CHAPTER 18

Cognitive Psychology

Cognitive psychology includes such topics as memory, concept formation, attention, reasoning, problem solving, judgment, and language. Clearly cognitive psychology is very popular within contemporary psychology. However, in psychology's long history some form of cognition has almost always been emphasized. The few exceptions included the materialistic philosophies or psychologies of Democritus, Hobbes, Gassendi, La Mettrie, Watson, and Skinner, which denied the existence of mental events. The schools of voluntarism and structuralism concentrated on the experimental study of cognition, and the school of functionalism studied both cognition and behavior. The supposed sterility of the research on cognition performed by members of these schools prompted Watson to create the school of behaviorism. Thus to say, as is common, that psychology is *becoming* more cognitively oriented is inaccurate, because with only a few exceptions it has always been cognitively oriented. But there was a period from about 1930 to about 1950 when radical behaviorism was highly influential, and when it was widely believed that cognitive events either did not exist or, if they did, were simply by-products (epiphenomena) of brain activity and could be ignored. As long as these beliefs were dominant, the study of cognitive processes was inhibited.

We mention here only a few of the people and events that helped loosen the grip of radical behaviorism, thus allowing cognitive psychology to gain its current popularity. For more see, for example, Mahoney, 1991, pp. 69–75.

Developments before 1950

Throughout most of psychology's history human attributes were studied philosophically. J. S. Mill (1843/1988) set the stage for psychology as an experimental science and encouraged the development of such a science. Fechner (1860/1966) took Mill's lead and studied cognitive events (sensations) *experimentally*. Ebbinghaus (1885/1964), under the influence of Fechner, studied learning and memory experimentally. William James's *The Principles of Psychology* (1890) cited considerable research on cognition and suggested many additional research possibilities. Sir Frederick Charles Bartlett (1886–1969), in *Remembering: A Study in Experimental and Social Psychology* (1932), demonstrated how memory is influenced more by personal, cognitive themes or schema than by the mechanical laws of association. In other words, he found that information is always encoded, stored, and recalled in terms of an individual's preconceptions and attitudes.

As early as 1926 Jean Piaget (1896–1980) began publishing research on intellectual development. During his long life Piaget published more than 50 books and monographs on genetic epistemology or developmental intelligence. In general, Piaget demonstrated that a child's interactions with the environment become more complex and adaptive as its cognitive structure becomes more articulated through maturation and experience. According to Piaget, the cognitive structure comprises schemata that determine the quality of one's interactions with

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the environment. For the young child, these schemata are sensory motor reflexes that allow only the most rudimentary interactions with the environment. With maturation and experience, however, the schemata become more cognitive and allow increasingly complex (intelligent) interactions with the environment. For Piaget, it was always the schemata contained within the cognitive structure that determine what kinds of interactions with the environment are possible. Piaget's theory followed the rationalistic rather than empiricistic tradition. More particularly, because it stressed the importance of schemata for determining a person's reality, it followed the Kantian tradition. Piaget wrote books about the child's conceptions of causality, reality, time, morality, and space, all showing the influence of Kant's proposed categories of thought. It is interesting to note that Piaget was an even more prolific writer than Wundt. In chapter 9 we noted that Wundt published 53,735 pages in his lifetime, or 2.20 pages a day; Zusne and Blakely (1985) report that Piaget published 62,935 pages in his lifetime, or 2.46 pages a day.

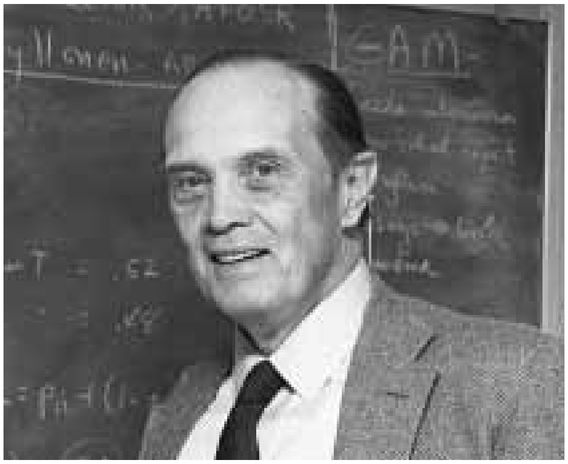
As we have seen, Gestalt psychology and radical behaviorism were created about the same time (1912 and 1913, respectively), and the cognitively oriented Gestalters were a constant thorn in the side of the behaviorists. Also, during the 1930s and 1940s, methodological behaviorists such as Hull and Tolman were willing to postulate events that intervene between stimuli (S) and responses (R). For Hull, these intervening variables are mainly physiological, but for Tolman they are mainly cognitive.

