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CHAPTER

Introduction to Cognitive Psychology

CHAPTER OUTLINE

Here are some of the questions we will explore in this chapter:

1. What is cognitive psychology?
2. How did psychology develop as a science?
3. How did cognitive psychology develop from psychology?
4. How have other disciplines contributed to the development of theory and research in cognitive psychology?
5. What methods do cognitive psychologists use to study how people think?
6. What are the current issues and various fields of study within cognitive psychology?

BELIEVE IT OR NOT

Now You See It, Now You Don't!

Cognitive psychology yields all kinds of surprising findings. Dan Simons of the University of Illinois is a master of surprises (see Simons, 2007; Simons & Ambinder, 2005; Simons & Rensink, 2005). Try it out yourself! Watch the following videos and see if you have any comments on them.

http://viscog.beckman.illinois.edu/flashmovie/23.php

Note: Do not read on before you have watched the video.

Did you notice that the person who answers the phone is not the same as the one who was at the desk? Note that they are wearing distinctively different clothing. You have just seen an example of *change blindness*—our occasional inability to recognize changes. You will learn more about this concept in Chapter 3.

Now view the following video. Your task will be to count the number of times that students in *white shirts* pass the basketball. You must not count passes by students wearing black shirts:

http://viscog.beckman.illinois.edu/flashmovie/15.php

Note: Do not read on before you have watched the video.

Well, it doesn't really matter how many passes there were. Did you notice the person in the gorilla outfit walk across the video as the students were throwing the balls? Most people don't notice. This video demonstrates a phenomenon called *inattentional blindness*. You will learn more about this concept in Chapter 4. Throughout this book, we will explore these and many other phenomena.

Think back to the last time you went to a party or social gathering. There were probably tens and maybe hundreds of students in a relatively small room. Maybe music played in the background, and you could hear chatter all around. Yet, when you talked to your friends, you were able to figure out and even concentrate on what they said, filtering out all the other conversations that were going on in the background. Suddenly, however, your attention might have shifted because you heard someone in another conversation nearby mention your name. What processes would have been at work in this situation? How were you able to filter out irrelevant voices in your mind and focus your attention on just one of the many voices you heard? And why did you notice your name being mentioned, even though you did

When you are at a party, you are usually able to filter out many irrelevant voice streams in order to concentrate on the conversation you are leading. However, you will likely notice somebody saying your name in another conversation even if you were not listening intently to that conversation.

not purposefully listen to the conversations around you? Our ability to focus on one out of many voices is one of the most striking phenomena in cognitive psychology, and is known as the "cocktail party effect."

Cognitive processes are continuously taking place in your mind and in the minds of the people around you. Whether you pay attention to a conversation, estimate the speed of an approaching car when crossing the street, or memorize information for a test at school, you are perceiving information, processing it, and remembering or thinking about it. This book is about those cognitive processes that are often hidden in plain sight and that we take for granted because they seem so automatic to us. This chapter will introduce you to some of the people who helped form the field of cognitive psychology and make it what it is today. The chapter also will discuss methods used in cognitive-psychological research.

Cognitive Psychology Defined

What will you study in a textbook about cognitive psychology?

Cognitive psychology is the study of how people perceive, learn, remember, and think about information. A cognitive psychologist might study how people perceive various shapes, why they remember some facts but forget others, or how they learn language. Consider some examples:

- Why do objects look farther away on foggy days than they really are? The discrepancy can be dangerous, even deceiving drivers into having car accidents.
- Why do many people remember a particular experience (e.g., a very happy moment or an embarrassment during childhood), yet they forget the names of people whom they have known for many years?

- Why are many people more afraid of traveling in planes than in automobiles? After all, the chances of injury or death are much higher in an automobile than in a plane.
- Why do you often well remember people you met in your childhood but not people you met a week ago?
- Why do marketing executives in large companies spend so much company money on advertisements?

These are some of the kinds of questions that we can answer through the study of cognitive psychology.

Consider just the last of these questions: Why does Apple, for example, spend so much money on advertisements for its iPhone? After all, how many people remember the functional details of the iPhone, or how those functions are distinguished from the functions of other phones? One reason Apple spends so much is because of the *availability heuristic*, which you will study in Chapter 12. Using this heuristic, we make judgments on the basis of how easily we can call to mind what we perceive as relevant instances of a phenomenon (Tversky & Kahneman, 1973). One such judgment is the question of which phone you should buy when you need a new cell phone. We are much more likely to buy a brand and model of a phone that is familiar. Similarly, Microsoft paid huge amounts of money to market its roll-out of Windows 7 in order to make the product cognitively available to potential customers and thus increase the chances that the potential customers would become actual ones. The bottom line is that understanding cognitive psychology can help us understand much of what goes on in our everyday lives.

Why study the history of cognitive psychology? If we know where we came from, we may have a better understanding of where we are heading. In addition, we can learn from past mistakes. For example, there are numerous newspaper stories about how one educational program or another has resulted in particular gains in student achievement. However, it is relatively rare to read that a control group has been used. A control group would tell us about the achievement of students who did not have that educational program or who maybe were in an alternative program. It may be that these students also would show a gain. We need to compare the students in the experimental group to those in the control group to determine whether the gain of the students in the experimental group was greater than the gain of those in the control group. We can learn from the history of our field that it is important to include control groups, but not everyone learns this fact.

In cognitive psychology, the ways of addressing fundamental issues have changed, but many of the fundamental questions remain much the same. Ultimately, cognitive psychologists hope to learn how people think by studying how people have thoughts about thinking.

The progression of ideas often involves a *dialectic*. A dialectic is a developmental process where ideas evolve over time through a pattern of transformation. What is this pattern? In a dialectic:

- **A thesis is proposed.** A *thesis* is a statement of belief. For example, some people believe that human nature governs many aspects of human behavior (e.g., intelligence or personality; Sternberg, 1999). After a while, however, certain individuals notice apparent flaws in the thesis.

- **An antithesis emerges.** Eventually, or perhaps even quite soon, an antithesis emerges. An *antithesis* is a statement that counters a previous statement of belief. For example, an alternative view is that our nurture (the environmental contexts in which we are reared) almost entirely determines many aspects of human behavior.
- **A synthesis integrates the viewpoints.** Sooner or later, the debate between the thesis and the antithesis leads to a synthesis. A *synthesis* integrates the most credible features of each of two (or more) views. For example, in the debate over nature versus nurture, the interaction between our innate (inborn) nature and environmental nurture may govern human nature.

The dialectic is important because we may be tempted to think that if one view is right, another seemingly contrasting view must be wrong. For example, in the field of intelligence, there has been a tendency to believe that intelligence is either all or mostly genetically determined, or else all or mostly environmentally determined. A similar debate has raged in the field of language acquisition. Often, we are better off posing such issues not as either/or questions, but rather as examinations of how different forces covary and interact with each other. Indeed, the most widely accepted current contention is that the "nature or nurture" view is incomplete. Nature and nurture work together in our development.

Nurture can work in different ways in different cultures. Some cultures, especially Asian cultures, tend to be more dialectical in their thinking, whereas other cultures, such as European and North American ones, tend to be more linear (Nisbett, 2003). In other words, Asians are more likely to be tolerant of holding beliefs that are contradictory, seeking a synthesis over time that resolves the contradiction. Europeans and Americans expect their belief systems to be consistent with each other.

Similarly, people from Asian cultures tend to take a different viewpoint than Westerners when approaching a new object (e.g., a movie of fish in an ocean; Nisbett & Masuda, 2003). In general, people from Western cultures tend to process objects independently of the context, whereas people from many Eastern cultures process objects in conjunction with the surrounding context (Nisbett & Miyamoto, 2005). Asians may emphasize the context more than the objects embedded in those contexts. So if people see a movie of fish swimming around in the ocean, Europeans or Americans will tend to pay more attention to the fish, and Asians may attend to the surround of the ocean in which the fish are swimming. The evidence suggests that culture influences many cognitive processes, including intelligence (Lehman, Chiu, & Schaller, 2004).

If a synthesis seems to advance our understanding of a subject, it then serves as a new thesis. A new antithesis then follows it, then a new synthesis, and so on. Georg Hegel (1770–1831) observed this dialectical progression of ideas. He was a German philosopher who came to his ideas by his own dialectic. He synthesized some of the views of his intellectual predecessors and contemporaries. You will see in this chapter that psychology also evolved as a result of dialectics: Psychologists had ideas about how the mind works and pursued their line of research; then other psychologists pointed out weaknesses and developed alternatives as a reaction to the earlier ideas. Eventually, characteristics of the different approaches are often integrated into a newer and more encompassing approach.

Philosophical Antecedents of Psychology: Rationalism versus Empiricism

Where and when did the study of cognitive psychology begin? Historians of psychology usually trace the earliest roots of psychology to two approaches to understanding the human mind:

- *Philosophy* seeks to understand the general nature of many aspects of the world, in part through *introspection*, the examination of inner ideas and experiences (from *intro-*, "inward, within," and *-spect*, "look");
- *Physiology* seeks a scientific study of life-sustaining functions in living matter, primarily through *empirical* (observation-based) methods.

Two Greek philosophers, Plato (ca. 428–348 B.C.) and his student Aristotle (384–322 B.C.), have profoundly affected modern thinking in psychology and many other fields. Plato and Aristotle disagreed regarding how to investigate ideas.

Plato was a rationalist. A **rationalist** believes that the route to knowledge is through thinking and logical analysis. That is, a rationalist does not need any experiments to develop new knowledge. A rationalist who is interested in cognitive processes would appeal to reason as a source of knowledge or justification.

In contrast, Aristotle (a naturalist and biologist as well as a philosopher) was an empiricist. An **empiricist** believes that we acquire knowledge via empirical evidence—that is, we obtain evidence through experience and observation (Figure 1.1). In order to explore how the human mind works, empiricists would design experiments and conduct studies in which they could observe the behavior and processes of interest to them. Empiricism therefore leads directly to empirical investigations of psychology.

In contrast, rationalism is important in theory development. Rationalist theories without any connection to observations gained through empiricist methods may not be valid; but mountains of observational data without an organizing theoretical framework may not be meaningful. We might see the rationalist view of the world as a thesis and the empirical view as an antithesis. Most psychologists today seek a synthesis of the two. They base empirical observations on theory in order to explain

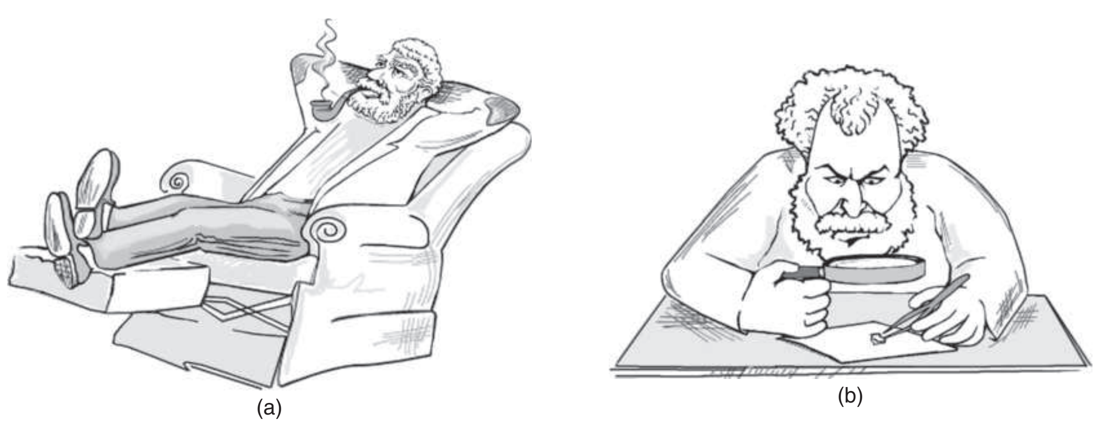

Figure 1.1 (a) According to the rationalist, the only route to truth is reasoned contemplation; (b) according to the empiricist, the only route to truth is meticulous observation. Cognitive psychology, like other sciences, depends on the work of both rationalists and empiricists.

what they have observed in their experiments. In turn, they use these observations to revise their theories when they find that the theories cannot account for their real-world observations.

