *y*-axis is 4 inches, the *x*-axis should be about 3 inches long. Notice that the *y*-axis is now in whole seconds, to save some space and preserve the graph's proportions.

Now the data. The points we plot in the graph are almost always the mean or average of the dependent variable, RT in this case. Both panels show two curves or lines each, one for college students, the other for fourth-grade students; Campbell and Graham (1985) tested



Vocal response times (RTs) to multiplication problems. (Data from Campbell & Graham, 1985.)

fourth-graders and college students on the simple multiplication problems. Notice first that the curves for fourth-graders are much higher. If you read the values from the *y*-axis in the left panel, the average fourth-grader took 1,940 milliseconds to answer "6" to the problem 2×3, compared to 737 milliseconds for the average college student. In the right panel, the average fourth-grader took about 2,400 milliseconds to respond to small problems, 4,100 to medium, and 4,550 to large. Compare this much greater increase in RT as the problems get larger with the pattern for college students: There was still an increase, but only from 730 milliseconds to almost 900 milliseconds.

Why did Campbell and Graham find slower performance for fourth-graders? No doubt because college students have had far more practice in doing simple multiplication problems than have fourth-graders. In other words, college students know multiplication better, have the facts stored more strongly in long-term memory, and so can access and retrieve the facts more rapidly. It is a perfectly sensible, cognitive effect that the strength of information in memory influences the speed of your retrieval. And it is easily grasped by looking at and understanding the graphed results. (You will read about this experiment again in Chapter 2, including a variety of interpretations for the other major result in the figures, that RT was longer for the larger problems.)

2. *What is 723 divided by 6?*

This question relies on a different kind of knowledge than the Aristotle question: the knowledge of arithmetic that you learned in grade school. Just as was true as you read the words in the first question, many of your mental processes happened more or less automatically for the division problem: identifying the digits, accessing your knowledge of arithmetic procedures, and so on. Yet you were probably consciously aware of the problem-solving 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 would include your knowledge of how to do long division. Cognitive psychology is no less interested in your mental processing of arithmetic problems or in the knowledge you acquired in school than in the informal reasoning processes you used for Question 1. In other words, the fact that you were explicitly taught how to divide does not make your mental processes less interesting. If anything, it may make them more interesting because we might be able to find parallels between teaching methods and people's mental processes (see Chapter 12 for some further information on the cognitive psychology of arithmetic and math).

The third question is in many ways more typical of cognitive psychology's interests and research than the first two. For reasons that will become more convincing throughout the book, a great deal of research in cognitive psychology has timed people as they make simple yes-or-no decisions about questions such as the following:

3. *Does a robin have wings?*

Most adults find themselves unable to say much of anything about their train of thoughts when answering this question. Indeed, many people insist, "I just knew the answer was yes." (In honesty, many people also question the sanity of an investigator who asks such seemingly trivial questions.) One purpose of the informal analysis for

Question 1 was to illustrate just how much of our cognitive processing can occur below the level of awareness, or automatically. As you probably realize by now, cognitive psychology does not find the notion that "I just knew it" to be particularly useful, however certain you are that no other thoughts occurred to you. Clearly, you had to read the words, find their meanings in memory, check the relevant facts, and make your decision in a similar fashion to the previous examples. Each of these steps (and there are many more steps involved here) is a *bona fide* mental act, the very substance of cognitive psychology. Furthermore, each step takes some amount of time to be completed. A question such as Question 3 takes adults about one second to answer; the question "Does a robin have feet?" takes a little longer, around 1.2 or 1.3 seconds. Even such small time differences can give us a wealth of information about mental processing and human memory.

What seems strikingly different for Question 3 is that almost none of the mental processes required much awareness or conscious activity; the question seems to have been processed automatically. Because such automatic processes are so pervasive in mental activity, we are particularly interested in understanding them.

Section Summary

- Cognitive psychology is the scientific study of human mental processes. This includes perceiving, remembering, using language, reasoning, and solving problems.
- Intuitive analysis of examples such as "How many hands did Aristotle have?" and "Does a robin have wings?" indicates that many mental processes occur automatically (very rapidly and below the level of conscious awareness).

MEMORY AND COGNITION DEFINED

Now that you have an idea of the topics we are concerned with in cognitive psychology, we need to state more formal definitions of the terms *memory* and *cognition*. It will also be useful to spend a moment discussing the topics you will and will not find covered in this text. Most of us have a reasonably good idea of what the term *memory* means, something like "being able to remember or recall some information." As defined in Webster's *New World Dictionary* (1980), memory consists of "the power, act, or process of recalling to mind facts previously learned or past experiences." Note that both of these definitions are hopelessly circular; memory is "being able to remember" or "the process of recalling to mind." Although this circularity is unfortunate, the definitions do point to several critical ideas (note that the circularity is almost built into the words, all of which came from related Indo-European bases meaning "to think" and "to remember").

First, the event or information being recalled from memory is one from the past. In other words, we *remember* things from the past but *experience* things in the present. Quite literally, any past event that is currently recalled is evidence of memory; it could be a childhood memory from years ago or something that only happened moments ago. Second, the term *memory* refers to a process, a mental act in which stored information is recovered for some current use. This recovery or retrieval of what has been placed in memory specifies the process of interest, "getting out" something that was previously "put in." Note that the term *retrieval* here includes both varieties of remembering: the conscious, intentional recalling to mind implied in Webster's definition and the more automatic (or even unaware) kind of retrieval discussed in the examples earlier.

Finally, the term *memory* also refers to a place, a location where all the events, information, and knowledge of a lifetime are stored. This sense of the word is especially evident in the models and theories of cognition that rely on divisions such as short-term and long-term memory. Although it is obviously true that there is some physical location in your brain where facts and processes are stored, this "location" sense of the word was often taken rather metaphorically; regardless of *where* it happens, there is some memory system that holds information for later retrieval. But especially now, with the advent of modern imaging devices such as positron emission tomography (PET) and magnetic resonance imaging (MRI), neuroscience is making progress in exploring functions and processes as they occur—or occasionally are disrupted—in the brain and identifying regions and areas responsible for those functions and processes. Chapter 2 introduces you to some of this new methodology and orientation, preparing you to read about recent advances in our knowledge of brain-cognition relationships throughout this book.

A formal definition of the term *memory* captures the essential ingredients of the preceding discussion. Consider **memory** to mean *the mental processes of acquiring and retaining information for later retrieval and the mental storage system that enables these processes.* Operationally, memory is demonstrated whenever the processes of retention and retrieval influence your behavior or performance in some way, even if you are unaware of the influence. Furthermore, we understand this definition to include retention not just across hours, weeks, or years, but even across very brief spans of time, in any situation in which the original stimulus event is no longer present. Note also that memory refers to three different kinds of mental activities in this definition: initial acquisition of information (usually called learning or encoding), subsequent retention of the information, and then retrieval of the information (Melton, 1963). Because all three activities are logically necessary to demonstrate that remembering has taken place, we include them in our broader definition of the term *memory* as well.