In 1942 Carl Rogers (1902–1987) published *Counseling and Psychotherapy: Newer Concepts in Practice* that challenged both radical behaviorism and psychoanalysis by emphasizing the importance of conscious experience in the therapeutic situation. In 1943 Abraham Maslow (1908–1970) first proposed his theory of human motivation based on the hierarchy of needs. In spite of the efforts of individuals such as Rogers and the popularity of behaviorism during the 1920s, 1930s, and 1940s, psychoanalysis remained very influential, especially among clinical psychologists and psychiatrists. Donald Hebb (1904–1985) was an early critic of radical behaviorism and did much to reduce its influence. In his book *The Organization of Behavior* (1949), Hebb not only sought biological explanations of behavior but also urged the study of cognitive processes. As we shall see in chapter 19, Hebb continued to encourage the development of both physiological and cognitive psychology in the 1950s and 1960s. In 1949 Harry Harlow (1905–1981) published "The Formation of Learning Sets," which provided evidence that monkeys employ mental strategies in their solving of discrimination problems. This finding was clearly in conflict with the behavioristic psychology of the time.

In 1948 Norbert Wiener (1894–1964) defined *cybernetics* as the study of the structure and function of information-processing systems. Of particular interest to Wiener was how mechanical or biological systems can achieve a goal or maintain a balance by automatically utilizing feedback from their activities. The automatic pilots on airplanes and thermostats are examples of such systems. Soon it was realized that purposive human behavior could also be explained in such mechanistic terms, thus overcoming the argument that the study of purposive (goal-directed) behavior must necessarily be subjective. In 1949 Claude E. Shannon, working for the Bell Telephone Laboratories, and Warren Weaver, working for the Rockefeller Foundation, were seeking ways of improving the purity of messages between the time they are sent and the time they are received. The work of Shannon and Weaver began what came to be called *information theory*. Information theory notes the various transformations information undergoes as it enters a communication system, as it operates within the system, and as it leaves the system. As we will see later in this chapter, information-processing psychology, like information theory, attempts to understand those structures, processes, and mechanisms that determine what happens to information from the time it is received to the time it is acted on.

Developments during the 1950s

According to Bernard Baars (1986), "There is little doubt that George A. Miller . . . has been the single most effective leader in the emergence of cognitive


GEORGE A. MILLER

George A. Miller

psychology" (p. 198). Miller remembers that, during the 1950s, "'cognition' was a dirty word because cognitive psychologists were seen as fuzzy, hand-waving, imprecise people who really never did anything that was testable" (p. 254). Miller argued that modern cognitive psychology began during a symposium on information theory sponsored by the Massachusetts Institute of Technology on September 10–12, 1956. During the symposium, Allen Newell and Herbert Simon presented papers on computer logic, Noam Chomsky presented his views on language as an inherited, rule-governed system, and Miller described his research demonstrating that people can discriminate only seven different aspects of something—for example, hues of color or pitches of sound. Also, people can only retain about seven meaningful units of experience (chunks) such as numbers, words, or short sentences. Miller summarized his research in his influential article "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information" (1956). Participants in the MIT symposium did much to bring the terminology and concepts of information theory and cybernetics into psychology. At about the same time, the English psychologist Donald Broadbent (1957, 1958) was doing the same thing. Crowther-Heyck (1999) discusses the importance of Miller's work in the early development of cognitive psychology.

In 1951 Karl Lashley (1890–1958) argued that the explanation of serial or chained behavior, offered by the behaviorists, that stressed the importance of external stimulation was insufficient. Rather, he said, such organized behavior could emanate only from within the organism. In an influential publication, "Drives and the C.N.S. (Conceptual Nervous System)" (1955), Hebb continued to show his willingness to "physiologize" about cognitive processes and thus to engage in battle with the behaviorists. Leon Festinger (1919–1989) noted that the ideas one entertains may be compatible with or incompatible with one another. Incompatibility exists, for example, if one is engaged in an obviously boring task but is encouraged to describe it as exciting, or if one smokes cigarettes and yet believes that smoking causes cancer. When ideas are incompatible, a state of dissonance exists that motivates a person to change beliefs or behavior. In the cases above, for example, a person could reduce cognitive dissonance by telling the truth about the task being boring or become convinced that the task is actually exciting. With the smoker, cognitive dissonance could be reduced by quitting the habit or by believing there really is no proven relationship between smoking and cancer. Festinger's influential book *A Theory of Cognitive Dissonance* (1957) made no reference to behavioristic ideas. In the early 1950s Jerome Bruner became interested in thinking and concept formation and in 1955 he assisted Sir Frederic Bartlett in arranging, at Cambridge, one of the first conferences on cognitive psychology (Bruner, 1980). In 1956 Bruner, along with Jacqueline Goodnow and George Austin, published *A Study in Thinking,* which emphasized concept learning. Although concept learning had been studied earlier by Hull and Thorndike, their explanations of such learning were couched in terms of passive, associationistic principles. The explanation offered by Bruner and his colleagues stressed the active utilization of cognitive strategies in such learning. In 1959 Tracy and Howard Kendler analyzed childrens' discrimination learning in terms of concept utilization rather than in terms of behavioristic principles. Also in 1959 Chomsky published his influential review of Skinner's book *Verbal Learning* (1957). We will have more to say about Chomsky's review in chapter 19 when we discuss behavioral genetics.