The contrasting ideas of rationalism and empiricism became prominent with the French rationalist René Descartes (1596–1650) and the British empiricist John Locke (1632–1704). Descartes viewed the introspective, reflective method as being superior to empirical methods for finding truth. The famous expression "cogito, ergo sum" (I think, therefore I am) stems from Descartes. He maintained that the only proof of his existence is that he was thinking and doubting. Descartes felt that one could not rely on one's senses because those very senses have often proven to be deceptive (think of optical illusions, for example). Locke, in contrast, had more enthusiasm for empirical observation (Leahey, 2003). Locke believed that humans are born without knowledge and therefore must seek knowledge through empirical observation. Locke's term for this view was *tabula rasa* (meaning "blank slate" in Latin). The idea is that life and experience "write" knowledge on us. For Locke, then, the study of learning was the key to understanding the human mind. He believed that there are no innate ideas.

In the eighteenth century, German philosopher Immanuel Kant (1724–1804) dialectically synthesized the views of Descartes and Locke, arguing that both rationalism and empiricism have their place. Both must work together in the quest for truth. Most psychologists today accept Kant's synthesis.

Psychological Antecedents of Cognitive Psychology

Cognitive psychology has roots in many different ideas and approaches. The approaches that will be examined include early approaches such as structuralism and functionalism, followed by a discussion of associationism, behaviorism, and Gestalt psychology.

Early Dialectics in the Psychology of Cognition

Only in recent times did psychology emerge as a new and independent field of study. It developed in a dialectical way. Typically, an approach to studying the mind would be developed; people then would use it to explore the human psyche. At some point, however, researchers would find that the approach they learned to use had some weaknesses, or they would disagree with some fundamental assumptions of that approach. They then would develop a new approach. Future approaches might integrate the best features of past approaches or reject some or even most of those characteristics. In the following section, we will explore some of the ways of thinking early psychologists employed and trace the development of psychology through the various schools of thinking.

Understanding the Structure of the Mind: Structuralism

An early dialectic in the history of psychology is that between structuralism and functionalism (Leahey, 2003; Morawski, 2000). Structuralism was the first major school of thought in psychology. **Structuralism** seeks to understand the structure (configuration of elements) of the mind and its perceptions by analyzing those perceptions into their constituent components (affection, attention, memory, sensation, etc.).

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Consider, for example, the perception of a flower. Structuralists would analyze this perception in terms of its constituent colors, geometric forms, size relations, and so on. In terms of the human mind, structuralists sought to deconstruct the mind into its elementary components; they were also interested in how those elementary components work together to create the mind.

Wilhelm Wundt (1832–1920) was a German psychologist whose ideas contributed to the development of structuralism. Wundt is often viewed as the founder of structuralism in psychology (Structuralism, 2009). Wundt used a variety of methods in his research. One of these methods was introspection. **Introspection** is a deliberate looking inward at pieces of information passing through consciousness. The aim of introspection is to look at the elementary components of an object or process.

The introduction of introspection as an experimental method was an important change in the field because the main emphasis in the study of the mind shifted from a rationalist approach to the empiricist approach of trying to observe behavior in order to draw conclusions about the subject of study. In experiments involving introspection, individuals reported on their thoughts as they were working on a given task. Researchers interested in problem solving could ask their participants to think aloud while they were working on a puzzle so the researchers could gain insight into the thoughts that go on in the participants' minds. In introspection, then, we can analyze our own perceptions.

The method of introspection has some challenges associated with it. First, people may not always be able to say exactly what goes through their mind or may not be able to put it into adequate words. Second, what they say may not be accurate. Third, the fact that people are asked to pay attention to their thoughts or to speak out loud while they are working on a task may itself alter the processes that are going on.

Wundt had many followers. One was an American student, Edward Titchener (1867–1927). Titchener (1910) is sometimes viewed as the first full-fledged structuralist. In any case, he certainly helped bring structuralism to the United States. His experiments relied solely on the use of introspection, exploring psychology from the vantage point of the experiencing individual. Other early psychologists criticized both the method (introspection) and the focus (elementary structures of sensation) of structuralism. These critiques gave rise to a new movement—functionalism.

Understanding the Processes of the Mind: Functionalism

An alternative that developed to counter structuralism, functionalism suggested that psychologists should focus on the *processes* of thought rather than on its contents. **Functionalism** seeks to understand what people *do* and *why* they do it. This principal question about processes was in contrast to that of the structuralists, who had asked what the elementary contents (structures) of the human mind are. Functionalists held that the key to understanding the human mind and behavior was to study the processes of how and why the mind works as it does, rather than to study the

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structural contents and elements of the mind. They were particularly interested in the practical applications of their research.

Functionalists were unified by the kinds of questions they asked but not necessarily by the answers they found or by the methods they used for finding those answers. Because functionalists believed in using whichever methods best answered a given researcher's questions, it seems natural for functionalism to have led to pragmatism. **Pragmatists** believe that knowledge is validated by its usefulness: What can you *do* with it? Pragmatists are concerned not only with knowing what people do; they also want to know what we can do with our knowledge of what people do. For example, pragmatists believe in the importance of the psychology of learning and memory. Why? Because it can help us improve the performance of children in school. It can also help us learn to remember the names of people we meet.

A leader in guiding functionalism toward pragmatism was William James (1842–1910). His chief functional contribution to the field of psychology was a single book: his landmark *Principles of Psychology* (1890/1970). Even today, cognitive psychologists frequently point to the writings of James in discussions of core topics in the field, such as attention, consciousness, and perception. John Dewey (1859–1952) was another early pragmatist who profoundly influenced contemporary thinking in cognitive psychology. Dewey is remembered primarily for his pragmatic approach to thinking and schooling.

Although functionalists were interested in how people learn, they did not really specify a mechanism by which learning takes place. This task was taken up by another group, Associationists.

An Integrative Synthesis: Associationism

Associationism, like functionalism, was more of an influential way of thinking than a rigid school of psychology. **Associationism** examines how elements of the mind,

PRACTICAL APPLICATIONS OF COGNITIVE PSYCHOLOGY

PRAGMATISM

Take a moment right now to put the idea of pragmatism into use. Think about ways to make the information you are learning in this course more useful to you. Notice that the chapter begins with questions that make the information more coherent and useful, and the chapter summary returns to those questions. Come up with your own questions and try organizing your notes in the form of answers to your questions.

Also, try relating this material to other courses or activities you participate in. For example, you may be called on to explain to a friend how to use a new computer program. A good way to start would be to ask your friend, "Do you have any questions?" That way, the information you provide is more directly useful to your friend rather than forcing your friend to search for the information by listening to a long, one-sided lecture.

How can pragmatism be useful in your life (other than in your college coursework)?

like events or ideas, can become associated with one another in the mind to result in a form of learning. For example, associations may result from:

- *contiguity* (associating things that tend to occur together at about the same time);
- *similarity* (associating things with similar features or properties); or
- *contrast* (associating things that show polarities, such as hot/cold, light/dark, day/night).

In the late 1800s, associationist Hermann Ebbinghaus (1850–1909) was the first experimenter to apply associationist principles systematically. Specifically, Ebbinghaus studied his own mental processes. He made up lists of nonsense syllables that consisted of a consonant and a vowel followed by another consonant (e.g., zax). He then took careful note of how long it took him to memorize those lists. He counted his errors and recorded his response times. Through his self-observations, Ebbinghaus studied how people learn and remember material through *rehearsal*, the conscious repetition of material to be learned (Figure 1.2). Among other things, he found that frequent repetition can fix mental associations more firmly in memory. Thus, repetition aids in learning (see Chapter 6).

Another influential associationist, Edward Lee Thorndike (1874–1949), held that the role of "satisfaction" is the key to forming associations. Thorndike termed this principle the *law of effect* (1905): A stimulus will tend to produce a certain response over time if an organism is rewarded for that response. Thorndike believed that an organism learns to respond in a given way (the *effect*) in a given situation if it is rewarded repeatedly for doing so (the *satisfaction*, which serves as a stimulus to future actions). Thus, a child given treats for solving arithmetic problems learns to solve arithmetic problems accurately because the child forms associations between valid solutions and treats. These ideas were the predecessors of the development of behaviorism.

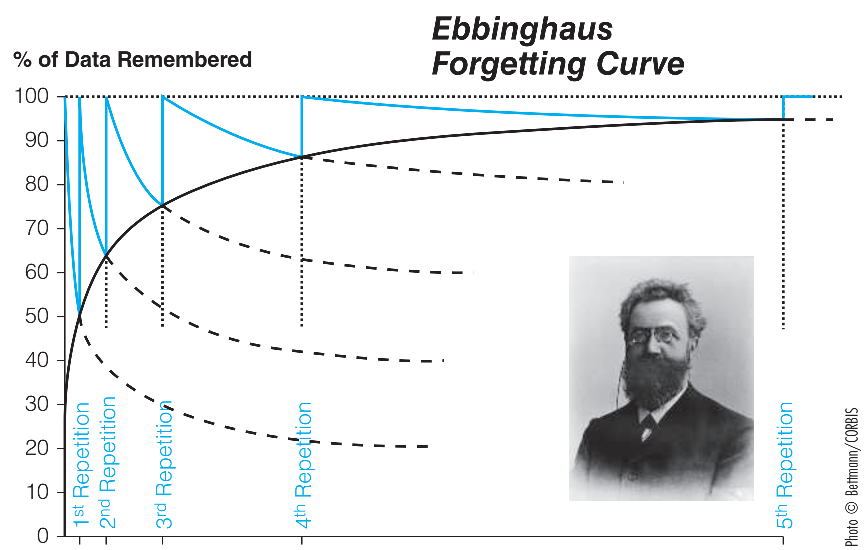


Figure 1.2 The Ebbinghaus Forgetting Curve shows that the first few repetitions result in a steep learning curve. Later repetitions result in a slower increase of remembered words.

It's Only What You Can See That Counts: From Associationism to Behaviorism

Other researchers who were contemporaries of Thorndike used animal experiments to probe stimulus–response relationships in ways that differed from those of Thorndike and his fellow associationists. These researchers straddled the line between associationism and the emerging field of behaviorism. **Behaviorism** focuses only on the relation between observable behavior and environmental events or stimuli. The idea was to make physical whatever others might have called "mental" (Lycan, 2003). Some of these researchers, like Thorndike and other associationists, studied responses that were voluntary (although perhaps lacking any conscious thought, as in Thorndike's work). Other researchers studied responses that were involuntarily triggered in response to what appear to be unrelated external events.