The term *cognition* is much richer in its connotations and is an umbrella term for all higher mental processes. One dictionary defines it as "the mental process or faculty of knowing, including aspects such as awareness, perception, reasoning, and judgment" (*The American Heritage College Dictionary*, 1997). In Neisser's (1967) landmark book, *Cognitive Psychology*, he claimed 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 a definition that is somewhat easier to remember but just as broad: **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.*

Whereas our definition of the term *memory* is fairly specific, the definition of cognition is still somewhat slippery. A term such as *thinking* in a scientific definition begs for clarification or at least a catalog of examples. You might decide that dreaming is a

perfectly valid act of cognition, according to the definition, and it is. However, you would then be puzzled that cognitive psychology largely ignores dreaming (but see Mandler, 1984, and Antrobus, 1991, for example), in part because it is so hard to study the content of dreams accurately. So, why do we include some topics but ignore others?

One purpose of the examples in the previous section is to suggest that cognitive psychology is largely, though not exclusively, interested in what might be considered everyday, ordinary mental processes. The processes by which we read and understand, for instance, are entirely commonplace—not simple, by any means, but certainly routine. On the other hand, we should not amend the definition to include only "normal" mental activities. It is true that cognitive psychology generally does not directly deal with the psychologically "abnormal," such as the varieties of thought disturbance associated with schizophrenia (although a cognitive approach to these problems is certainly possible). The problem with excluding the "nonnormal" processes is that the unusual or rare may also be tossed out, impoverishing our science in the process. Rather than change the definition, we assume that cognition usually refers to the customary, commonplace mental activities that most people engage in as they interact with the world around them. As you will see, this still casts a rather broad net as we fish for topics to investigate and interpretations to explain our results.

Nonetheless, there are still omissions, sometimes glaring and sometimes not. To the distress of some (e.g., Neisser, 1976), most of our research deals with the sense modalities of vision and hearing rather than other sensory ways of knowing the world, and it focuses very heavily on language; as Keil (1991, p. 287) quipped, "Minds talk a lot . . . they see a little, but they don't feel much else." More disturbing, possibly, is our reliance on seemingly sterile experimental techniques and methods (this is Neisser's more substantive criticism), techniques that ask simple questions and may therefore yield overly simple views about the operation of cognitive systems. In Neisser's term, much of our cognitive research lacks **ecological validity**, or *generalizability to the real-world situations in which people think and act.* As a simple example, imagine how different your reading and comprehension processes might be if you were shown this paragraph one word at a time, each word for only a fraction of a second. The method would prevent you from slowing down when your comprehension lagged, from returning your gaze to a previous word or sentence you may have misinterpreted, and so on. And yet this method has been used to investigate reading and comprehension.

Although Neisser's criticism was sensible, it was possibly premature. We find great complexity in cognitive processing, even when artificially simple tasks are performed. At our current level of sophistication, we might be overwhelmed if our tasks were permitted to be more complex or if we tried to investigate the full range of a behavior in all its detail and nuance. In other words, in the early 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.* After all, an artificially simple situation can sometimes reveal rather than obscure a process, and sometimes we gain insight by preventing a process from occurring in its regular fashion (see Mook, 1983, for a fine discussion of the entire issue of ecological validity). Of course, it is also reasonable to expect that scientists eventually will put the pieces back together again and deal with the larger event as a whole. In fact, recent developments seem to hold just that sort of promise.

Section Summary

- Memory is composed of the mental processes of acquiring and retaining information for later use (encoding), the mental retention system (storage), and then using that information (retrieval).
- Cognition is the complex collection of mental processes and activities used in perceiving, remembering, and thinking and the act of using those processes.

AN INTRODUCTORY HISTORY OF COGNITIVE PSYCHOLOGY

You have now encountered cognitive psychology by example and by definition, so we next turn to its history and development. This treatment should give you a better appreciation of what cognitive psychology is and how it became so. Figure 1-1 summarizes

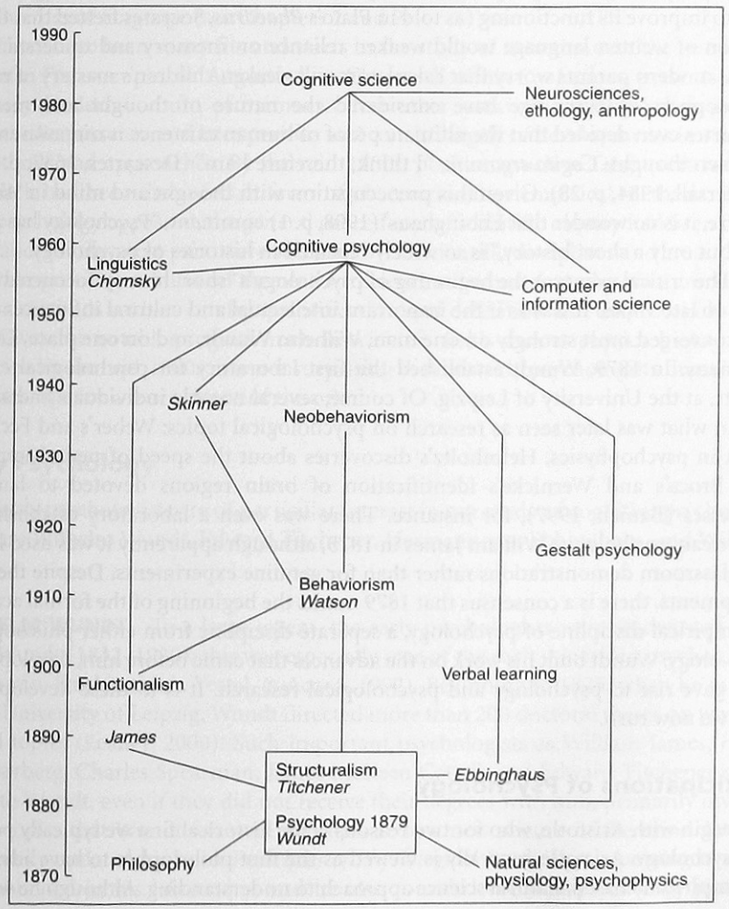


FIGURE 1-1

the main patterns of influence that produced cognitive psychology and cognitive science, with approximate dates shown along the side. As you read, study the figure to decide which pathways indicate positive influences and where ideas and questions from an earlier movement continued to inspire the approach that followed. Think also about the pathways that indicate negative influences, where a later approach specifically rejected elements of its predecessor.