Also during the 1950s, humanistic theorists such as Maslow, Kelly, Rogers, and May continued developing their ideas, as did the Gestalt psychologists and the psychoanalysts.

Developments after the 1950s

In 1960 Miller and his colleagues Eugene Galanter and Karl Pribram published *Plans and the Structure of Behavior,* in which it was argued that cybernetic concepts (such as information feedback) explain human goal-directed behavior better than S–R concepts do, and at least as objectively. Also in 1960 Miller and Jerome Bruner founded the Center for Cognitive Studies at Harvard. In addition to promoting research on cognitive processes, the center did much to popularize the ideas of Piaget among U.S. psychologists. In 1962 Miller published an article entitled "Some Psychological Studies of Grammar" (1962a), which introduced Chomsky's nativistic analysis of language into psychology. In 1890 William James had defined psychology as "the science of mental life"; in 1962 Miller purposefully used James's definition as the title of his text *Psychology: The Science of Mental Life* (1962b).

In 1963 as evidence of how far cognitive psychology had progressed and in recognition of Miller's role in that progress, Miller was presented a Distinguished Scientific Contribution Award by the APA. Miller served as president of the APA in 1969, received the Gold Medal for Life Achievement in Psychological Science from the American Psychological Foundation (APF) in 1990, and was Awarded a National Medal of Science by President George Bush in 1991. Miller is currently professor emeritus and senior research psychologist at Princeton University.

In 1959 Donald Hebb served as president of the APA, and his presidential address "The American Revolution" was published in 1960. In this address, Hebb was referring not to America's political revolution but to its psychological revolution. According to Hebb, only one phase of the American revolution in psychology had taken place. This was the behavioristic phase and it produced precise, factual knowledge and scientific rigor that had not previously existed in psychology. However, in their effort to be entirely objective the behaviorists had minimized or banished such topics as thought, imagery, volition, and attention. Hebb urged that the second phase of psychology's revolution use the scientific rigor promoted by the behaviorists to study the long-neglected cognitive processes. Concerning the second phase of the revolution, Hebb (1960) said, "The camel already has his nose inside the tent" (p. 741). He noted the works of Festinger, Broadbent, Kendler and Kendler, Miller, Galanter, and Pribram as good starts toward a rigorous cognitive psychology. He was especially impressed by the possibility of the computer acting as a model for studying cognitive processes. He prophesized that such a model will become "a powerful contender for the center of the stage" (1960, p. 741). Hebb's preferred approach to studying cognitive processes was to speculate about their biological foundations. We will have more to say about Hebb when we consider psychobiology in chapter 19.

In 1962 and 1963 M. D. Egger and Neal Miller demonstrated that, contrary to tradition, classical conditioning phenomena could not be explained in terms of associative principles alone. Rather the information conveyed by the stimuli involved had to be taken into consideration. In 1967 Ulric Neisser, who studied with George Miller, published his influential book *Cognitive Psychology,* in which Neisser defined the term cognition as, "All the processes by which . . . sensory input is transformed, reduced, elaborated, stored, recovered and used" (p. 4). Also in this book, Neisser attempted to integrate research on such topics as perception, concept formation, meaning, language, and thinking, using a few concepts adopted primarily from information theory.

Once the grip of behaviorism—especially radical behaviorism—had been loosened many earlier efforts in experimental cognitive psychology were appreciated. About the influence of Ebbinghaus, Michael Wertheimer (1987) said, "His seminal experiments can . . . be viewed as the start of what was to become the currently popular field of cognitive psychology" (p. 78). Concerning the influence of Gestalt psychology, Hearst (1979) said, "Present-day cognitive psychology—with its emphasis on organization, structure, relationships, the active role of the subject, and the important part played by perception in learning and memory—reflects the influence of its Gestalt antecedents" (p. 32). In an interview with Baars, Neisser describes how Gestalt psychology influenced him:

> I . . . became particularly interested in Gestalt psychology. It had an idealistic quality that appealed to me. To the Gestalt psychologists human nature was something wonderful, worth exploring, worth knowing about. They were constantly doing battle with the behaviorists, who seemed to see human nature as a mere collection of conditioned responses or blind associations. From the Gestalt viewpoint, the mind is something beautiful, well-structured, in harmony with the universe. (Baars, 1986, p. 274)

And, regarding Piaget's influence, Jerome Kagan (1980) said, "With Freud, Piaget has been a seminal figure in the sciences of human development" (p. 246).