In Russia, Nobel Prize–winning physiologist Ivan Pavlov (1849–1936) studied involuntary learning behavior of this sort. He began with the observation that dogs salivated in response to the sight of the lab technician who fed them. This response occurred before the dogs even saw whether the technician had food. To Pavlov, this response indicated a form of learning (classically conditioned learning), over which the dogs had no conscious control. In the dogs' minds, some type of involuntary learning linked the technician to the food (Pavlov, 1955). Pavlov's landmark work paved the way for the development of behaviorism. His ideas were made known in the United States especially through the work of John B. Watson (see next section). Classical conditioning involves more than just an association based on temporal contiguity (e.g., the food and the conditioned stimulus occurring at about the same time; Ginns, 2006; Rescorla, 1967). Effective conditioning requires *contingency* (e.g., the presentation of food being contingent on the presentation of the conditioned stimulus; Rescorla & Wagner, 1972; Wagner & Rescorla, 1972). Contingencies in the form of reward and punishment are still used today, for example, in the treatment of substance abuse (Cameron & Ritter, 2007).

Behaviorism may be considered an extreme version of associationism. It focuses entirely on the association between the environment and an observable behavior. According to strict, extreme ("radical") behaviorists, any hypotheses about internal thoughts and ways of thinking are nothing more than speculation.

Proponents of Behaviorism

The "father" of radical behaviorism is John Watson (1878–1958). Watson had no use for internal mental contents or mechanisms. He believed that psychologists should concentrate only on the study of observable behavior (Doyle, 2000). He dismissed thinking as nothing more than subvocalized speech. Behaviorism also differed from previous movements in psychology by shifting the emphasis of experimental research from human to animal participants. Historically, much behaviorist work has been conducted (and still is) with laboratory animals, such as rats or pigeons, because these animals allow for much greater behavioral control of relationships between the environment and the behavior emitted in reaction to it (although behaviorists also have conducted experiments with humans). One problem with using nonhuman animals, however, is determining whether the research can be *generalized* to humans (i.e., applied more generally to humans instead of just to the kinds of nonhuman animals that were studied).

B. F. Skinner (1904–1990), a radical behaviorist, believed that virtually all forms of human behavior, not just learning, could be explained by behavior emitted in reaction to the environment. Skinner conducted research primarily with nonhuman animals. He rejected mental mechanisms. He believed instead that *operant conditioning*—involving the strengthening or weakening of behavior, contingent on the presence or absence of reinforcement (rewards) or punishments—could explain all forms of human behavior. Skinner applied his experimental analysis of behavior to many psychological phenomena, such as learning, language acquisition, and problem solving. Largely because of Skinner's towering presence, behaviorism dominated the discipline of psychology for several decades.

Criticisms of Behaviorism

Behaviorism was challenged on many fronts like language acquisition, production, and comprehension. First, although it seemed to work well to account for certain kinds of learning, behaviorism did not account as well for complex mental activities such as language learning and problem solving. Second, more than understanding people's behavior, some psychologists wanted to know what went on inside the head. Third, it often proved easier to use the techniques of behaviorism in studying nonhuman animals than in studying human ones. Nonetheless, behaviorism continues as a school of psychology, although not one that is particularly sympathetic to the cognitive approach, which involves metaphorically and sometimes literally peering inside people's heads to understand how they learn, remember, think, and reason. Other criticisms emerged as well, as discussed in the next section.

Behaviorists Daring to Peek into the Black Box

Some psychologists rejected radical behaviorism. They were curious about the contents of the mysterious *black box*. Behaviorists regarded the mind as a black box that is best understood in terms of its input and output, but whose internal processes cannot be accurately described because they are not observable. For example, a critic, Edward Tolman (1886–1959), thought that understanding behavior required taking into account the purpose of, and the plan for, the behavior. Tolman (1932) believed

BELIEVE IT OR NOT

Scientific Progress!?

The progress of science can take quite unbelievable turns at times. From the early 1930s to the 1960s, lobotomies were a popular and accepted means of treating mental disorders. A lobotomy involves cutting the connections between the frontal lobes of the brain and the thalamus. Psychiatrist Walter Freeman developed a particular kind of lobotomy in 1946—the transorbital or "ice pick" lobotomy. In this procedure, he used an instrument that looked like an ice pick and inserted it through the orbit of the eyes into the frontal lobes where it was moved back and forth. The patient had been previously rendered unconscious by means of a strong electrical shock. By the late 1950s, tens of thousands of Americans had been subjected to this "psychosurgery." According to some accounts, people felt reduced tension and anxiety after the surgery; however, there were many people who died or were permanently incapacitated after the lobotomy. Famous lobotomy patients include John F. Kennedy's sister Rosemary. Unbelievably, lobotomy was even performed on patients who were not aware they were receiving the surgery. The shocking story of Howard Dully, who was lobotomized at age 12 and did not find out about the procedure until much later in life, can be found at

http://www.npr.org/templates/story/story.php?storyId=5014080 (Helmes & Velamoor, 2009; MSNBC, 2005).

that all behavior is directed toward a goal. For example, the goal of a rat in a maze may be to try to find food in that maze. Tolman is sometimes viewed as a forefather of modern cognitive psychology.

Bandura (1977b) noted that learning appears to result not merely from direct rewards for behavior, but it also can be social, resulting from observations of the rewards or punishments given to others. The ability to learn through observation is well documented and can be seen in humans, monkeys, dogs, birds, and even fish (Brown & Laland, 2001; Laland, 2004). In humans, this ability spans all ages; it is observed in both infants and adults (Mejia-Arauz, Rogoff, & Paradise, 2005). This view emphasizes how we observe and model our own behavior after the behavior of others. We learn by example. This consideration of social learning opens the way to considering what is happening inside the mind of the individual.

The Whole Is More Than the Sum of Its Parts: Gestalt Psychology

Of the many critics of behaviorism, Gestalt psychologists may have been among the most avid. **Gestalt psychology** states that we best understand psychological phenomena when we view them as organized, structured wholes. According to this view, we cannot fully understand behavior when we only break phenomena down into smaller parts. For example, behaviorists tended to study problem solving by looking for subvocal processing—they were looking for the observable behavior through which problem solving can be understood. Gestaltists, in contrast, studied insight, seeking to understand the unobservable mental event by which someone goes from having no idea about how to solve a problem to understanding it fully in what seems a mere moment of time.

The maxim "the whole is more than the sum of its parts" aptly sums up the Gestalt perspective. To understand the perception of a flower, for example, we would have to take into account the whole of the experience. We could not understand such a perception merely in terms of a description of forms, colors, sizes, and so on. Similarly, as noted in the previous paragraph, we could not understand problem solving merely by looking at minute elements of observable behavior (Köhler, 1927, 1940; Wertheimer, 1945/1959). We will have a closer look at Gestalt principles in Chapter 3.

Emergence of Cognitive Psychology

In the early 1950s, a movement called the "cognitive revolution" took place in response to behaviorism. **Cognitivism** is the belief that much of human behavior can be understood in terms of how people think. It rejects the notion that psychologists should avoid studying mental processes because they are unobservable. Cognitivism is, in part, a synthesis of earlier forms of analysis, such as behaviorism and Gestaltism. Like behaviorism, it adopts precise quantitative analysis to study how people learn and think; like Gestaltism, it emphasizes internal mental processes.

Early Role of Psychobiology

Ironically, one of Watson's former students, Karl Spencer Lashley (1890–1958), brashly challenged the behaviorist view that the human brain is a passive organ merely responding to environmental contingencies outside the individual (Gardner, 1985). Instead, Lashley considered the brain to be an active, dynamic organizer of behavior. Lashley sought to understand how the macro-organization of the human brain made possible such complex, planned activities as musical performance, game playing, and using language. None of these activities were, in his view, readily explicable in terms of simple conditioning.

In the same vein, but at a different level of analysis, Donald Hebb (1949) proposed the concept of cell assemblies as the basis for learning in the brain. Cell assemblies are coordinated neural structures that develop through frequent stimulation. They develop over time as the ability of one neuron (nerve cell) to stimulate firing in a connected neuron increases. Behaviorists did not jump at the opportunity to agree with theorists like Lashley and Hebb. In fact, behaviorist B. F. Skinner (1957) wrote an entire book describing how language acquisition and usage could be explained purely in terms of environmental contingencies. This work stretched Skinner's framework too far, leaving Skinner open to attack. An attack was indeed forthcoming. Linguist Noam Chomsky (1959) wrote a scathing review of Skinner's ideas. In his article, Chomsky stressed both the biological basis and the creative potential of language. He pointed out the infinite numbers of sentences we can produce with ease. He thereby defied behaviorist notions that we learn language by reinforcement. Even young children continually are producing novel sentences for which they could not have been reinforced in the past.

Add a Dash of Technology: Engineering, Computation, and Applied Cognitive Psychology

By the end of the 1950s, some psychologists were intrigued by the tantalizing notion that machines could be programmed to demonstrate the intelligent processing of information (Rychlak & Struckman, 2000). Turing (1950) suggested that soon it would be hard to distinguish the communication of machines from that of humans. He suggested a test, now called the "Turing test," by which a computer program would be judged as successful to the extent that its output was indistinguishable, by humans, from the output of humans (Cummins & Cummins, 2000). In other words, suppose you communicated with a computer and you could not tell that it was a computer. The computer then passed the Turing test (Schonbein & Bechtel, 2003).

By 1956 a new phrase had entered our vocabulary. **Artificial intelligence (AI)** is the attempt by humans to construct systems that show intelligence and, particularly, the intelligent processing of information (*Merriam-Webster's Collegiate Dictionary*, 2003). Chess-playing programs, which now can beat most humans, are examples of artificial intelligence. However, experts greatly underestimated how difficult it would be to develop a computer that can think like a human being. Even today, computers have trouble reading handwriting and understanding and responding to spoken language with the ease that humans do.

Many of the early cognitive psychologists became interested in cognitive psychology through applied problems. For example, according to Berry (2002), Donald Broadbent (1926–1993) claimed to have developed an interest in cognitive

"This problem had been my life's work. I planned to devote my remaining years to it. It's just been solved in four seconds."

psychology through a puzzle regarding AT6 aircraft. The planes had two almost identical levers under the seat. One lever was to pull up the wheels and the other to pull up the flaps. Pilots apparently regularly mistook one for the other, thereby crashing expensive planes upon take-off. During World War II, many cognitive psychologists, including one of the senior author's advisors, Wendell Garner, consulted with the military in solving practical problems of aviation and other fields that arose out of warfare against enemy forces. Information theory, which sought to understand people's behavior in terms of how they process the kinds of bits of information processed by computers (Shannon & Weaver, 1963), also grew out of problems in engineering and informatics.

Applied cognitive psychology also has had great use in advertising. John Watson, after he left Johns Hopkins University as a professor, became an extremely successful executive in an advertising firm and applied his knowledge of psychology to reach his success. Indeed, much of advertising has directly used principles from cognitive psychology to attract customers to products (Benjamin & Baker, 2004).

By the early 1960s, developments in psychobiology, linguistics, anthropology, and artificial intelligence, as well as the reactions against behaviorism by many mainstream psychologists, converged to create an atmosphere ripe for revolution.