To a remarkable extent, the scientific study of human memory and cognition is quite new. Although elements of our explanations, and certainly many of our experimental tasks, appeared even in the earliest years of psychology, the bulk of the work theorizing has been created since the 1950s. And yet, as is true of most topics in psychology, interest in human memory and cognitive processes is as old as recorded history. Aristotle, born in 384 BC, considered the basic principles of human memory and proposed a theory of memory in his treatise *De Memoria* (*Concerning Memory;* Hothersall, 1984). Even a casual reading of ancient works such as Homer's *The Iliad* or *The Odyssey* reveals that people have always wondered about how the mind works and how to improve its functioning (as told in Plato's *Phaedrus*, Socrates fretted that the invention of written language would weaken reliance on memory and understanding, just as modern parents worry that calculators will weaken children's mastery of math). Philosophers of every age have considered the nature of thought and memory. Descartes even decided that the ultimate proof of human existence is our awareness of our own thought: *Cogito ergo sum,* "I think, therefore I am" (Descartes, 1637, p. 52, in Hothersall, 1984, p. 28). Given this preoccupation with thought and mind in Western culture, it is no wonder that Ebbinghaus' (1908, p. 1) comment, "Psychology has a long past but only a short history," is so widely repeated in histories of psychology.

The critical events at the beginning of psychology's "short history" occurred in the mid- to late 1800s. It was as if the important intellectual and cultural influences of the day converged most strongly on one man, Wilhelm Wundt, and on one place, Leipzig, Germany. In 1879, Wundt established the first laboratory for psychological experiments, at the University of Leipzig. Of course, several notable individuals had already begun what was later seen as research on psychological topics: Weber's and Fechner's work in psychophysics, Helmholtz's discoveries about the speed of neural impulses, and Broca's and Wernicke's identification of brain regions devoted to language processes (Banich, 1997), for instance. There was even a laboratory established by American psychologist William James in 1875, although apparently it was used largely for classroom demonstrations rather than for genuine experiments. Despite these developments, there is a consensus that 1879 marks the beginning of the formal academic, empirical discipline of psychology, a separate discipline from either philosophy or physiology. Wundt built his work on the advances that came before him, developments that gave rise to psychology and psychological research. It is to these developments that we now turn.

Anticipations of Psychology

We begin with Aristotle, who for two reasons is the historical first we typically point to in psychology. Aristotle generally is viewed as the first philosopher to have advocated an empirically based, natural science approach to understanding. Although he was certainly not the only great thinker to have insisted on *observation as the basis for all science,* he was the first to express this fundamentally important idea—the position known as **empiricism**. Second, Aristotle's inquiry into the nature of thought and mind by his own natural science method led him to a reasonably objective explanation of how learning and memory take place. This explanation could not be considered a theory of memory by modern standards, nor should we expect it to be. On the other hand, the basic principle Aristotle identified, that of associations, has figured prominently in many psychological theories of the past century.

Equally important to psychology as a whole was *Aristotle's insistence that the mind is a "blank slate" at birth*, a ***tabula rasa***, or clean sheet of paper (Watson, 1968). This notion claims that the experiences of the individual are of paramount importance because experience, rather than inborn factors, "writes" a record onto the blank paper. It is possible that no other issue has so preoccupied philosophers of all ages, an issue we call the "nature versus nurture" or "heredity versus environment" debate. In cognitive psychology, we encounter the controversy in several places, most notably when we discuss theories of language (see Chapters 2 and 9).

There have been many fits and starts in the study of memory over the years since Aristotle. For example, St. Augustine, in Chapter X of his *Confessions*, presents a surprisingly modern account of memory. Most other anticipations of psychology date from the Renaissance and later periods and consist largely of developments in scientific methods and approaches. By the mid-1800s, positions such as Descartes's rational approach had been discarded in favor of observational or empirical methods. By the time psychology appeared, the general procedures of scientific inquiry had been developed and, for the most part, were accepted by all scientific disciplines and areas. There was widespread agreement on the need for science to be based on objective procedures and on methods such as careful quantification and definition and empirical observation. Given the notable progress made 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 true science of the mind.

Early Psychology

Four early psychologists are of particular interest in our study of cognitive psychology. They are Wilhelm Wundt, Edward Titchener, Hermann von Ebbinghaus, and William James.

WILHELM WUNDT To a large extent, the early psychologists were students of Wilhelm Wundt (1832–1920); this was especially true of the early American psychologists (Benjamin, Durkin, Link, Vestal, & Acord, 1992). Beginning in 1875, when he moved to the University of Leipzig, Wundt directed more than 200 doctoral theses on psychological topics (Leahey, 2000). Such important psychologists as William James, Hugo Munsterberg, Charles Spearman, James McKeen Cattell, and Edward Titchener studied with Wundt, even if they did not receive their degrees with him, primarily investigating topics that Wundt felt were appropriate to a new science of the mind. Wundt continually updated his book *Principles of Physiological Psychology*, reporting new results obtained in his laboratory, and he also founded the first psychology journal,

Wilhelm Wundt

Philosophical Studies (neither of these titles seems to match modern connotations of the terms). His influence was far reaching because his was the first truly psychological system. In fact, Leahey (1992b) credited Wundt with starting the only true scientific revolution in psychology.

Unfortunately, Wundt's interests in the last 20 years of his career went largely unrecognized until recently. His work on language, according to Leahey (2000), foreshadowed some modern insights to a remarkable degree but was largely ignored in his own time. And his work on child psychology and other applied topics (his term was *Volkerpsychologie,* or psychology of the people) was rejected; the influential Titchener, for instance, believed that these topics did not belong in psychology. American psychologists, never enthusiastic about contributions from Europe, may have found an additional excuse for their narrow and biased attitudes when Wundt became an enthusiastic German nationalist during World War I (Benjamin et al., 1992).

In terms of psychology, Wundt believed strongly that the proper topic of study for psychology was "conscious processes and immediate experience"; today, we would place these topics somewhere near the areas of sensation, perception, and attention. To study such processes in a scientific manner, in addition to the extensive use of response time measures, Wundt devised the method of *Selbst-Beobachtung.* Translated literally as "self-observation," this generally is known in English as **introspection**, *a method in which one looks carefully inward, reporting on inner sensations and experiences.* By all accounts, Wundt intended this to be a careful, reliable, and, above all else, scientific method. For instance, Hothersall (1984, pp. 88–89) noted, "Wundt's introspection was a rigidly controlled, arduous, experimental procedure. . . . To yield valid introspections Wundt insisted that certain rules be enforced: the observer had to be 'master of the situation,' in a state of 'strained attention.' . . . All observations were to be repeated many times; and finally, experimental conditions were to be varied systematically to allow a general description of mental contents." The observers in these experiments needed a great deal of training so that they would report only the elements of experience that were immediate and conscious. Reports in which memory intruded—Wundt's term was *mediate* or *mediated experience*—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 to direct its psychology laboratory. Titchener's work with Wundt had convinced him that psychology's knowledge was obtainable only with the introspection. As his career at Cornell progressed, Titchener became more dogmatic in his convictions and his definition of psychology. Topics like mental illness, educational applications, and social psychology (including Wundt's broader interests) were "impure" because they could not be studied with introspection. Like Wundt, Titchener insisted on careful control and rigorous training for his introspectors, who were required to avoid what he called "the stimulus error" of describing the physical stimulus rather than the mental experience of that stimulus. Moreover, "certain introspections were defined as correct, and certain others as in error, with the final authority being Titchener himself" (Hothersall, 1984, p. 105). By these means, Titchener studied *the structure of the conscious mind, the sensations, images, and feelings that were the very elements of the mind's structure.* He called this **structuralism**, the first major movement or school of psychological thought (see Figure 1-1).