One of the most popular cognitive theories in contemporary psychology is Albert Bandura's *social cognitive theory*. In several ways, Bandura's theory can be understood as a direct descendent of Tolman's theory.

> If one had to choose a theory of learning that is closest to Bandura's, it would be Tolman's theory. Although Tolman was a behaviorist, he used mentalistic concepts to explain behavioral phenomena . . . and Bandura does the same thing. Also, Tolman believed learning to be a constant process that does not require reinforcement, and Bandura believes the same thing. Both Tolman's theory and Bandura's theory are cognitive in nature, and neither are reinforcement theories. A final point of agreement between Tolman and Bandura concerns the concept of motivation. Although Tolman believed that learning was constant, he believed further that the information gained through learning was only acted on when there was reason for doing so, such as when a need arose. For example, one may know full well where a drinking fountain is but will act on that information only when one is thirsty. For Tolman, this distinction between learning and performance was extremely important, and it is also important in Bandura's theory. (Hergenhahn & Olson, 2001, pp. 319–320)

(See Bandura, 1986, for an excellent summary of his extensive research in *Social Cognitive Theory*.)

The journal *Cognitive Psychology* was founded in 1969, and within the next two decades 15 additional journals were established featuring research articles on such topics as attention, problem solving, memory, perception, language, and concept formation. Interest in experimental cognitive psychology had become so extensive that many believe a revolution, or paradigm shift, had occurred in psychology (for example Baars, 1986; Gardner, 1985; Sperry, 1993). Others, however, suggest that contemporary cognitive psychology represents a *return* to a kind of psychology that existed before the domination of behaviorism. If anything, then, there occurred a counterrevolution rather than a revolution (see Hergenhahn, 1994b). Even George Miller, who, as we have seen, was as responsible as anyone for the current popularity of cognitive psychology, rejects the idea that a revolution took place:

> What seems to have happened is that many experimental psychologists who were studying human learning, perception, or thinking began to call themselves cognitive psychologists without changing in any obvious way what they had always been thinking and doing—as if they suddenly discovered they had been speaking cognitive psychology all their lives. So our victory may have been more modest than the written record would have led you to believe. (Bruner, 1983, p. 126)

Robins, Gosling, and Craik (1999) note that the popularity of cognitive psychology has increased dramatically over the last three decades. They agree with Miller, however, that it is incorrect to refer to this increased popularity as a "cognitive revolution."

In any case, from the many forms of cognitive psychology that existed prior to the 1970s, information-processing psychology emerged as the dominant form. Information-processing psychology is the kind of cognitive psychology that took the computer

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program as a metaphor for the workings of the mind. Before discussing information-processing psychology, however, we will first review the field of artificial intelligence that influenced its development.

Artificial Intelligence

Developments in cybernetics, information theory, and computer technology combined to form the field of artificial intelligence. Fetzer (1991) defines **artificial intelligence (AI)** as a "special branch of computer science that investigates the extent to which the mental powers of human beings can be captured by means of machines" (p. xvi). In 1950 the brilliant mathematician Alan M. Turing (1912–1954) founded the field of artificial intelligence in an article entitled "Computing Machinery and Intelligence," in which he raised the question, Can machines think? Because the term *think* is so ambiguous, Turing proposed an objective way of answering his own question.

The Turing test. Turing proposed that we play the "imitation game" to answer the question, Can machines (like computers) think? He asked that we imagine an interrogator asking probing questions to a human and to a computer, both hidden from the interrogator's view. The questions and answers are typed on a keyboard and displayed on a screen. The only information the interrogator is allowed is that which is furnished during the question-and-answer session. The human is instructed to answer the questions truthfully and to attempt to convince the interrogator that he or she really is the human. The computer is programmed to respond as if it were human. If after a series of such tests the interrogator is unable to consistently identify the human responder, the computer passes the **Turing test** and can be said to think.

Weak versus strong artificial intelligence. What does it mean when a computer passes the Turing test for some human cognitive function? For example, if an interrogator cannot distinguish between a human and a computer with regard to thinking, reasoning, and problem solving, does that mean that the computer possesses those mental attributes just as humans do? No, say the proponents of **weak artificial intelligence,** who claim that, at best, a computer can only simulate human mental attributes. Yes, say the proponents of **strong artificial intelligence,** who claim that the computer is not merely a tool used to study the mind (as the proponents of weak AI claim). Rather, an appropriately programmed computer really *is* a mind capable of understanding and having mental states. According to strong AI, human minds are computer programs, and therefore there is no reason they cannot be duplicated by other, nonbiological, computer programs. For the proponents of strong AI, computers do not *simulate* human cognitive processes; they *duplicate* them.