Early cognitivists (e.g., Miller, Galanter, & Pribram, 1960; Newell, Shaw, & Simon, 1957b) argued that traditional behaviorist accounts of behavior were inadequate precisely because they said nothing about how people think. One of the most famous early articles in cognitive psychology was, oddly enough, on "the magic number seven." George Miller (1956) noted that the number seven appeared in many different places in cognitive psychology, such as in the literature on perception and memory, and he wondered whether there was some hidden meaning in its frequent reappearance. For example, he found that most people can remember about seven items of information. In this work, Miller also introduced the concept of *channel capacity*, the upper limit with which an observer can match a response to information given to him or her. For example, if you can remember seven digits presented to you sequentially, your channel capacity for remembering digits is seven. Ulric Neisser's book *Cognitive Psychology* (Neisser, 1967) was especially critical in bringing cognitivism to prominence by informing undergraduates, graduate students, and academics about the newly developing field.

Neisser defined *cognitive psychology* as the study of how people learn, structure, store, and use knowledge. Subsequently, Allen Newell and Herbert Simon (1972) proposed detailed models of human thinking and problem solving from the most basic levels to the most complex. By the 1970s cognitive psychology was recognized widely as a major field of psychological study with a distinctive set of research methods.

In the 1970s, Jerry Fodor (1973) popularized the concept of the modularity of mind. He argued that the mind has distinct modules, or special-purpose systems, to deal with linguistic and, possibly, other kinds of information. Modularity implies that the processes that are used in one domain of processing, such as the linguistic (Fodor, 1973) or the perceptual domain (Marr, 1982), operate independently of processes in other domains. An opposing view would be one of domain-general processing, according to which the processes that apply in one domain, such as perception or language, apply in many other domains as well. Modular approaches are useful in studying some cognitive phenomena, such as language, but have proven less useful in studying other phenomena, such as intelligence, which seems to draw upon many different areas of the brain in complex interrelationships.

Curiously, the idea of the mind as modular goes back at least to phrenologist Franz-Joseph Gall (see Boring, 1950), who in the late eighteenth century believed that the pattern of bumps and swells on the skull was directly associated with one's pattern of cognitive skills. Although phrenology itself was not a scientifically valid technique, the practice of mental cartography lingered and eventually gave rise to ideas of modularity based on modern scientific techniques.

✔ CONCEPT CHECK

1. What is pragmatism, and how is it related to functionalism?
2. How are associationism and behaviorism both similar and different?
3. What is the fundamental idea behind Gestalt psychology?
4. What is the meaning of modularity of mind?
5. How does cognitivism incorporate elements of the schools that preceded it?

Cognition and Intelligence

Human intelligence can be viewed as an integrating, or "umbrella" psychological construct for a great deal of theory and research in cognitive psychology. **Intelligence** is the capacity to learn from experience, using metacognitive processes to enhance learning, and the ability to adapt to the surrounding environment. It may require different adaptations within different social and cultural contexts. People who are more intelligent tend to be superior in processes such as divided and selective attention, working memory, reasoning, problem solving, decision making, and concept formation. So when we come to understand the mental processes involved in each of these cognitive functions, we also better understand the bases of individual differences in human intelligence.

What Is Intelligence?

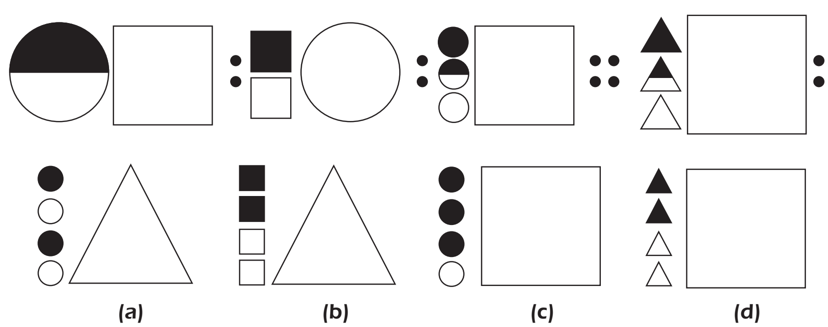
Before you read about how cognitive psychologists view intelligence, test your own intelligence with the tasks in *Investigating Cognitive Psychology: Intelligence*.

Each of the tasks in *Investigating Cognitive Psychology* is believed, at least by some cognitive psychologists, to require some degree of intelligence. (The answers are at the end of this section.) Intelligence is a concept that can be viewed as tying together all of cognitive psychology. Just what is intelligence, beyond the basic definition? In a recent article, researchers identified approximately 70 different definitions of intelligence (Legg & Hutter, 2007). In 1921, when the editors of the *Journal of*

INVESTIGATING COGNITIVE PSYCHOLOGY

Intelligence

1. Candle is to tallow as tire is to (a) automobile, (b) round, (c) rubber, (d) hollow.
2. Complete this series: 100%, 0.75, 1/2; (a) whole, (b) one eighth, (c) one fourth.
3. The first three items form one series. Complete the analogous second series that starts with the fourth item:



4. You are at a party of truth-tellers and liars. The truth-tellers always tell the truth, and the liars always lie. You meet someone new. He tells you that he just heard a conversation in which a girl said she was a liar. Is the person you met a liar or a truth-teller?

Educational Psychology asked 14 famous psychologists that question, the responses varied but generally embraced these two themes. Intelligence involves:

1. the capacity to learn from experience, and
2. the ability to adapt to the surrounding environment.

Sixty-five years later, 24 cognitive psychologists with expertise in intelligence research were asked the same question (Sternberg & Detterman, 1986). They, too, underscored the importance of learning from experience and adapting to the environment. They also broadened the definition to emphasize the importance of *metacognition*—people's understanding and control of their own thinking processes. Contemporary experts also more heavily emphasized the role of culture. They pointed out that what is considered intelligent in one culture may be considered stupid in another culture (Serpell, 2000).

There are actually a number of cultural differences in the definition of intelligence. These differences have led to a field of study within intelligence research that examines understanding of cultural differences in the definition of intelligence. This field explores what is termed *cultural intelligence*, or CQ. This term is used to describe a person's ability to adapt to a variety of challenges in diverse cultures (Ang et al., 2010; Sternberg & Grigorenko, 2006; Triandis, 2006). Research also shows that personality variables are related to intelligence (Ackerman, 1996, 2010). Taken together, this evidence suggests that a comprehensive definition of intelligence incorporates many facets of intellect.

Definitions of intelligence also frequently take on an assessment-oriented focus. In fact, some psychologists have been content to define intelligence as whatever it is that the tests measure (Boring, 1923). This definition, unfortunately, is circular. According to it, the nature of intelligence is what is tested. But what is tested must necessarily be determined by the nature of intelligence. Moreover, what different tests of intelligence measure is not always the same thing. Different tests measure somewhat different constructs (Daniel, 1997, 2000; Kaufman, 2000; Kaufman & Lichtenberger, 1998). So it is not feasible to define intelligence by what tests measure, as though they all measured the same thing. By the way, the answers to the questions in *Investigating Cognitive Psychology: Intelligence* are:

1. Rubber. Candles are frequently made of tallow, just as tires are frequently made of (c) rubber.
2. 100%, 0.75, and 1/2 are quantities that successively decrease by 1/4; to complete the series, the answer is (c) one fourth, which is a further decrease by 1/4.
3. The first series was a circle and a square, followed by two squares and a circle, followed by three circles and a square; the second series was three triangles and a square, which would be followed by (b), four squares and a triangle.
4. The person you met is clearly a liar. If the girl about whom this person was talking were a truth-teller, she would have said that she was a truth-teller. If she were a liar, she would have lied and said that she was a truth-teller also. Thus, regardless of whether the girl was a truth-teller or a liar, she would have said that she was a truth-teller. Because the man you met has said that she said she was a liar, he must be lying and hence must be a liar.

Three Cognitive Models of Intelligence

There have been many models of intelligence. Three models are particularly useful when linking human intelligence to cognition: the three-stratum model, the theory of multiple intelligences, and the triarchic theory of intelligence.

Carroll: Three-Stratum Model of Intelligence

According to the **three-stratum model of intelligence**, intelligence comprises a hierarchy of cognitive abilities comprising three strata (Carroll, 1993):

- Stratum I includes many narrow, specific abilities (e.g., spelling ability, speed of reasoning).
- Stratum II includes various broad abilities (e.g., fluid intelligence, crystallized intelligence, short-term memory, long-term storage and retrieval, information-processing speed).
- Stratum III is just a single general intelligence (sometimes called *g*).

Of these strata, the most interesting is the middle stratum, which is neither too narrow nor too all-encompassing.

In the middle stratum are fluid ability and crystallized ability. *Fluid ability* is speed and accuracy of abstract reasoning, especially for novel problems. *Crystallized ability* is accumulated knowledge and vocabulary (Cattell, 1971). In addition to fluid intelligence and crystallized intelligence, Carroll includes several other abilities in the middle stratum. They are learning and memory processes, visual perception, auditory perception, facile production of ideas (similar to verbal fluency), and speed (which includes both sheer speed of response and speed of accurate responding). Carroll's model is probably the most widely accepted of the measurement-based models of intelligence. You will learn about these processes in later chapters.

Gardner: Theory of Multiple Intelligences

Howard Gardner (1983, 1993b, 1999, 2006) has proposed a **theory of multiple intelligences**, in which intelligence comprises multiple independent constructs, not just a single, unitary construct. However, instead of speaking of multiple abilities that together constitute intelligence (e.g., Thurstone, 1938), this theory distinguishes eight distinct intelligences that are relatively independent of each other (Table 1.1). Each is a separate system of functioning, although these systems can interact to produce what we see as intelligent performance. Looking at Gardner's list of intelligences, you might want to evaluate your own intelligences, perhaps rank ordering your strengths in each.

Gardner does not entirely dismiss the use of psychometric tests. But the base of evidence used by Gardner (e.g., the existence of exceptional individuals in one area, brain lesions that destroy a particular kind of intelligence, or core operations that are essential to performance of a particular intelligence) does not rely on the factor analysis of various psychometric tests alone. Take a moment to reflect:

- In thinking about your own intelligences, how fully integrated do you believe them to be?
- How much do you perceive each type of intelligence as depending on any of the others?

Gardner's view of the mind is modular. Modularity theorists believe that different abilities—such as Gardner's intelligences—can be isolated as emanating from distinct portions or modules of the brain. Thus, a major task of existing and future research on intelligence is to isolate the portions of the brain responsible for each of the intelligences. Gardner has speculated as to at least some of these locales, but hard evidence for the existence of these separate intelligences has yet to be produced. Furthermore, some scientists question the strict modularity of Gardner's theory (Nettelbeck & Young, 1996). Consider the phenomenon of preserved specific

Table 1.1 Gardner's Eight Intelligences

On which of Howard Gardner's eight intelligences do you show the greatest ability? In what contexts can you use your intelligences most effectively? (After Gardner, 1999.)