Such an exclusive system was destined for difficulties. In particular, it seems (not just in retrospect) downright unscientific that a person, Titchener, would be the ultimate authority to validate the observations, instead of relying on more conventional methods (e.g., replication of results by other investigators). As other researchers applied the introspective methods in their own laboratories, differences and contradictory results began to crop up. For instance, a controversy developed over "imageless thought" (see Leahey, 2000, for example). Researchers of the Würzburg School found evidence of imageless thought in their studies. When Titchener found no such evidence in his own studies, he claimed that the Würzburg researchers' findings were wrong, merely the product of sloppy methods and poorly trained observers. (In a similar dispute over sensory and motor reaction times, Titchener's methodological criticism was that the participants had been untrained observers. He would surely have disapproved of modern insistence on naive volunteers from Intro Psych.) These disputes, along with other developments, hastened the decline of Titchener's once-powerful structuralism.

HERMANN VON EBBINGHAUS In contrast to the structuralism of Wundt and Titchener, there was the theoretically modest but eventually more influential work of Hermann von Ebbinghaus (see Chapter 6). Ebbinghaus was a contemporary of Wundt in Germany, although he never studied with Wundt in person. In fact, Ebbinghaus' achievements in memory and forgetting are all the more impressive because he worked outside the establishment of the time. Watson (1968) noted that Ebbinghaus was familiar with Wundt's writings but, if anything, viewed Wundt's pessimism about studying higher mental processes as a challenge rather than a deterrent to pursuing that work. 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 serving in a nonpsychological academic position with no similar-minded colleagues, Ebbinghaus was forced to rely on his own resources to study memory, even to the extent that he alone served as a subject in his research. Ebbinghaus' goal was to study memory, using thoroughly objective methods. He reasoned that for this goal to be accomplished, he needed to use materials that had no preexisting associations. Thus the first step in his method involved constructing stimulus lists of *nonsense syllables,* consonant–vowel–consonant (CVC)

trigrams that, by definition, had *no* meaning whatsoever. Ebbinghaus would learn a list (e.g., of 16 items) to an arbitrary criterion of mastery (e.g., two perfect recitations), then set the list aside. On a later occasion, he would relearn the same list, noting how many fewer trials he needed to relearn the list to the same criterion. His measure of learning in these studies was the "savings score," the number (or proportion) of trials that had been saved in memory between the first and second sessions. By this method, Ebbinghaus examined forgetting as a function of time that intervened between the two learning sessions, 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' methods and results, described in his 1885 book, were acclaimed widely as the very model of scientific inquiry into the processes of memory; for instance, Titchener praised Ebbinghaus' work as the most significant progress in studying associations since Aristotle (1919; cited in Hall, 1971). It is difficult to point to another psychologist of his day, aside from Freud, whose specific contributions or methods continue to be used. It is certainly true that the field of verbal learning, throughout the 20th century, owed a great deal to Ebbinghaus; after all, he was the first to invent a reasonably scientific, enduring method to study memory and mental processes. The Ebbinghaus tradition, depicted in Figure 1-1, is one of the strongest of all the influences on cognitive psychology. Perhaps no other influence in the figure is as positive as this century-old tradition begun by Ebbinghaus.

William James

WILLIAM JAMES American philosopher and psychologist William James, a contemporary of Wundt, Titchener, and Ebbinghaus, provided at Harvard an alternative to Titchener's rigid system. His approach to psychology was strongly influenced by the writings of Darwin, and was a kind of **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 on a variety of topics. To note one of interest to us, he proposed that memory consists of two parts: an immediately available memory of which we are currently aware and a larger memory, usually hidden or passive, that is the repository for past experience. The notion of memory being divided into several parts, based on their different functions, is popular today. Indeed, the first serious models of human information processing, in the 1950s and 1960s, included the two kinds of memory James discussed in 1890.

Probably because of his personal distaste for experimentation and his far-reaching interests, James seems not to have espoused the Ebbinghaus methods of studying memory, although he apparently had high regard for that work. Titchener dismissed James as a "half hearted" researcher (Boring, 1950), and—worse yet—interested in topics Titchener found inappropriate. Ultimately, however, James's far-reaching thoughts and proposals were far more influential to psychology than any of Titchener's work (see Miller's introduction to the 1983 edition of James's classic 1890 book *Principles of Psychology*).

Given other developments at the time, however, James's influence on the psychology of human memory and cognition was delayed, for it was John B. Watson, in 1913, who stridently solidified the new direction American psychology was taking, a direction that specifically rejected both the structuralist and functionalist approaches as well as many of their concerns. This new direction was behaviorism.

Behaviorism and Neobehaviorism

It is a mistake to suggest that all American psychology from 1910 through the 1950s was completely behaviorist. During this time, the fields of clinical, educational, and social psychology, to name a few, continued in their own development, pursuing their own agendas. In a sense, other branches of psychology developed parallel to behaviorism; they were contemporary fields with little contact or mutual influence. Furthermore, Leahey (2000) noted that there were significant changes within behaviorism itself, changes that eventually smoothed the transition to cognitive psychology; Leahey called it "mediated neobehaviorism," meaning that there were some unobservable, mediating variables included in neobehaviorism's theorizing. Nonetheless, experimental psychology traditionally has been the discipline of researchers concerned with learning, memory, perception, thought, and related topics. These psychologists, mostly in academic settings, were responsible for the birth and rearing of behaviorism and for its eventual dominance in American experimental psychology.

Everyone who has taken introductory psychology knows of John B. Watson, the early behaviorist who offered, "Give me a dozen healthy infants, well-formed, and my own specified world to bring them up in and I'll guarantee to take any one at random and train him to become any type of specialist I might select—doctor, lawyer, artist, merchant, chief and, yes, even beggarman and thief, regardless of the talents, penchants, tendencies, abilities, vocations, and race of his ancestors" (Watson, 1924, p. 104). Although Watson admitted in his very next sentence that he was exaggerating, he made it clear that he viewed experience as the primary factor in determining even the largest aspects of one's behavior. Rarely in the history of science has anyone taken so extreme a position on the nature versus nurture issue as Watson. (Histories of psychology note that this extreme position of "environmentalism" was not typical of his early, scholarly works but only of his later writings.)

Watson's firm belief, stated unequivocally in his 1913 "manifesto," was that observable, quantifiable behavior was the proper topic of psychology, not the fuzzy and unscientific concepts of thought, mind, and consciousness. He viewed attempts to understand the "unobservables" of mind and thought as inherently and hopelessly unscientific, and 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 here for hidden mental processes because behavioral laws were supposed to relate observable behavior to objective, observable stimulus conditions within the environment. To Watson, being a doctor was a matter of learning appropriate "doctor behaviors." No appeal to the mind, to innate abilities, or to

mental activities was necessary, and no important limitations on the learning process were acknowledged.