Searle's argument against strong artificial intelligence. John Searle (1980, 1990) describes his now famous "Chinese Room" rebuttal to proponents of strong AI. Thinking, according to strong AI, is the manipulation of symbols according to rules, and because computer programs manipulate symbols according to rules, they think. According to strong AI, "the mind is to the brain as the program is to the hardware" (Searle, 1990, p. 26). To refute this claim, Searle asks you to consider a language you do not understand—say, Chinese. Now suppose you are placed in a room containing baskets full of Chinese symbols, along with a rule book written in English telling how to match certain Chinese symbols with other Chinese symbols. The rules instruct you how to match symbols entirely by their shapes and does not require any understanding of the meaning of the symbols. "The rules might say such things as, 'take a squiggle-squiggle sign from basket number one and put it next to a squoggle-squoggle sign from basket number two'" (Searle, 1990, p. 26). Imagine further that there are people outside the room who understand Chinese and who slip batches of symbols into your room, which you then manipulate according to your rule book. You then slip the results back out of the room. Searle likens the rule book to the computer program. The people who wrote the rule book are the "programmers," and you are the "computer." The baskets full of symbols are the "database," the small batches of symbols slipped into the room are "ques-

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JOHN SEARLE

John Searle

tions," and the small batches of transformed symbols you slip out of the room are "answers."

Finally, imagine that your rule book is written in such a way that the "answers" you generate are indistinguishable from those of a native Chinese speaker. In other words, unknown to you, the symbols slipped into your room may constitute the question, What is the capital of France? and your answer, again unknown to you, was Paris. After several such questions and answers, you pass the Turing test for understanding Chinese although you are totally ignorant of Chinese. Furthermore, in your situation there is no way that you could ever come to understand Chinese because you could not learn the meaning of any symbols. Like a computer, you manipulate symbols but attach no meaning to them. Searle (1990) concludes:

> The point of the thought experiment is this: If I do not understand Chinese solely on the basis of running a computer program for understanding Chinese, then neither does any other digital computer solely on that basis. Digital computers merely manipulate formal symbols according to rules in the program.
>
> What goes for Chinese goes for other forms of cognition as well. Just manipulating the symbols is not by itself enough to guarantee cognition, perception, understanding, thinking and so forth. And since computers, qua computers, are symbol-manipulating devices, merely running the computer program is not enough to guarantee cognition. (p. 26)

Any problem that can be stated in terms of formal symbols and solved according to specified rules can be solved by a computer, such as balancing a checking account or playing chess and checkers. The manipulation of symbols according to specified rules is called *syntax*. *Semantics*, on the other hand, involves the assignment of meaning to symbols. According to Searle, computer programs have syntax but not semantics. Human thoughts, perceptions, and understandings have a mental content, and they can refer to objects or events in the world; they have a meaning or, to use Brentano's term, they have *intentionality*. A computer program (or you enclosed in the Chinese room) simply manipulates symbols without any awareness of what they mean. Again, although a computer may pass the Turing test, it is not really thinking as humans think, and therefore strong AI is false. "You can't get semantically loaded thought contents from formal computations alone" (Searle, 1990, p. 28). Our brains are constructed so that they cause mental events: "Brains are specific biological organs, and their specific biochemical properties enable them to cause consciousness and other sorts of mental phenomena" (p. 29). Computer programs can provide useful simulations of the formal aspects of brain processes, but simulation should not be confused with duplication. "No one expects to get wet in a pool filled with Ping-Pong-ball models of water molecules. So why would anyone think a computer model of thought processes would actually think?" (p. 31).

Are humans machines? The argument about whether machines (in this case, computers) can think reintroduces into modern psychology a number

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of questions that have persisted throughout psychology's history. One such question is, What is the nature of human nature? As we have seen, one answer has been that humans are machines. Most of the English and French Newtonians of the mind took Newton's conception of the universe as a machine and applied it to humans. For anyone who believes that humans are nothing but complex machines—and there have been many philosophers and psychologists with such a belief—there would be no reason that a nonhuman machine could not be built that would *duplicate* every human function. This might require placing a computer into a sophisticated robot, but in principle there is no reason a nonhuman machine could not duplicate every human function, because humans too are nothing but machines. For example, materialists have no trouble with the contention that machines like robots could be built that duplicate all human functions. Humans, say the materialists, are nothing but physical systems. However, for the materialists there is no "ghost in the machine" (that is, a mind); thus there is no reason to wonder whether a nonhuman machine can think or not. Neither nonhuman machines nor humans can think. Thoughts, ideas, concepts, perceptions, and understandings cannot exist if they are thought to be nonphysical in nature; only physical things exist. To suggest otherwise, say the materialists, is to embrace dualism. Being materialists, radical behaviorists do not deny that machines could be made that duplicate human *behavior*. However, such a machine could not think any more than humans can think and, therefore, talk of duplicating human thought processes is plain nonsense. For materialists, such as the radical behaviorists, both weak and strong AI are useless concepts.