Type of Intelligence	Tasks Reflecting This Type of Intelligence
Linguistic intelligence	Used in reading a book; writing a paper, a novel, or a poem; and understanding spoken words
Logical-mathematical intelligence	Used in solving math problems, in balancing a checkbook, in solving a mathematical proof, and in logical reasoning
Spatial intelligence	Used in getting from one place to another, in reading a map, and in packing suitcases in the trunk of a car so that they all fit into a compact space
Musical intelligence	Used in singing a song, composing a sonata, playing a trumpet, or even appreciating the structure of a piece of music
Bodily-kinesthetic intelligence	Used in dancing, playing basketball, running a mile, or throwing a javelin
Interpersonal intelligence	Used in relating to other people, such as when we try to understand another person's behavior, motives, or emotions
Intrapersonal intelligence	Used in understanding ourselves—the basis for understanding who we are, what makes us tick, and how we can change ourselves, given our existing constraints on our abilities and our interests
Naturalist intelligence	Used in understanding patterns in nature

cognitive functioning in autistic savants. Savants are people with severe social and cognitive deficits but with corresponding high ability in a narrow domain. They suggest that such preservation fails as evidence for modular intelligences. The narrow long-term memory and specific aptitudes of savants may not really be intelligent (Nettelbeck & Young, 1996). Thus, there may be reason to question the intelligence of inflexible modules.

Sternberg: The Triarchic Theory of Intelligence

Whereas Gardner emphasizes the separateness of the various aspects of intelligence, Robert Sternberg tends to emphasize the extent to which they work together in his triarchic theory of human intelligence (Sternberg, 1985a, 1988, 1996b, 1999). According to the **triarchic theory of human intelligence**, intelligence comprises three aspects: creative, analytical, and practical.

- *Creative abilities* are used to generate novel ideas.
- *Analytical abilities* ascertain whether your ideas (and those of others) are good ones.

- *Practical abilities* are used to implement the ideas and persuade others of their value.

Figure 1.3 illustrates the parts of the theory and the interrelationships of the three parts.

According to the theory, cognition is at the center of intelligence. Information processing in cognition can be viewed in terms of three different kinds of components. First are metacomponents—higher-order executive processes (i.e., metacognition) used to plan, monitor, and evaluate problem solving. Second are performance components—lower-order processes used for implementing the commands of the metacomponents. And third are knowledge-acquisition components—the processes used for learning how to solve the problems in the first place. The components are highly interdependent.

Suppose that you were asked to write a term paper. You would use metacomponents for higher-order decisions. Thus, you would use them to decide on a topic, plan the paper, monitor the writing, and evaluate how well your finished product succeeds in accomplishing your goals for it. You would use knowledge-acquisition components for research to learn about the topic. You would use performance components for the actual writing.

Sternberg and his colleagues performed a comprehensive study testing the validity of the triarchic theory and its usefulness in improving performance. They predicted that matching students' instruction and assessment to their abilities would lead to improved performance (Sternberg et al., 1996; Sternberg et al., 1999). Students were selected for one of five ability patterns: high only in analytical ability, high only in creative ability, high only in practical ability, high in all three abilities, or not high in any of the three abilities. Then students were assigned at random to one of four instructional groups. Instruction in the groups emphasized either memory-based, analytical, creative, or practical learning. Then the memory-based, analytical, creative, and practical achievement of all students was

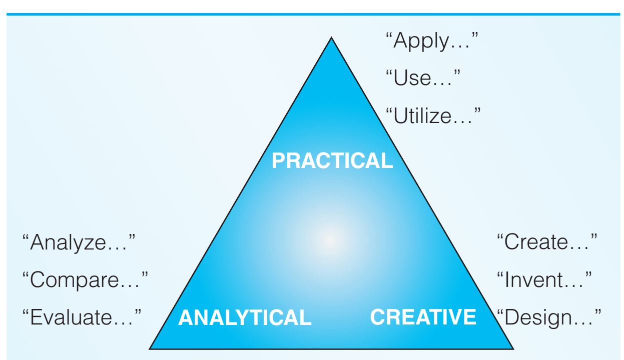


Figure 1.3 According to Robert Sternberg, intelligence comprises analytical, creative, and practical abilities. In analytical thinking, we solve familiar problems by using strategies that manipulate the elements of a problem or the relationships among the elements (e.g., comparing, analyzing). In creative thinking, we solve new kinds of problems that require us to think about the problem and its elements in a new way (e.g., inventing, designing). In practical thinking, we solve problems that apply what we know to everyday contexts (i.e., applying, using).

assessed. The researchers found that students who were placed in an instructional condition that matched their strength in terms of pattern of ability outperformed students who were mismatched. Thus, the prediction of the experiment was confirmed. For example, a high-analytical student being placed in an instructional condition that emphasized analytical thinking outperformed a high-analytical student being placed in an instructional condition that emphasized practical thinking.

Teaching students to use all of their analytic, creative, and practical abilities has resulted in improved school achievement for every student, whatever their ability pattern (Grigorenko, Jarvin, & Sternberg, 2002; Sternberg & Grigorenko, 2004; Sternberg, Torff, & Grigorenko, 1998). One important consideration in light of such findings is the need for changes in the assessment of intelligence (Sternberg & Kaufman, 1996). Current measures of intelligence are somewhat one-sided. They measure mostly analytical abilities. They involve little or no assessment of creative and practical aspects of intelligence (Sternberg et al., 2000; Wagner, 2000). A more well-rounded assessment and instruction system could lead to greater benefits of education for a wider variety of students—a nominal goal of education.

One attempt to accomplish this goal can be seen through the Rainbow Project. In the Rainbow Project, students completed the SAT and additional assessments. These additional assessments included measures of creative and practical as well as of analytical abilities (Sternberg & the Rainbow Project Collaborators, 2006). The addition of these supplemental assessments resulted in superior prediction of college grade point average (GPA) as compared with scores on the SAT and high school GPA. In fact, the new tests doubled the prediction of first-year college GPA obtained just by the SAT. Moreover, the new assessments substantially reduced differences in scores among members of diverse ethnic groups.

We have discussed how human intelligence provides a conceptual base for understanding phenomena in cognitive psychology. What methods do we use to study these phenomena?

Research Methods in Cognitive Psychology

Researchers employ a variety of research methods. These methods include laboratory or other controlled experiments, psychobiological research, self-reports, case studies, naturalistic observation, and computer simulations and artificial intelligence. Each of these methods will be discussed in detail in this section. To better understand the specific methods used by cognitive psychologists, one must first grasp the goals of research in cognitive psychology.

Goals of Research

Briefly, research goals include data gathering, data analysis, theory development, hypothesis formulation, hypothesis testing, and perhaps even application to settings outside the research environment. Often researchers simply seek to gather as much information as possible about a particular phenomenon. They may or may not have preconceived notions regarding what they may find while gathering the data. Their research focuses on describing particular cognitive phenomena, such as how people recognize faces or how they develop expertise.

Data gathering reflects an empirical aspect of the scientific enterprise. Once there are sufficient data on the cognitive phenomenon of interest, cognitive psychologists use various methods for drawing inferences from the data. Ideally, they use multiple converging types of evidence to support their hypotheses. Sometimes, just a quick glance at the data leads to intuitive inferences regarding patterns that emerge from those data. More commonly, however, researchers use various statistical means of analyzing the data.

Data gathering and statistical analysis aid researchers in describing cognitive phenomena. No scientific pursuit could get far without such descriptions. However, most cognitive psychologists want to understand more than the *what* of cognition; most also seek to understand the *how* and the *why* of thinking. That is, researchers seek ways to explain cognition as well as to describe it. To move beyond descriptions, cognitive psychologists must leap from what is observed directly to what can be inferred regarding observations.

Suppose that we wish to study one particular aspect of cognition. An example would be how people comprehend information in textbooks. We usually start with a theory. A **theory** is an organized body of general explanatory principles regarding a phenomenon, usually based on observations. We seek to test a theory and thereby to see whether it has the power to predict certain aspects of the phenomena with which it deals. In other words, our thought process is, "If our theory is correct, then whenever *x* occurs, outcome *y* should result." This process results in the generation of **hypotheses**, tentative proposals regarding expected empirical consequences of the theory, such as the outcomes of research.

Next, we test our hypotheses through experimentation. Even if particular findings appear to confirm a given hypothesis, the findings must be subjected to statistical analysis to determine their statistical significance. **Statistical significance** indicates the likelihood that a given set of results would be obtained if only chance factors were in operation. For example, a statistical significance level of .05 would mean that the likelihood of a given set of data would be a mere 5% if only chance factors were operating. Therefore, the results are not likely to be due merely to chance. Through this method we can decide to retain or reject hypotheses.

Once our hypothetical predictions have been experimentally tested and statistically analyzed, the findings from those experiments may lead to further work. For example, the psychologist may engage in further data gathering, data analysis, theory development, hypothesis formulation, and hypothesis testing. Based on the hypotheses that were retained and/or rejected, the theory may have to be revised. In addition, many cognitive psychologists hope to use insights gained from research to help people use cognition in real-life situations. Some research in cognitive psychology is applied from the start. It seeks to help people improve their lives and the conditions under which they live their lives. Thus, basic research may lead to everyday applications. For each of these purposes, different research methods offer different advantages and disadvantages.

Distinctive Research Methods

Cognitive psychologists use various methods to explore how humans think. These methods include (a) laboratory or other controlled experiments, (b) psychobiological research, (c) self-reports, (d) case studies, (e) naturalistic observation, and (f) computer simulations and artificial intelligence. See Table 1.2 for descriptions and examples of each method. As the table shows, each method offers distinctive advantages and disadvantages.

IN THE LAB OF HENRY L. ROEDIGER

The Science of the Mind


HENRY L. ROEDIGER

In 1620 Sir Francis Bacon wrote: "If you read a piece of text through twenty times, you will not learn it by heart so easily as if you read it ten times while attempting to recite from time to time and consulting the text when your memory fails." How did he know that? The answer is that he did not know, for sure, but based his judgment on his own personal experience. The case is interesting because Bacon was one of the originators of the scientific method and laid out the framework for experimental science.

Science in Bacon's time was applied to the natural world, what today would be called the physical sciences (chiefly, physics and chemistry). The idea that scientific methods could be applied to people was not even dreamt of and, had the notion been raised, it would have been hooted down. Human beings were not dross stuff; they had souls, they had free will—surely they could not be studied scientifically! It took another 250 years before pioneers would question this assumption and take the brave step to create a science of psychology, the study of the mind. The date usually given is 1879, when Wilhelm Wundt founded the first psychology laboratory in Leipzig, Germany.

Edwin G. Boring, the great historian of psychology, wrote that the "application of the experimental method to the problem of mind is the great outstanding event in the study of the mind, an event to which no other is comparable" (1929, p. 659). Boring is right, and the textbook you hold relates the fascinating story of cognitive psychology, today's experimental study of mind.

But what about Bacon's assertion? Does reciting material really help one learn it more than studying it? This idea seems odd, because in education we think of studying as being how we learn; and of testing as only measuring what has been learned.

My students and I have been studying the possible validity of Bacon's claim in a variety of experimental contexts (although, truth be told, we found the quotation after the studies were well under way). In our experiments, students learn materials (either simple sets of words or more complex textbook passages—the material does not matter) by various combinations of studying and testing the material. The general finding is that retrieval (or reciting, as Bacon called it) during a test provides a great boost to later retention, much more so than repeated studying (Roediger & Karpicke, 2006).