Why did such a radical redefinition of psychology's interests have such broad appeal, gain so many adherents, and become so dominant? There is no doubt that part of the enthusiasm for a psychology of behavior was a result of the work that Pavlov and others were doing on conditioning and learning. Here was a definite, scientific approach that was going somewhere, in contrast to the seemingly endless debates in structuralism. (Strangely, Watson seems to have been unaware of Ebbinghaus' careful, empirical studies of learning and memory, work that even the dogmatic Titchener saw as valuable.) Furthermore, the measurement and quantification that accompanied behaviorism mirrored the already successful sciences such as physics. By modeling psychology on their methods and quantification, psychology might also gain acceptance as a true science as well (Leahey, 2000, calls this mentality "physics envy").

Beginning in the late 1890s, the new behaviorism attracted many practitioners and adherents (Leahey, 2000). In a very real sense, Watson's 1913 article was not a rallying cry but a final statement of behaviorist triumph. However, not all psychologists were eager to climb on this bandwagon. Naturally, some took an early wait-and-see attitude. For instance, Titchener's loyal student Edwin G. Boring, whose definitive book, *History of Experimental Psychology*, appeared in 1929, condescended in his preface that behaviorism was "as yet undignified by the least trace of antiquity." However, in his 1950 edition, Boring admitted that "for a while in the 1920s it seemed as if all America had gone behaviorist" (p. 645, although this admission is contained in a chapter somewhat pejoratively called "Behavioristics"). And other research traditions, especially the verbal learning tradition begun by Ebbinghaus, continued along as well. But these traditions were "second-class citizens" as behaviorism's emphasis on observable stimuli and responses came to dominate American experimental psychology. Two of behaviorism's greatest legacies to modern psychology were its emphasis on methodological rigor in its experiments and the reliance on observables, methodological traditions continued to this day.

This period of behaviorism and then neobehaviorism was one of inactivity for cognitive psychology. For instance, the word most commonly used to describe Watson is *antimentalistic*. Any concept or idea that smacked of mentalism, such as consciousness, memory, or mind, was to be excluded from psychology. This restriction in the scope of psychology, in hindsight, seems almost a willful blindness to the existence of obviously important phenomena. And it certainly produced some curious and convoluted explanations. For instance, because of the need to explain such ostensibly mental activities as thought and language in nonmentalistic terms, Watson developed the notion of implicit behavior. Implicit or covert behavior was said to be a reduced, inner version of the normally observable behavior that psychology investigated. Thus "thought" to Watson was "nothing more than subvocal talking or muscular habits learned in overt speech which become inaudible as we grow up" (Watson, 1968, p. 427).

Although a few psychologists continued to pursue cognitive topics—Bartlett of Great Britain is a notable example—the most visible part of American experimental psychology focused on observable, learned behaviors, especially in animals (but see Dewsbury, 2000, for the rich history of research on animal cognition during the behaviorist period). Even the decidedly 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, and interpretation based closely on the observable stimuli in an experimental situation. Gestalt psychology, which emigrated 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 loyalties of many American experimentalists (although we look back now at some of their research with greater respect).

Thus the behaviorist view continued to dominate American experimental psychology until the 1940s, when B. F. Skinner emerged as one of its most vocal, even extreme, advocates. Much 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, necessarily, but that they are unobservable and hence unnecessary to a scientific explanation of behavior.

Dissatisfaction with Behaviorism: The Winds of Change

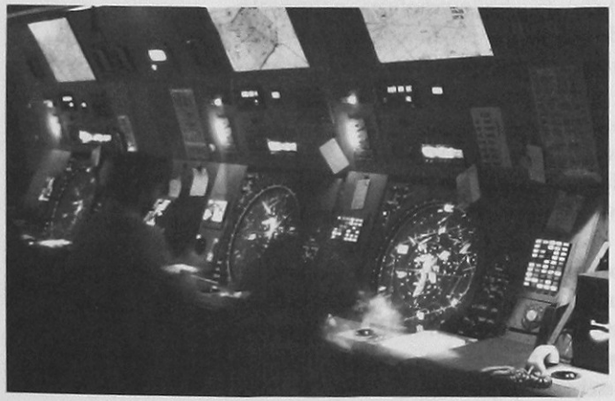
As we saw earlier, it is difficult, if not impossible, to determine precisely when historical change takes place, when a movement or trend gains sufficient recognition to be proclaimed a *fait accompli*. 1879 saw the founding of academic, empirical psychology, yet we point to important research, and even to books with "psychology" in their titles, that predate 1879. Watson's 1913 article has been called the manifesto that instituted behaviorism, yet it is more properly viewed as the culmination of two decades of gradually shifting allegiances.

It is even more difficult to pinpoint historical change when it is recent. Many psychologists look kindly on the idea that there was a cognitive revolution in the mid- to late 1950s, an abrupt change in research activities, interests, and scientific beliefs on the part of experimentalists, a definitive break from the previously dominant behaviorism (Baars, 1986). However, several psychologists disagree; see Leahey (1992a, p. 458), who suspected that such talk was largely a kind of "radical chic" more appropriate to the 1960s. Regardless of the debate, it is indisputably true that the experimental psychology of today is quite different from that of the 1940s and 1950s. Psychology seemed to "lose its mind" during behaviorism's day in the sense that memory, thought, and other mental activities were largely ignored. Conversely, our psychology of today has "come back to its senses"—and to its memory and mental activities as well.

Because of the nature and scope of these changes, many psychologists regard the current cognitive approach as a revolution, a revolution in which behaviorism was rejected because of its lack of progress on—or even interest in—important questions. It was replaced with cognitive psychology and the information-processing approach. Lachman et al. (1979) provided an especially compelling account of the cognitive revolution from the standpoint of Kuhn's (1962) classic work on the history of science. However, some historians claim that the cognitive revolution was not a true scientific revolution at all but merely "rapid, evolutionary change" (see Leahey, 1992b, for this lively counterargument). In either case, the years from 1945 through 1960 were a period of crisis for American neobehaviorism and of rapid reform in the thinking and research of experimental psychologists. The serious challenges to neobehaviorism came

both from within its own ranks and from outside, prodding psychologists toward the new direction to be taken.