Psychologists and philosophers who accept dualism may or may not find AI useful. Postulating a cognitive component to human nature does not require that such a component be unlawful. Most of the British empiricists and French sensationalists embraced mentalism, but the mental events they postulated were governed by the laws of association. Even being a rationalist does not preclude being a determinist concerning mental events. For example, Spinoza believed thought to be lawful, and therefore a machine analogy of the mind would not have been far-fetched for him. Similarly, the philosophers, like Kant, who divided the mind into various faculties were dualists. However, these faculties were often viewed as transforming sensory information in automatic, mechanistic, lawful ways, and therefore both the physical and mental aspects of humans were machinelike. In more recent times, the methodological behaviorists, like Tolman, who postulated cognitive events that mediate between stimuli and responses followed in the tradition of the faculty psychologists. Thus being a dualist does not preclude one from viewing humans as machines and thus embracing some form of AI. As we will see, information-processing psychology is a form of cognitive psychology that followed in the traditions of faculty psychology and methodological behaviorism and so found much that was useful in AI.

Standing in firm opposition to using any form of AI as a model for understanding the human mind would be all rationalistic philosophers or psychologists who postulated a free will (like Descartes). Also in opposition would be the romantic and existential philosophers and the modern humanistic psychologists. Aside from postulating human free will, humanistic psychologists claim that there are so many important unique human attributes (such as creativity and the innate tendency toward self-actualization) that the very idea of machine simulation of human attributes is ridiculous and perhaps even dangerous. It may be dangerous because if we view humans as machines, we may treat them as machines; and if we treat them as machines, they may act like machines. According to the humanistic psychologists, this is what tends to happen when the methods and assumptions of the natural sciences are applied to the study of humans. With such methods, humans are treated like physical objects (machines) and are thus desacralized. Most humanistic psychologists find the very idea of AI repulsive.

Information-Processing Psychology

There is no better example of how developments outside psychology can influence psychology than the emergence of **information-processing psychology.** Although individuals such as George Miller (1956) and Donald Broadbent (1957, 1958) had already used the computer metaphor to study human cognition, it is generally agreed that the 1958 article by Allen Newell, J. C. Shaw, and Herbert Simon marked the transition between artificial intelligence and information-processing psychology. In their article, the authors claimed that the computer programs they developed solved problems the same way humans do. That is, they claimed that both the human mind and computer programs are general problem-solving devices. This claim was highly influential, and an increasing number of psychologists began to note the similarities between humans and computers: Both receive input, process that input, have a memory, and produce output. For information-processing psychologists, the term *input* replaces the term *stimulus*, the term *output* replaces the terms *response* and *behavior*, and terms such as *storage*, *encoding*, *processing*, *capacity*, *retrieval*, *conditional decisions*, and *programs* describe the information-processing events that occur between the input and the output. Most of these terms have been borrowed from computer technology. The information-processing psychologist usually concentrates his or her research on normal, rational thinking and behavior and views the human as an active seeker and user of information.

As we have seen throughout this book, assumptions made about human nature strongly influence how humans are studied. The assumption that the mind or brain either is or acts like a computer demonstrates this point:

> Computers take symbolic input, recode it, make decisions about the recorded input, make new expressions from it, store some or all of the input, and give back symbolic output. By analogy, that is most of what cognitive psychology is about. It is about how people take in information, how they recode and remember it, how they make decisions, how they transform their internal knowledge states, and how they transform these states into behavioral outputs. The analogy is important. It makes a difference whether a scientist thinks of humans as if they were laboratory animals or as if they were computers. Analogies influence an experimenter's choice of research questions, and they guide his or her theory construction. They color the scientist's language, and a scientist's choice of terminology is significant. The terms are pointers to a conceptual infrastructure that defines an approach to a subject matter. Calling a behavior a *response* implies something very different from calling it an *output*. It implies different beliefs about the behavior's origin, its history, and its explanation. Similarly, the terms *stimulus* and *input* carry very different implications about how people process them. (Lachman, Lachman, & Butterfield, 1979, p. 99)

Information-processing follows in the rationalistic tradition, and, like most rationalist theories, information-processing theory has a strong nativistic component:

> We do not believe in postulating mysterious instincts to account for otherwise unexplainable behavior, but we do feel that everything the human does is the result of inborn capacities, as well as learning. We give innate capacities more significance than behaviorists did. We think part of the job of explaining human cognition is to identify how innate capacities and the results of experience combine to produce cognitive performance. This leads us, especially in the area of language, to suppose that some aspects of cognition have evolved primarily or exclusively in humans. (p. 118)

Note the similarity between the Gestalt position and the following statement of Lachman, Lachman, and Butterfield: "The human mind has parts, and they interrelate as a *natural system*" (p. 128). Also note the similarity between Kant's philosophy and another statement made by Lachman, Lachman, and Butterfield: "Man's cognitive system is constantly active; it adds to its environmental input and literally *constructs* its reality" (p. 128). In fact, considerable similarity exists between Kant's rationalistic philosophy and information-processing psychology. Many consider Kant to be the founding father of information-processing psychology: "When cognitive scientists discuss their philosophical forebears one hears the name of Immanuel Kant more than any other" (Flanagan, 1991, p. 181). As we saw in chapter 6, Kant postulated a number of categories of thought (faculties of the mind) that act on sensory information, thereby giving it structure and meaning that it otherwise would not have. In other words, according to Kant, the faculties of the mind process information. It is Kant's philosophy that creates a kinship among Piaget's theory of intellectual

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development, Gestalt psychology, and information-processing psychology.