Let's consider just one experiment here to make the point. Zaromb and Roediger (2011) gave students lists of words to remember in preparation for a test that would be given two days later. Students in one condition studied the material eight times with short breaks, but students in two other conditions received either two or four tests in place of some of the study trials. If *S* denotes a study trial and *T* denotes a test (or recitation), the three conditions can be labeled *SSSSSSSS*, *STSSSTSS*, or *STSTSTST*. If studying determines later recall, then the three conditions just listed should be ordered in terms of decreasing effectiveness (from eight to six to four study trials). However, if Bacon is right, the conditions should be ordered in increasing effectiveness for later retention (from zero to two to four test trials). The result: the proportion recalled two days later was .17, .25 and .39 for the three conditions in the order listed above.

Sir Francis Bacon was right: Reciting is more effective than studying (although of course some studying is required). To my knowledge, no one has done the actual experiment he suggested (20 trials), but it would make a fine class project with 20 study trials for one condition or 10 study and 10 test trials for the other. By the way, self-testing on material is a good way to study for your courses (Roediger, McDermott & McDaniel, 2011).

Experiments on Human Behavior

In controlled experimental designs, an experimenter will usually conduct research in a laboratory setting. The experimenter controls as many aspects of the experimental situation as possible. There are basically two kinds of variables in any given experiment. **Independent variables** are aspects of an investigation that are individually *manipulated*, or carefully regulated, by the experimenter, while other aspects of the investigation are held constant (i.e., not subject to variation). **Dependent variables** are outcome responses, the values of which depend on how one or more independent variables influence or affect the participants in the experiment. When you tell some student research participants that they will do very well on a task, but you do not say anything to other participants, the independent variable is the amount of information that the students are given about their expected task performance. The dependent variable is how well both groups actually perform the task—that is, their score on the math test.

When the experimenter manipulates the independent variables, he or she controls for the effects of irrelevant variables and observes the effects on the dependent variables (outcomes). These irrelevant variables that are held constant are called *control variables*. For example, when you conduct an experiment on people's ability to concentrate when subjected to different kinds of background music, you should make sure that the lighting in the room is always the same, and not sometimes extremely bright and other times dim. The variable of light needs to be held constant.

Another type of variable is the confounding variable. *Confounding variables* are a type of irrelevant variable that has been left uncontrolled in a study. For example, imagine you want to examine the effectiveness of two problem-solving techniques. You train and test one group under the first strategy at 6 A.M. and a second group under the second strategy at 6 P.M. In this experiment, time of day would be a confounding variable. In other words, time of day may be causing differences in performance that have nothing to do with the problem-solving strategy. Obviously, when conducting research, we must be careful to avoid the influence of confounding variables.

In implementing the experimental method, experimenters must use a representative and random sample of the population of interest. They must exert rigorous control over the experimental conditions so that they know that the observed effects can be attributed to variations in the independent variable and nothing else. For example, in the above mentioned experiment, people's ability to concentrate did not depend on the general lighting conditions in the room, per se, because during a few sessions, the sun shone directly into the eyes of the subjects so that they had trouble seeing.

The experimenter also must randomly assign participants to the treatment and control conditions. For example, you would not want to end up in an experiment on concentration with lots of people with ADD—Attention Deficit Disorder—in your experimental group, but no such people in your control group. If those requisites for the experimental method are fulfilled, the experimenter may be able to infer probable causality. This inference is of the effects of the independent variable or variables (the treatment) on the dependent variable (the outcome) for the given population.

Many different dependent variables are used in cognitive-psychological research. Two common variables are percent correct (or its additive inverse, error rate) and reaction time. These measures are popular because they can tell the investigator, respectively, the accuracy and speed of mental processing. Independent and dependent variables must be chosen with great care, because no matter what processes one is observing, what is learned from an experiment will depend almost exclusively on the variables one chooses to isolate from the often complex behavior one is observing.

Table 1.2 Research Methods

Cognitive psychologists use controlled experiments, psychobiological research, self-reports, case studies, naturalistic observation, and computer simulations and artificial intelligence when studying cognitive phenomena.

Method	**Controlled Laboratory Experiments**	**Psychobiological Research**	**Self-Reports, such as Verbal Protocols, Self-Rating, Diaries**
Description of method	Obtain samples of performance at a particular time and place	Study animal brains and human brains, using postmortem studies and various psychobiological measures or imaging techniques (see Chapter 2)	Obtain participants' reports of own cognition in progress or as recollected
Random assignment of subjects	Usually	Not usually	Not applicable
Experimental control of independent variables	Usually	Varies widely, depending on the particular technique	Probably not
Sample size	May be any size	Often small	Probably small
Sample representativeness	May be representative	Often not representative	May be representative
Ecological validity	Not unlikely; depends on the task and the context to which it is being applied	Unlikely under some circumstances	Maybe; see strengths and weaknesses
Information about individual differences	Usually de-emphasized	Yes	Yes
Strengths	• Easy to administer, score, and do statistical analyses • High probability of drawing valid causal inferences	• "Hard" evidence of cognitive functions through physiological activity • Alternative view of cognitive processes • Possibility to develop treatments for cognitive deficits	• Access to introspective insights from participants' point of view
Weaknesses	• Difficulty in generalizing results beyond a specific place, time, and task setting • Discrepancies between behavior in real life and in the laboratory	• Limited accessibility for most researchers (need appropriate subjects and expensive equipment) • Small samples • Decreased generalizability when abnormal brains or animal brains are investigated	• Inability to report on processes occurring outside conscious awareness • **Verbal protocols & self-ratings:** May influence cognitive process being reported • **Recollections:** Discrepancies between actual cognition and recollected cognitive processes and products
Examples	Karpicke (2009) developed a laboratory task in which participants had to learn and recall Swahili-English word pairs. After subjects first recalled the meaning of a word, that pair was either dropped, presented twice more in a study period, or presented twice more in test periods. Subjects took a final recall test one week later.	New and colleagues (New et al., 2009) have found that Borderline patients with Intermittent Explosive Disorder responded more aggressively to a provocation than did normal control subjects. The patients particularly showed an increase in glucose consumption in brain areas associated with emotion like the amygdala and less activity in dorsal brain regions that serve to control aggression.	In a study about the relation between cortisol levels (which are stress-dependent) and sleep, self-rated health, and stress, participants kept diaries and collected saliva samples over four weeks (Dahlgren et al., 2009).

Case Studies	Naturalistic Observations	Computer Simulations and Artificial Intelligence
Engage in intensive study of single individuals, drawing general conclusions about behavior	Observe real-life situations, as in classrooms, work settings, or homes	**Simulations:** Attempt to make computers simulate human cognitive performance on various tasks **AI:** Attempt to make computers demonstrate intelligent cognitive performance, regardless of whether the process resembles human cognitive processing
Highly unlikely	Not applicable	Not applicable
Highly unlikely	No	Full control of variables of interest
Almost certain to be small	Probably small	Not applicable
Not likely to be representative	May be representative	Not applicable
High ecological validity for individual cases; lower generalizability to others	Yes	Not applicable
Yes; richly detailed information regarding individuals	Possible, but emphasis is on environmental distinctions, not on individual differences	Not applicable
• Access to detailed information about individuals, including historical and current contexts • May lead to specialized applications for special groups (e.g., prodigies, persons with brain damage)	• Access to rich contextual information	• Exploration of possibilities for modeling cognitive processes • Allows clear hypothesis testing • Wide range of practical applications (e.g., robotics for performing dangerous tasks)
• Applicability to other persons • Limited generalizability due to small sample size and nonrepresentativeness of sample	• Lack of experimental control • Possible influence on behavior due to presence of observer	• Limitations imposed by the hardware (i.e., the computer circuitry) and the software (i.e., the programs written by the researchers) • Simulations may imperfectly model the way that the human brain thinks
A case study with a breast cancer patient showed that a new technique (problem-solving therapy) can reduce anxiety and depression in cancer patients (Carvalho & Hopko, 2009).	A study using questionnaires and observation found that Mexicans on average consider themselves less sociable than U.S. Americans consider themselves; however, Mexicans behave much more sociably than U.S. Americans in their everyday lives (Ramirez-Esparza et al., 2009).	**Simulations:** Through detailed computations, David Marr (1982) attempted to simulate human visual perception and proposed a theory of visual perception based on his computer models. **AI:** Various AI programs have been written that can demonstrate expertise (e.g., playing chess), but they probably do so via different processes than those used by human experts.

Psychologists who study cognitive processes with reaction time often use the *subtraction method*, which involves estimating the time a cognitive process takes by subtracting the amount of time information processing takes with the process from the time it takes without the process (Donders, 1868/1869). If you are asked to scan the words *dog, cat, mouse, hamster, chipmunk* and to say whether the word *chipmunk* appears in it, and then are asked to scan *dog, cat, mouse, hamster, chipmunk, lion* and to say whether *lion* appears, the difference in the reaction times might be taken, by some models of mental processing, roughly to indicate the amount of time it takes to process each stimulus.

Suppose the outcomes in the treatment condition show a statistically significant difference from the outcomes in the control condition. The experimenter then can infer the likelihood of a causal link between the independent variable(s) and the dependent variable. Because the researcher can establish a likely causal link between the given independent variables and the dependent variables, controlled laboratory experiments offer an excellent means of testing hypotheses.

Suppose that we wanted to see whether loud, distracting noises influence the ability to perform well on a particular cognitive task (e.g., reading a passage from a textbook and responding to comprehension questions). Ideally, we first would select a random sample of participants from within our total population of interest. We then would randomly assign each participant to a treatment condition or a control condition. Then we would introduce some distracting loud noises to the participants in our treatment condition. The participants in our control condition would not receive this treatment. We would present the cognitive task to participants in both the treatment condition and the control condition and then measure their performance by some means (e.g., speed and accuracy of responses to comprehension questions). Finally, we would analyze our results statistically. We thereby would examine whether the difference between the two groups reached statistical significance.

Suppose the participants in the treatment condition showed poorer performance at a statistically significant level than the participants in the control condition. We might infer that loud, distracting noises influenced the ability to perform well on this particular cognitive task.

In cognitive-psychological research, though the dependent variables may be quite diverse, they often involve various outcome measures of accuracy (e.g., frequency of errors), of response times, or of both. Among the myriad possibilities for independent variables are characteristics of the situation, of the task, or of the participants. For example, characteristics of the situation may involve the presence versus the absence of particular stimuli or hints during a problem-solving task. Characteristics of the task may involve reading versus listening to a series of words and then responding to comprehension questions. Characteristics of the participants may include age differences, differences in educational status, or differences based on test scores.

On the one hand, characteristics of the situation or task may be manipulated through random assignment of participants to either the treatment or the control group. On the other hand, characteristics of the participant are not easily manipulated experimentally. For example, suppose the experimenter wants to study the effects of aging on speed and accuracy of problem solving. The researcher cannot randomly assign participants to various age groups because people's ages cannot be manipulated (although participants of various age groups can be assigned at random to various experimental conditions). In such situations, researchers often use other kinds of studies, for example, studies involving *correlation* (a statistical relationship between two or more attributes, such as characteristics of the participants or of a situation). Correlations are usually expressed through a correlation coefficient known as Pearson's *r*. Pearson's *r* is a number that can range from –1.00 (a negative correlation) to 0 (no correlation) to 1.00 (a positive correlation).