CHALLENGES AND CHANGES: THE 1940S AND 1950S To neobehaviorism, the ultimate importance of learning—the acquisition of new behaviors by means of conditioning—was the central article of faith; learning *was* psychology. Although some behaviorists paid lip service to the notion of instincts, species-specific behaviors, and other nonlearned sorts of behavior, none of the important theories of learning gave serious consideration to these ideas. Speaking anthropomorphically, we find that the animal subjects often thumbed their noses at such theoretical purity and behaved according to their own laws. Researchers began finding significant instances in which conditioned behaviors, supposedly under the control of reinforced learning, began to change in the direction of instinctive behavior. For instance, "the Brelands found instances in which animals did not perform as they should. In 1961, they reported their difficulties in a paper whose title, 'The Misbehavior of Organisms,' puns on Skinner's first book, *The Behavior of Organisms.* For example, they tried to teach pigs to carry wooden coins and deposit them in a piggy bank (how cute!). Although they could teach behaviors, the Brelands found that the behavior degenerated in pig after pig. The animals would eventually pick up the coin, drop it on the ground and root it . . . [as if] 'trapped by strong instinctive behaviors' that overwhelm learned behaviors" (Leahey, 2000, p. 501). Garcia's work (Garcia, McGowan, & Green, 1972) on conditioned nausea led to similar conclusions. Rather than associating the current environment with beginning to feel sick, rats correctly associated the nausea with the fluid they'd drunk an hour earlier, a sensible instinctive outcome that contradicted behaviorism's laws.



For behaviorism, committed to the *tabula rasa* position that exalts learned behaviors, these were serious difficulties. No ready explanation by means of the principles of reinforced learning was available to account for instinctive drift or for the fact that the immediately present stimulus was less important than the fluid that actually induced nausea. Incorporating instincts into the theories would have been a blunt admission that the laws of conditioning and learning were not general, that they were modified by other overpowering, central factors. To make matters worse, Skinner asserted that a theory of behavior was not even necessary, finding theory building to be a distraction from the main business of gathering data. Such a position seemed to undermine the intense efforts that had been exerted in developing and testing theoretical positions such as Hull's (1943) and Tolman's (1948). What an unpleasant time to have been a behaviorist, beset by significant nonlearned behaviors, unresolvable theoretical disputes, and a position that asserted that theorizing was a waste of time!

WORLD WAR II Lachman et al. (1979) made an additional point about this growing dissatisfaction within the ranks of the neobehaviorists. They noted that many academic psychologists were involved with the U.S. war effort during World War II, in one capacity or another. 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.

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 these practical concerns, wartime psychologists were forced to conceive of human behavior differently. The concepts of attention and vigilance, for instance, were important to an understanding of sonar operators' performance; experiments on the practical and then theoretical aspects of vigilance began (see especially Broadbent, 1958, Chapter 6, and Wickens, 1984, on the emergence of human factors as a distinct area of psychology). Decision making was a necessary part of this performance, too, and from these considerations 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 new outlooks and perspectives on human behavior were gained. They had seen firsthand how empty the behaviorist toolbox was and how other approaches held promise for their own work. 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 sometimes words.* Earlier, the groundbreaking research of Hermann von Ebbinghaus was mentioned, in which objective methods for studying human memory were invented and used. This work started the verbal learning tradition within experimental

psychology (see Chapter 6), which derives its name from the behaviorist context in which it found itself. Verbal learning was defined as the use of verbal materials in various learning paradigms. Even casual examination of published articles during the 1920s and 1930s reveals a fairly large body of verbal learning research, with reasonably well-established methods and procedures. Tasks such as serial learning, paired-associate learning, and to an extent free recall were the accepted methods of investigation, using Ebbinghaus-inspired nonsense syllables.

Verbal learners held many beliefs similar to the behaviorists. For example, verbal learners agreed on the need to use objective methods; although an occasional allusion to introspections was made, this was usually in the sense that they "confirmed" the conclusions drawn from more objective measures. 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 proposed a number of concepts that are widely accepted today. For example, a great deal of verbal learning was oriented around providing accounts of interference among related but competing items that had been learned in the experiment. They were "behavior*alists*," in Leahey's (1992b) description, committed to the methods of observing behavior but not bound to the "empty organism" view of radical behaviorism.

Lachman et al. argued that this more moderate view in verbal learning circles made it easy for psychologists to accept the new cognitive psychology of the 1950s and 1960s: There were many indications in their results that an adequate psychology of human learning and memory needed more than just observable behaviors. For instance, the presence of meaningfulness in almost any "nonsense" syllable 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 the experiments, to avoid contamination of the results. Later, it became apparent that the memory processes that yielded those associations were more interesting to study than to control. Hall (1971) called this the "new look" in verbal learning, with its greater emphasis on memory rather than on learning processes.

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

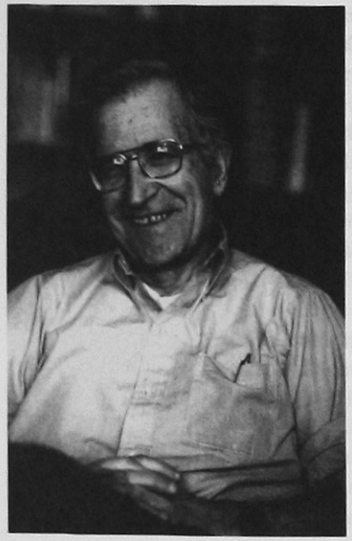
Another outstanding achievement of the verbal learning tradition was the derivation and refinement of laboratory tasks for learning and memory that remain useful today. In acceptance of the need for objective procedures and methods, the verbal learners borrowed from Ebbinghaus' example of careful attention to rigorous methodology. From this they developed tasks that seem to measure the outcomes of mental processes in valid and useful ways. Some of these tasks were more closely associated with behaviorism than others, such as the paired-associate learning task. Because these tasks lent themselves to tests of S–R associations in seemingly direct ways, they became somewhat overused. (Some have noted the popularity of the paired-associate task and the verbal learners' tendency to study performance on the task rather than the principles of human memory revealed by the task. One of our professors likened this situation to "an archaeologist who studies his shovel.") Nonetheless, verbal learning gave cognitive psychology an objective, reliable methodology for studying mental processes; research that was built upon later (e.g., Stroop, 1935); and a set of inferred processes such as storage and retrieval to investigate. Therefore, the influence of verbal learning on cognitive psychology, as shown in Figure 1-1, was almost entirely positive.

LINGUISTICS The changes in verbal learning from its early work to around 1960 seem to have been a gradual evolutionary shifting of interests and interpretations that blended almost seamlessly into cognitive psychology. In sharp contrast, 1959 saw the publication of an explicit, defiant challenge to behaviorism. Watson's 1913 article has been called a behaviorist manifesto, crystallizing the view against introspective methods and those who practiced them. To an equal degree, Noam Chomsky's 1959 article was a cognitive manifesto, an utter rejection of purely behaviorist explanation of the most human of all behaviors: language.

A bit of background is needed to appreciate the significance of Chomsky's article (see Leahey's Chapter 14, titled "Years of Turmoil," for an amplified version of this story). In 1957, B. F. Skinner published a book titled *Verbal Behavior*, a treatment of human language from the radical behaviorist standpoint of reinforcement, stimulus–response associations, extinction, and so on. His central point was that the psychology of learning, that is, the conditioning of new behavior by means of reinforcement, provided a useful and scientific account of human language. In oversimplified terms, Skinner's basic notion was that human language, "verbal behavior," followed the same laws of learning that had been discovered in the animal learning laboratory: A reinforced response is expected to increase in frequency, a nonreinforced response should extinguish, a response conditioned to a certain stimulus should be emitted to the same stimulus in the future, and so on. In principle then, human language, obviously a learned behavior, could be explained by the same sort of mechanism, with knowledge of the current reinforcement contingencies and past reinforcement history of the individual.