The return of faculty psychology. Largely because of its relationship with phrenology, faculty psychology came into disfavor and was essentially discarded along with phrenology. To some, discarding faculty psychology with phrenology was like throwing out the baby with the bath water. We just saw that information-processing psychology marks a return to faculty psychology. The recent discovery that the brain is organized into many "modules" (groups of cells), each associated with some specific function such as face recognition, also marks a return to faculty psychology. As Jerrold Fodor (1983) noted:

> Faculty psychology is getting to be respectable again after centuries of hanging around with phrenologists and other dubious types. By faculty psychology I mean, roughly, the view that many fundamentally different types of psychological mechanisms must be postulated in order to explain the facts of mental life. Faculty psychology takes seriously the apparent heterogeneity of the mental and is impressed by such prima facie differences as between, say, sensation and perception, volition and cognition, learning and remembering, or language and thought. Since, according to faculty psychologists, the mental causation of behavior typically involves the simultaneous activity of a variety of distinct psychological mechanisms, the best research strategy would seem to be divide and conquer: first study the intrinsic characteristics of each of the presumed faculties, then study the ways in which they interact. Viewed from the faculty psychologist's perspective, overt, observable behavior is an interaction effect par excellence. (p. 1)

In his influential book *How the Mind Works* (1997), Steven Pinker also embraces faculty psychology: "the mind, I claim, is not a single organ but a system of organs, which we can think of as psychological faculties or mental modules" (p. 27).

The return of the mind-body problem. The current popularity of all varieties of cognitive psychology, including information-processing psychology, brings the mind-body problem back into psychology—not that it ever completely disappeared. The radical behaviorists "solved" the problem by denying the existence of a mind. For them, so-called mental events are nothing but physiological experiences to which we assign cognitive labels. That is, the radical behaviorists "solved" the mind-body problem by assuming materialism or physical monism. Cognitive psychology, however, assumes the existence of cognitive events. These events are viewed sometimes as the by-products of brain activity (epiphenomenalism), sometimes as automatic, passive processors of sensory information (mechanism), and sometimes as important causes of behavior (interactionism). In each case, bodily events and cognitive events are assumed, and therefore the relationship between the two must be explained. A number of contemporary cognitive psychologists believe they have avoided dualism by noting the close relationship between certain brain activities and certain cognitive events (for example, Sperry, 1993). The fact that it appears likely that such a relationship will soon be discovered for all mental events is sometimes offered in support of materialism. D. N. Robinson (1986) explained why such reasoning is fallacious:

> This is hardly a justification for materialistic monism, since *dualism* does not require that there be no brain! Indeed, dualism does not even necessarily require that mental events not be the effects of neural causes. A modest dualism only asserts that there *are* mental events. To show, then, that such events are somehow caused by material events, far from establishing the validity of a monist position, virtually guarantees the validity of a dualist position. (pp. 435–436)

Replacing the term *mind-body* with the term *mind-brain* does little to solve the problem of how something material (the brain) can cause something mental (ideas, thinking).

In the 1970s a number of information-processing psychologists attempting to understand cognition combined their efforts with philosophers, anthropologists, linguists, neuroscientists, engineers, and computer scientists, thus creating **cognitive science.** Like information-processing psychologists, the cognitive scientists seek to understand the mental processes that intervene between stimuli and responses, but they take a broader base in studying those processes.

However, even with the development of cognitive science, or perhaps because of it, there was a growing realization that information-processing psychology and the AI from which it developed had become sterile. Even Ulric Neisser, whose 1967 book *Cognitive Psychology* did so much to promote information-processing psychology, eventually became disenchanted with that kind of psychology. In 1976 Neisser published *Cognition and Reality*, in which he argued that information-processing psychology be replaced by *ecological psychology*. Ecological psychology moves away from computer models of human cognition and the narrow confines of laboratory experimentation and toward a study of cognition as it occurs naturally in real-life situations. Neisser's new approach to cognitive psychology was influential, but the influence of AI in the study of cognitive processes was far from over. Enthusiasm for AI was rekindled by a dramatic new development that uses the brain as a model for cognitive functioning instead of the computer—new connectionism. We will discuss new connectionism in chapter 19.