A correlation is a description of a relationship. The correlation coefficient describes the strength of the relationship. The closer the coefficient is to 1 (either positive or negative), the stronger the relationship between the variables is. The sign (positive or negative) of the coefficient describes the direction of the relationship. A positive relationship indicates that as one variable increases (e.g., vocabulary size), another variable also increases (e.g., reading comprehension). A negative relationship indicates that as the measure of one variable increases (e.g., fatigue), the measure of another decreases (e.g., alertness). No correlation—that is, when the coefficient is 0—indicates that there is no pattern or relationship in the change of two variables (e.g., intelligence and earlobe length). In this final case, both variables may change, but the variables do not vary together in a consistent pattern.

Correlational studies are often the method of choice when researchers do not want to deceive their subjects by using manipulations in an experiment or when they are interested in factors that cannot be manipulated ethically (e.g., lesions in specific parts of the human brain). However, because researchers do not have any control over the experimental conditions, causality cannot be inferred from correlational studies.

Findings of statistical relationships are highly informative. Their value should not be underrated. Also, because correlational studies do not require the random assignment of participants to treatment and control conditions, these methods may

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"He's pretty good at rote categorization and single-object relational tasks, but he's not so hot at differentiating between representational and associational signs, and he's very weak on syntax."

be applied flexibly. However, correlational studies generally do not permit unequivocal inferences regarding causality. As a result, many cognitive psychologists strongly prefer experimental data to correlational data.

Psychobiological Research

Through *psychobiological research*, investigators study the relationship between cognitive performance and cerebral events and structures. Chapter 2 describes various specific techniques used in psychobiological research. These techniques generally fall into three categories:

- techniques for studying an individual's brain *postmortem* (after the death of an individual), relating the individual's cognitive function prior to death to observable features of the brain;
- techniques for studying images showing structures of or activities in the brain of an individual who is known to have a particular cognitive deficit;
- techniques for obtaining information about cerebral processes during the normal performance of a cognitive activity.

Postmortem studies offered some of the first insights into how specific *lesions* (areas of injury in the brain) may be associated with particular cognitive deficits. Such studies continue to provide useful insights into how the brain influences cognitive function. Recent technological developments also increasingly enable researchers to study individuals with known cognitive deficits *in vivo* (while the individual is alive). The study of individuals with abnormal cognitive functions linked to cerebral damage often enhances our understanding of normal cognitive functions.

Psychobiological researchers also study normal cognitive functioning by studying cerebral activity in animal participants. Researchers often use animals for experiments involving neurosurgical procedures that cannot be performed on humans because such procedures would be difficult, unethical, or impractical. For example, studies mapping neural activity in the cortex have been conducted on cats and monkeys (e.g., psychobiological research on how the brain responds to visual stimuli; see Chapter 3).

Can cognitive and cerebral functioning of animals and of abnormal humans be generalized to apply to the cognitive and cerebral functioning of normal humans? Psychobiologists have responded to these questions in various ways. For some kinds of cognitive activity, the available technology permits researchers to study the dynamic cerebral activity of normal human participants during cognitive processing (see the brain-imaging techniques described in Chapter 2).

Self-Reports, Case Studies, and Naturalistic Observation

Individual experiments and psychobiological studies often focus on precise specification of discrete aspects of cognition across individuals. To obtain richly textured information about how particular individuals think in a broad range of contexts, researchers may use other methods. These methods include:

- *self-reports* (an individual's own account of cognitive processes);
- *case studies* (in-depth studies of individuals); and
- *naturalistic observation* (detailed studies of cognitive performance in everyday situations and nonlaboratory contexts).

Experimental research is most useful for testing hypotheses; however, research based on self-reports, case studies, and naturalistic observation is often particularly useful for the formulation of hypotheses. These methods are also useful to generate descriptions of rare events or processes that we have no other way to measure.

In very specific circumstances, these methods may provide the only way to gather information. An example is the case of Genie, a girl who was locked in a room until the age of 13 and thus provided with severely limited social and sensory experiences. As a result of her imprisonment, Genie had severe physical impairments and no language skills. Through case-study methods, information was collected about how she later began to learn language (Fromkin et al., 1974; Jones, 1995; LaPointe, 2005). It would have been unethical experimentally to deny a person any language experience for the first 13 years of life. Therefore, case-study methods are the only reasonable way to examine the results of someone being denied language and social exposure.

Similarly, traumatic brain injury cannot be manipulated in humans in the laboratory. Therefore, when traumatic brain injury occurs, case studies are the only way to gather information. For example, consider the case of Phineas Gage, a railroad worker who, in 1848, had a large metal spike driven through his frontal lobes in a freak accident (Torregrossa, Quinn, & Taylor, 2008; see also Figure 1.4). Surprisingly, Mr. Gage survived. His behavior and mental processes were drastically changed by the accident, however. Obviously, we cannot insert large metal rods into the brains of experimental participants. Therefore, in the case of traumatic brain injury, we must rely on case-study methods to gather information.

The reliability of data based on self-reports depends on the candor of the participants. A participant may misreport information about his or her cognitive processes for a variety of reasons. These reasons can be intentional or unintentional. Intentional misreports can include trying to edit out unflattering information.

Figure 1.4 When an explosion forced an iron rod through his head, Phineas Gage sustained frontal lobe damage. Gage was the subject of case studies both during his life and after his death.

Unintentional misreports may involve not understanding the question or not remembering the information accurately. For example, when a participant is asked about the problem-solving strategies he or she used in high school, the participant may not remember. The participant may try to be completely truthful in his or her reports. But reports involving recollected information (e.g., diaries, retrospective accounts, questionnaires, and surveys) are notably less reliable than reports provided during the cognitive processing under investigation. The reason is that participants sometimes forget what they did.

In studying complex cognitive processes, such as problem solving or decision making, researchers often use a verbal protocol. In a *verbal protocol*, the participants describe aloud all their thoughts and ideas during the performance of a given cognitive task (e.g., "I like the apartment with the swimming pool better, but I can't really afford it, so I might have to choose the one without the swimming pool.").

An alternative to a verbal protocol is for participants to report specific information regarding a particular aspect of their cognitive processing. For example, consider a study of insightful problem solving (see Chapter 11). Participants were asked at 15-second intervals to report numerical ratings indicating how close they felt they were to reaching a solution to a given problem. Unfortunately, even these methods of self-reporting have their limitations. What kind of limitations? Cognitive processes may be altered by the act of giving the report (e.g., processes involving brief forms of memory; see Chapter 5). Or, cognitive processes may occur outside of conscious awareness (e.g., processes that do not require conscious attention or that take place so rapidly that we fail to notice them; see Chapter 4). To get an idea of some of the difficulties with self-reports, carry out the following *Investigating Cognitive Psychology: Self-Reports* tasks. Reflect on your experiences with self-reports.

Case studies (e.g., an in-depth study of individuals who are exceptionally gifted) and naturalistic observations (such as detailed observations of the performance of employees operating in nuclear power plants) may be used to complement findings from laboratory experiments. These two methods of cognitive research offer high **ecological validity**, the degree to which particular findings in one environmental

INVESTIGATING COGNITIVE PSYCHOLOGY

Self-Reports

1. Without looking at your shoes, try reporting aloud the various steps involved in tying your shoe.
2. Recall aloud what you did on your last birthday.
3. Now, actually tie your shoe (or something else, such as a string tied around a table leg), reporting aloud the steps you take. Do you notice any differences between task 1 and task 3?
4. Report aloud how you pulled into consciousness the steps involved in tying your shoe or your memories of your last birthday. Can you report exactly how you pulled the information into conscious awareness? Can you report which part of your brain was most active during each of these tasks?

context may be considered relevant outside of that context. As you probably know, *ecology* is the study of the interactive relationship between an organism (or organisms) and its environment. Many cognitive psychologists seek to understand the interactive relationship between human thought processes and the environments in which humans are thinking. Sometimes, cognitive processes that are commonly observed in one setting (e.g., in a laboratory) are not identical to those observed in another setting (e.g., in an air-traffic control tower or a classroom).

Computer Simulations and Artificial Intelligence

Digital computers played a fundamental role in the emergence of the study of cognitive psychology. One kind of influence is indirect—through models of human cognition based on models of how computers process information. Another kind is direct—through computer simulations and artificial intelligence.

In *computer simulations*, researchers program computers to imitate a given human function or process. Examples are performance on particular cognitive tasks (e.g., manipulating objects within three-dimensional space) and performance of particular cognitive processes (e.g., pattern recognition). Some researchers have attempted to create computer models of the entire cognitive architecture of the human mind. Their models have stimulated heated discussions regarding how the human mind may function as a whole (see Chapter 8). Sometimes the distinction between simulation and artificial intelligence is blurred. For example, certain programs are designed to simulate human performance and to maximize functioning simultaneously.

Consider a computer program that plays chess. There are two entirely different ways to conceptualize how to write such a program. One is known as brute force: A researcher constructs an algorithm that considers extremely large numbers of moves in a very short time, potentially beating human players simply by virtue of the number of moves it considers and the future potential consequences of these moves. The program would be viewed as successful to the extent that it beat the best humans. This kind of artificial intelligence does not seek to represent how humans function, but done well, it can produce a program that plays chess at the highest possible level.

An alternative approach, simulation, looks at how chess grand masters solve chess problems and then seeks to function the way they do. The program would be successful if it chose, in a sequence of moves in a game, the same moves that the grand master would choose. It is also possible to combine the two approaches, producing a program that generally simulates human performance but can use brute force as necessary to win games.

Putting It All Together

Cognitive psychologists often broaden and deepen their understanding of cognition through research in cognitive science. **Cognitive science** is a cross-disciplinary field that uses ideas and methods from cognitive psychology, psychobiology, artificial intelligence, philosophy, linguistics, and anthropology (Nickerson, 2005; Von Eckardt, 2005). Cognitive scientists use these ideas and methods to focus on the study of how humans acquire and use knowledge.

Cognitive psychologists also profit from collaborations with other kinds of psychologists. Examples are social psychologists (e.g., in the cross-disciplinary field of social cognition), psychologists who study motivation and emotion, and engineering psychologists (i.e., psychologists who study human-machine interactions), but also clinical psychologists who are interested in psychological disorders. There is also close exchange and collaboration with a number of other related fields. Psychiatrists are interested in how the brain works and how it influences our thinking, feeling, and reasoning. Anthropologists in turn may explore how reasoning and perception processes differ from one culture to the next. Computer specialists try to develop computer interfaces that are highly efficient, given the way humans perceive and process information. Traffic planners can use information from cognitive psychology to plan and construct traffic situations that result in a maximal overview for traffic participants and therefore, hopefully, fewer accidents.

✔ CONCEPT CHECK

1. What is the meaning of "statistical significance"?
2. How do independent and dependent variables differ?
3. Why is the experimental method uniquely suited to drawing causal inferences?
4. What are some of the advantages and disadvantages of the case-study method?
5. How does a theory differ from a hypothesis?

Fundamental Ideas in Cognitive Psychology

Certain fundamental ideas keep emerging in cognitive psychology, regardless of the particular phenomenon one studies. Here are what might be considered five fundamental ideas. These ideas crosscut some of the Key Themes listed at the end of this chapter.

1. *Empirical data and theories are both important—data in cognitive psychology can be fully understood only in the context of an explanatory theory, and theories are empty without empirical data.*

   Theories give meaning to data. Suppose that we know that people's ability to recognize information that they have seen is better than their ability to recall such information. As an example, they are better at recognizing whether they heard a word said on a list than they are at recalling the word without the word being given. This is an interesting empirical generalization, but it does not, in the absence of an underlying theory, provide *explanation*. Another important goal of science is also *prediction*. Theory can suggest under which circumstances limitations to the generalization should occur. Theory thus assists both in explanation and in prediction.