Noam Chomsky, a linguist at the Massachusetts Institute of Technology, reviewed Skinner's book in the journal *Language* in 1959. The very first sentence of his review notes that many linguists and philosophers of language "expressed the hope that their studies might ultimately be embedded in a framework provided by behaviorist psychology" and therefore were interested in Skinner's formulation. Chomsky alluded to Skinner's optimism that the problem of verbal behavior would yield to behavioral analysis because the reinforcement principles discovered in the animal laboratory "are now fairly well understood . . . [and] can be extended to human behavior without serious modification" (Skinner, 1957, cited in Chomsky, 1959, p. 26).

But by the third page of his review, Chomsky stated that "the insights that have been achieved in the laboratories of the reinforcement theorist, though quite genuine, can be applied to complex human behavior only in the most gross and superficial way.



Noam Chomsky

. . . The magnitude of the failure of [Skinner's] attempt to account for verbal behavior serves as a kind of measure of the importance of the factors *omitted* from consideration" (p. 28, emphasis added). The fighting words continued. Chomsky asserted that if the critical terms *stimulus, response, reinforcement*, and so on are used in their technical, animal laboratory sense, then "the book covers almost no aspect of linguistic behavior" (p. 31) of interest. His central theme was that Skinner's account used the technical terms in a nontechnical, metaphorical way, which "creates the illusion of a rigorous scientific theory [but] is no more scientific than the traditional approaches to this subject matter, and rarely as clear and careful" (pp. 30–31).

To illustrate his criticism, Chomsky noted the careful operational definitions that Skinner provided in the animal learning laboratory, such as for the term *reinforcement*. But unlike the distinct and observable pellet of food in the Skinner box, Skinner claimed that reinforcement for human verbal behavior could even be administered by the person exhibiting the behavior, that is, self-reinforcement. In some cases, Skinner continued, reinforcement could be delayed for indefinite periods or never be delivered at all, as in the case of a writer who anticipates that her work may gain her fame for centuries to come. When an explicit and immediate reinforcer in the laboratory, along with its effect on behavior, is generalized to include nonexplicit and nonimmediate (and even nonexistent) reinforcers in the real world, it truly does seem, as Chomsky argued, that Skinner had brought along the vocabulary of a scientific explanation but left the substance behind. As Chomsky bluntly put it, "A mere terminological revision, in which a term borrowed from the laboratory is used with the full vagueness of the ordinary vocabulary, is of no conceivable interest" (p. 38). The explanation was merely dogmatic, not at all scientific.

Chomsky's own position on language, emphasizing the novelty of human language and the internal rules for language use, is discussed in Chapter 9; there, the influence of linguistics on cognitive psychology (Figure 1-1) is described in some detail. For now, the essential message involves the impact of Chomsky's review on experimental psychology (not to mention the impact on linguistics itself; see Wasow, 1989). As Lachman et al. (1979) note, this dispute could not easily be dismissed. Language *was* an important behavior—and a learned one at that—to be understood by psychology. A dominant approach that offered no help in understanding this was useless, not to mention embarrassing.

To a significant number of people, Chomsky's arguments summarized the dissatisfactions with behaviorism that had become so apparent. For these people, the irrelevance of behaviorism to the study of language, and, by extension, the study of any significant human behavior, was now painfully obvious. In combination with the other developments, the wartime fling with mental processes, the expansion of the catalog of such processes by verbal learning, and the disarray within behaviorism itself, it was clear that the new direction for psychology, growing in influence throughout the 1950s, would take hold.

Section Summary

- The modern history of cognitive psychology began in 1879 with Wundt and the beginnings of experimental psychology as a science.
- The behaviorist movement rejected the use of introspections and substituted the study of observable behavior.
- Modern cognitive psychology, which dates from approximately 1960, rejected much of the behaviorist position but accepted its methodological rigor. Many diverse viewpoints, assumptions, and methods converged to help form cognitive psychology, including those from verbal learning, linguistics, and computer science. This was at least a rapid, evolutionary change in interests, if not a true scientific revolution.

COGNITIVE PSYCHOLOGY AND INFORMATION PROCESSING

The New Direction

If we had to pick a date that marks the beginning of cognitive psychology, we might pick 1960. This is not to say that significant developments in the study of cognition were not present before this date, for they were. This is also not to say that most experimental psychologists who studied humans became cognitive psychologists that year, for they did not. As with any major change, it takes a while for the new approach to catch on, for people to learn the new rules, to feel free to speak the new language, and, indeed, to decide that the new direction is worth following (some decided it was not worth following; see Skinner, 1984, 1990, for example). Several significant events clustered around 1960, however, events we look back on from our period of hindsight as having been significant departures from the mainstream that came before. Just as 1879 is considered the formal beginning of psychology and 1913 the beginning of behaviorism, so 1960 seems to approximate the beginning of cognitive psychology in its modern form.[2]

Let's pick up the threads of what came before this date, to see what the new cognitive psychology and information processing approaches were all about. One of the most significant threads was Chomsky's 1959 review; such a forceful argument against a purely behaviorist position could not be—and was not—ignored. Chomsky argued that the truly interesting part of human language, indeed the very key to understanding it, was exactly what Skinner had omitted from his book: mental processes and cognitive structures. Chomsky also argued that language users follow rules when they

[2]Gardner (1985, p. 28) stated, "There has been nearly unanimous agreement among the surviving principals that cognitive science was officially recognized around 1956. The psychologist George A. Miller ... has even fixed the date, 11 September 1956." Miller recalled a conference from September 10 to 12, 1956, at MIT, attended by leading researchers in communication and psychology. On the second day of the conference, there were papers by Newell and Simon on the "Logic Theory Machine," by Chomsky on his theory of grammar and linguistic transformations, and by Miller himself on the capacity limitations of short-term memory. Others whom Gardner cited suggest that, at a minimum, the five-year period 1955 to 1960 was the critical time during which cognitive psychology emerged as a distinct and new approach. By analogy to psychology's selection of 1879 as the starting date for the whole discipline, 1960 is special in Gardner's analysis: In that year, Jerome Bruner and George Miller founded the Center for Cognitive Studies at Harvard University.

generate language, rules that are stored in memory, cognitive structures operated on by mental processes. The so-called empty organism psychology of stimulus–response connections was empty in the sense that behaviorists did not deal with properties of the organism that come between the physical stimulus and the behavioral response. In Chomsky's view, it was exactly there, *in* the organism, that the key to understanding language would be found.