Summary

Throughout most of psychology's history, human cognition was studied philosophically. J. S. Mill provided the framework within which human cognition could be studied scientifically. Fechner, Ebbinghaus, James, Bartlett, and Piaget were among the first psychologists to demonstrate that human cognition could be studied experimentally. Also included among the pioneers of experimental cognitive psychology were the Gestalt psychologists, Rogers, Hebb, Wiener, Shannon, and Weaver. During the 1950s, interest in experimental cognitive psychology increased mainly because of the efforts of such individuals as George Miller, Broadbent, Lashley, Festinger, Bruner, Tracy and Howard Kendler, Chomsky, the humanistic psychologists, and the psychoanalysts. In 1960 Hebb urged that the rigorous scientific methods utilized by the behaviorists to study behavior be applied to the study of human cognition. Also in 1960 Miller and Bruner founded the Center for Cognitive Studies at Harvard. In 1962 and 1963 Egger and Miller demonstrated that classical conditioning could not be understood in terms of associative principles alone. Rather the information conveyed by the stimuli involved had to be considered. In 1967 Neisser synthesized the diverse findings within experimental cognitive psychology, using a few basic principles primarily from information theory. In 1969 Miller served as president of the APA, illustrating how far experimental cognitive psychology based on information theory had come.

In 1950 Alan Turing created the field of artificial intelligence (AI). AI attempts to simulate or duplicate the intelligence exhibited by humans, using nonhuman machines such as computers. Turing proposed the "imitation game" as a means of determining whether a machine can think as a human does. If the answers to questions given by a machine (like a computer) are indistinguishable from those given by a human, the machine can be said to think. Those adhering to strong AI believe that nonhuman machines can duplicate human intelligence, and those adhering to weak AI believe that nonhuman machines can only simulate human intelligence. Searle argues that his thought experiment of the "Chinese Room" showed that computers manipulate symbols without assigning meaning to them, and therefore strong AI must be rejected. Whether or not AI is seen as a useful model for studying humans depends on one's view of human nature. According to materialists, such as the radical behaviorists, there is no reason machines cannot duplicate human behavior. However, efforts to construct machines that simulate or duplicate human thought processes must fail because such processes do not exist. But accepting a dualist position does not necessarily preclude the usefulness of AI, because many dualists are also mechanists. It is only those dualist positions that postulate unique features of the human mind (such as free will) that see AI as having little or no usefulness.

Information-processing cognitive psychology developed from AI. As the computer does, humans re-

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ceive input; process that input by using various programs, strategies, schemata, memories, and plans; and then produce output. The major goal of the information-processing psychologist was to determine the mechanisms humans employ in processing information. Information-processing psychologists followed in the rationalistic tradition, and their work and assumptions showed similarities to Kantian philosophy, Gestalt psychology, Piaget's theory of intellectual development, and methodological behaviorism. Both faculty psychology and the mind-body problem reemerged as cognitive psychology became popular. In the late 1970s, information-processing psychologists joined with researchers from other disciplines to form cognitive science.

Discussion Questions

1. Justify the contention that psychology has almost always been concerned with studying human cognition. Throughout most of psychology's history, how was cognition studied? What philosopher provided the framework within which cognition could be studied experimentally?
2. Give examples of early efforts (before 1950) to study human cognition experimentally.
3. Give examples of events that occurred in the 1950s that contributed to the development of experimental cognitive psychology.
4. Describe the pivotal events that occurred in the 1960s that contributed to the current popularity of experimental cognitive psychology.
5. Define each of the following: *cognitive science*, *artificial intelligence (AI)*, *strong AI*, and *weak AI*.
6. What is the Turing test, and for what was it used?
7. Describe Searle's thought experiment involving the "Chinese Room." What, according to Searle, does this experiment prove?
8. Which philosophies would tend to support the position of strong AI? weak AI? Which would deny the usefulness of either type of AI?
9. What are the major tenets of information-processing psychology? How is information-processing psychology related to AI?
10. Why can information-processing psychology be seen as following in the tradition of Kantian philosophy? Why can information-processing psychology be seen as marking a return to faculty psychology? a return to the mind-body problem?

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Glossary

Artificial intelligence (AI) A branch of computer science that investigates the extent to which machines can simulate or duplicate the intelligent behavior of living organisms. (*See also* **Strong artificial intelligence** and **Weak artificial intelligence.**)

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Cognitive science A multidiscipline approach to studying cognition in humans, animals, and machines.

Information-processing psychology The approach to studying cognition that follows in the tradition of faculty psychology and methodological (mediational) behaviorism and typically employs the computer as a model for human information processing.

Strong artificial intelligence The contention that machines (such as computers) can duplicate human cognitive processes.

Turing test A test devised by Turing (1950) to determine whether a machine can think. Questions are submitted to both a human and a machine. If the machine's answers are indistinguishable from those of the human, it is concluded that the machine can think.

Weak artificial intelligence The contention that machines (such as computers) can simulate human cognitive processes but not duplicate them.

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