To a large extent, researchers in verbal learning and other fields were making the same claim. As noted, Bousfield (1953) found that people cluster or group words together on the basis of the associations among them. Memory and a tendency to reorganize on the part of the person clearly were involved in this performance. Where were these associations? Where was this memory? And where was this tendency to reorganize? They were in the person, of course, in human memory and mental processes. A particularly clear statement of the involvement of a person's mental processes appeared in Tulving's 1962 article, "Subjective Organization in Free Recall of 'Unrelated' Words." Even when the words to be learned were unrelated, people still reorganized them, a strategy for recall that was clearly coming from within.

During the 1950s, there were reports on human attention, first from British researchers such as Cherry and Broadbent, that were thematically related to the wartime concern with attention and vigilance. Again, fascinating attention and perceptual processes were being isolated and investigated, processes whose unseen, mental nature could not be denied and yet whose existence could not be denied either. A classic paper in this area, Sperling's monograph on visual sensory memory, appeared in 1960. (MacLeod, 1992, noted that there was a marked increase around 1960 in citations to the rediscovered Stroop [1935] task.)

Possibly the single most startling development of this period, certainly in terms of its impact on society, was the invention of the modern digital computer. Initial work had begun in the 1930s and 1940s on what we now call computer science, although philosophers had conceived of such a machine in general terms long before the technology existed to build one (e.g., Haugeland, 1985). At some point during the 1950s, a few psychologists realized the possible relevance of computing to issues in psychology. It dawned on psychology, in a sense, that in some interesting and possibly useful ways, computers behave much like people (not surprising, according to Norman, 1986, p. 534, because "the architecture of the modern digital computer . . . was heavily influenced by people's naive view of how the mind operated"). They take in information, do something with it internally, then eventually produce some observable product. The product gives clues to what went on during the internal phase. The various operations performed by the computer were not unknowable merely because they occurred internally. They were under the direct control of the computer program, the instructions given to the machine to tell it what operations to perform.

The realization that human mental activity might be understood by analogy to the seemingly intelligent (or at least intelligent-acting) machine was a significant breakthrough. The computer provided an existence proof for the idea that unobservable processes could be reliably studied and understood. Especially important was the notion of symbols and their internal manipulation. That is, the computer is a symbol-manipulating machine; its operation involves interpreting the symbols fed to it in the computer program, then performing the operations that those symbols specify. The

insight that the human mind might also be fruitfully considered as a symbol-manipulating system usually is attributed to Allen Newell and Herbert Simon. According to Lachman et al. (1979), their conference in 1958 had a tremendous impact on those who attended, for at this conference Newell and Simon presented an explicit analogy between information processing in the computer and information processing in humans. This important work, probably as much as anything Simon did in the field of economics, was the basis for the Nobel Prize awarded to him in 1978 (see Leahey, 2003, for a full account of Simon's contributions).

Among the many indirect results of this conference was the 1960 publication of a book by Miller, Galanter, and Pribram called *Plans and the Structure of Behavior.* The book suggested that human problem solving could be understood as a kind of planning in which mental strategies or plans guide behavior toward its eventual goal. Why was this book viewed as a scientific contribution, involving as it did such mentalistic ideas as plans, goals, and strategies? Because the mentalistic plans, goals, and strategies were not just unobservable, hypothetical ideas. Instead, they were ideas that in principle could be exactly specified, in a program running on a lawful, physical device: the computer. (We will have much more to say about computers and computer models of cognition throughout the book.)

The Assumptions of Cognitive Psychology

We turn finally to three assumptions that pervade cognitive psychology: that mental processes exist, that they can be studied scientifically, and that people are active information processors.

MENTAL PROCESSES EXIST Surely by now you have figured out the single most defining feature of cognitive psychology: a scientific interest in human mental activity and processes. Whereas the behaviorists intentionally avoided any theorizing about the higher mental processes, these processes are exactly what cognitive psychology investigates. Our most basic assumption in cognitive psychology is that mental processes exist, that they are absolutely key to a complete, useful psychology.

MENTAL PROCESSES CAN BE STUDIED SCIENTIFICALLY Not only do mental processes exist, but their very reality means that they are an appropriate topic for scientific inquiry. That is, we believe that an objective, scientific study of mental processes can be accomplished and is exactly the province of the science of psychology. In science, saying that a phenomenon or effect exists in physical reality is basically the same as saying that it can be studied by the objective, quantifiable methods of scientific practice. By saying that mental processes exist, we are also claiming that they are lawful, systematic events and that they can be studied.

We are very mindful of the checkered history of investigations into the higher mental processes. We fault the structuralists, such as Wundt and Titchener, not for their interests but for their methods. Our biggest lesson from the behaviorist era, and also from the example set by verbal learning, was about scientific methods and procedures. Unlike the structuralists, cognitive psychology relies on measures of behavior that are as objective and reliable as possible. That is, we attempt to unravel the complex questions of mental activity with tasks and measures of behavior that are quantifiable,

open to scientific scrutiny, easily replicated by other investigators, and faithful to the scientific empirical tradition. As best we can, we avoid measures that are colored by subjective bias or influence, as the old introspectionism was.

ACTIVE INFORMATION PROCESSORS A third basic assumption, implied by the first two, is the idea that humans are active participants in the act of cognition. Miller (cited in Pylyshyn, 1984) called us *informavores,* beings that actively obtain and process information (in fact, Miller was referring to all information-processing systems by that term, even the kind built with silicon chips). The behaviorist, in contrast, viewed the subject as a largely passive creature, one who waited around for a stimulus to occur, then responded to it in ways determined by previous conditioning and current stimulus conditions.

Cognitive psychology rejects this behaviorist outlook. We believe that humans actively process the stimuli around them, selecting some parts of that environment for further processing, relating those selected parts to information already stored in memory, and then doing something as a result of processing. And if no external stimulation is present, we occupy ourselves with internal, mental stimulation. (To prove the point, try this: Stop reading for a moment and try to keep your mind completely inactive and blank for a full minute—no thoughts, recollections, or even daydreams.)

We believe that people do not passively respond on the basis of simple conditioning or reinforcement. Instead, people respond actively on the basis of their mental processing of events and information. And, as you saw in the examples at the beginning of the chapter, an enormous amount of mental activity can underlie even very simple question answering. All this mental processing is evidence of the active nature of people and their cognitive processes.

These three features form the core of cognitive psychology: our assumptions that human mental activities exist, that those activities can be studied scientifically, and that the person doing the relevant mental activities is an active information processor. These ideas have a *metatheoretical* status in cognitive psychology. That is, they are above and beyond any particular theory of cognitive processes; they are so central to our discipline that they are assumed to be true. It is the various implications drawn from them that are tested in our experiments.

Section Summary

- The three most basic assumptions of cognitive psychology are that mental processes exist, they can be studied scientifically, and humans are active information processors.

Key Terms

behaviorism (p. *17*)
cognition (p. *9*)
cognitive science (p. *2*)
ecological validity (p. *10*)
empiricism (p. *13*)
functionalism (p. *16*)
introspection (p. *14*)
memory (p. *9*)
reductionism (p. *10*)
structuralism (p. *15*)
tabula rasa (p. *13*)
verbal learning (p. *21*)