   At the same time, theory without data is empty. Almost anyone can sit in an armchair and propose a theory—even a plausible-sounding one. Science, however, requires empirical testing of such theories. Thus, theories and data depend on each other. Theories generate data collections, which help correct theories, which then lead to further data collections, and so forth.
2. *Cognition is generally adaptive, but not in all specific instances.*

   We can perceive, learn, remember, reason, and solve problems with great accuracy. And we do so even though we are constantly distracted by a plethora of stimuli. The same processes, however, that lead us to perceive, remember, and reason accurately in most situations also can lead us astray. Our memories and reasoning processes, for example, are susceptible to certain well-identified, systematic errors. For example, we tend to overvalue information that is easily available to us. While this tendency generally helps us to make cognitive processes more efficient, we do this even when this information is not optimally relevant to the problem at hand.

3. *Cognitive processes interact with each other and with noncognitive processes.*
   Although cognitive psychologists try to study and often to isolate the functioning of specific cognitive processes, they know that these processes work together. For example, memory processes depend on perceptual processes. What you remember depends in part on what you perceive. But noncognitive processes also interact with cognitive ones. For example, you learn better when you are motivated to learn. Cognitive psychologists therefore seek to study cognitive processes not only in isolation but also in their interactions with each other and with noncognitive processes.

   One of the most exciting areas of cognitive psychology today is at the interface between cognitive and biological levels of analysis. In recent years, it has become possible to localize activity in the brain associated with various kinds of cognitive processes. However, one has to be careful about assuming that the biological activity is causal of the cognitive activity. Research shows that learning that causes changes in the brain—in other words, cognitive processes—can affect biological structures just as biological structures can affect cognitive processes. The cognitive system does not operate in isolation. It works in interaction with other systems.

4. *Cognition needs to be studied through a variety of scientific methods.*
   There is no one right way to study cognition. All cognitive processes need to be studied through a variety of methods. The more different kinds of techniques that lead to the same conclusion, the higher the confidence one can have in that conclusion. For example, suppose studies of reaction times, error rates, and patterns of individual differences all lead to the same conclusion. Then one can have much more confidence in the conclusion than if only one method led to that conclusion.

   All these methods, however, must be *scientific*. They enable us to disconfirm our expectations when those expectations are wrong. Nonscientific methods do not have this feature. For example, methods of inquiry that simply rely on faith or authority to determine truth may have value in our lives, but they are not scientific.

5. *All basic research in cognitive psychology may lead to applications, and all applied research may lead to basic understandings.*
   But the truth is, the distinction between basic and applied research often is not clear at all. Research that seems like it will be basic often leads to immediate applications. Similarly, research that seems like it will be applied sometimes leads quickly to basic understandings. For example, a basic finding from research on memory is that learning is superior when it is spaced out over time rather than crammed into a short time interval. This basic finding has an immediate application to study strategies. At the same time, research on eyewitness testimony, which seems on its face to be very applied, has enhanced our basic understanding of memory systems and of the extent to which humans construct their own memories.

In this book, we emphasize the underlying common ideas and organizing themes across cognitive psychology, rather than simply to state the facts. We follow this path to help you perceive large, meaningful patterns within the domain of cognitive psychology. We also try to give you some idea of how cognitive psychologists think and how they structure their field in their day-to-day work. We hope that this approach will help you to contemplate problems in cognitive psychology at a deeper level than might otherwise be possible. Ultimately, the goal of cognitive psychologists is to understand not only how people may think in their laboratories but also how they think in their everyday lives.

Key Themes in Cognitive Psychology

If we review the important ideas in this chapter, we discover some of the major themes that underlie cognitive psychology, such as nature vs. nurture and rationalism vs. empiricism. These, and the other key themes listed here, address the core of the nature of the human mind. These themes appear again and again in the study of cognitive psychology.

As you read each chapter, think of the topics in terms of how they relate to the major themes in cognitive psychology. You will be encountering these themes throughout this text and can review them in each chapter's *Key Themes* section.

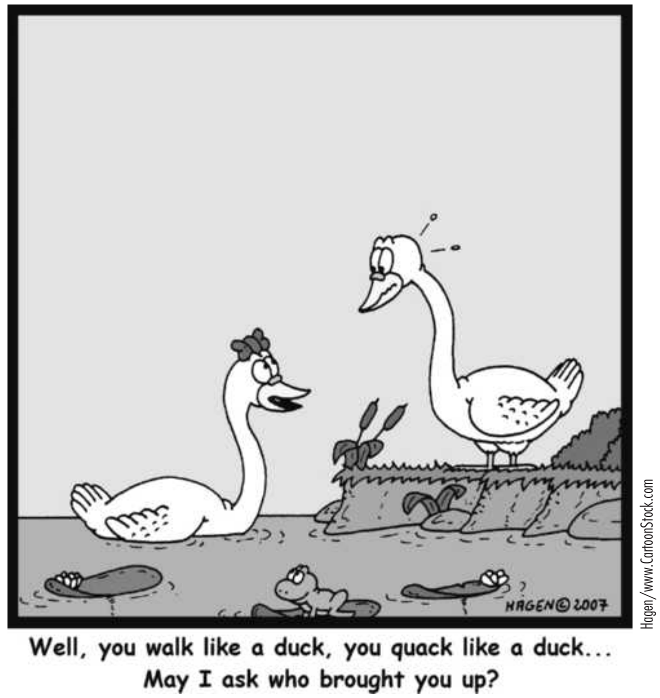
Note that these questions can be posed in the "either/or" form of thesis/antithesis or in the "both/and" form of a synthesis of views or methods. The synthesis view often proves more useful than one extreme position or another. For example, our nature may provide an inherited framework for our distinctive characteristics and patterns of thinking and acting. But our nurture may shape the specific ways in which we flesh out that framework.

We may use empirical methods for gathering data and for testing hypotheses. But we may use rationalist methods for interpreting data, constructing theories, and formulating hypotheses based on theories. Our understanding of cognition deepens when we consider both basic research into fundamental cognitive processes and applied research regarding effective uses of cognition in real-world settings. Syntheses are constantly evolving. What today may be viewed as a synthesis may be viewed tomorrow as an extreme position or vice versa.

Remember, each of the topics in this text (perception, memory, and so on) can be examined using these seven major themes in cognitive psychology:

1. ***Nature versus nurture***
   Thesis/Antithesis: Which is more influential in human cognition—nature or nurture? If we believe that innate characteristics of human cognition are more important, we might focus our research on studying innate characteristics of cognition. If we believe that the environment plays an important role in cognition, we might conduct research exploring how distinctive characteristics of the environment seem to influence cognition.
   Synthesis: We can explore how covariations and interactions in the environment (e.g., an impoverished environment) adversely affect someone whose genes otherwise might have led to success in a variety of tasks.

2. ***Rationalism versus empiricism***
   Thesis/Antithesis: How should we discover the truth about ourselves and about the world around us? Should we do so by trying to reason logically, based on



Nature vs. nurture: Both our genes and our environment may influence what we are, how we behave, and how we think.

what we already know? Or should we do so by observing and testing our observations of what we can perceive through our senses?
Synthesis: We can combine theory with empirical methods to learn the most we can about cognitive phenomena.

3. ***Structures versus processes***
Thesis/Antithesis: Should we study the structures (contents, attributes, and products) of the human mind? Or should we focus on the processes of human thinking?
Synthesis: We can explore how mental processes operate on mental structures.

4. ***Domain generality versus domain specificity***
Thesis/Antithesis: Are the processes we observe limited to single domains, or are they general across a variety of domains? Do observations in one domain apply also to all domains, or do they apply only to the specific domains observed?
Synthesis: We can explore which processes might be domain-general and which might be domain-specific.

5. ***Validity of causal inferences versus ecological validity***
Thesis/Antithesis: Should we study cognition by using highly controlled experiments that increase the probability of valid inferences regarding causality? Or

should we use more naturalistic techniques, which increase the likelihood of obtaining ecologically valid findings but possibly at the expense of experimental control?
Synthesis: We can combine a variety of methods, including laboratory methods and more naturalistic ones, so as to converge on findings that hold up, regardless of the method of study.

6. ***Applied versus basic research***
Thesis/Antithesis: Should we conduct research into fundamental cognitive processes? Or should we study ways in which to help people use cognition effectively in practical situations?
Synthesis: We can combine the two kinds of research dialectically so that basic research leads to applied research, which leads to further basic research, and so on.

7. ***Biological versus behavioral methods***
Thesis/Antithesis: Should we study the brain and its functioning directly, perhaps even scanning the brain while people are performing cognitive tasks? Or should we study people's behavior in cognitive tasks, looking at measures such as percent correct and reaction time?
Synthesis: We can try to synthesize biological and behavioral methods so that we understand cognitive phenomena at multiple levels of analysis.

Summary

1. **What is cognitive psychology?** Cognitive psychology is the study of how people perceive, learn, remember, and think about information.
2. **How did psychology develop as a science**? Beginning with Plato and Aristotle, people have contemplated how to gain understanding of the truth. Plato held that rationalism offers the clear path to truth, whereas Aristotle espoused empiricism as the route to knowledge. Centuries later, Descartes extended Plato's rationalism, whereas Locke elaborated on Aristotle's empiricism. Kant offered a synthesis of these apparent opposites. Decades after Kant proposed his synthesis, Hegel observed how the history of ideas seems to progress through a *dialectical* process.
3. **How did cognitive psychology develop from psychology?** By the twentieth century, psychology had emerged as a distinct field of study. Wundt focused on the structures of the mind (leading to *structuralism*), whereas James and Dewey focused on the processes of the mind (*functionalism*).

   Emerging from this dialectic was *associationism*, espoused by Ebbinghaus and Thorndike. It paved the way for behaviorism by underscoring the importance of mental associations. Another step toward behaviorism was Pavlov's discovery of the principles of classical conditioning. Watson, and later Skinner, were the chief proponents of *behaviorism*. It focused entirely on observable links between an organism's behavior and particular environmental contingencies that strengthen or weaken the likelihood that particular behaviors will be repeated. Most behaviorists dismissed entirely the notion that there is merit in psychologists trying to understand what is going on in the mind of the individual engaging in the behavior.

   However, Tolman and subsequent behaviorist researchers noted the role of cognitive processes in influencing behavior. A convergence of developments across many fields led to the emergence of *cognitive psychology* as a discrete discipline, spearheaded by such notables as Neisser.
4. **How have other disciplines contributed to the development of theory and research in cognitive psychology?** Cognitive psychology has

roots in philosophy and physiology. They merged to form the mainstream of psychology. As a discrete field of psychological study, cognitive psychology also profited from cross-disciplinary investigations.

Relevant fields include linguistics (e.g., How do language and thought interact?), biological psychology (e.g., What are the physiological bases for cognition?), anthropology (e.g., What is the importance of the cultural context for cognition?), and technological advances like artificial intelligence (e.g., How do computers process information?).

5. **What methods do cognitive psychologists use to study how people think?** Cognitive psychologists use a broad range of methods, including experiments, psychobiological techniques, self-reports, case studies, naturalistic observation, and computer simulations and artificial intelligence.
6. **What are the current issues and various fields of study within cognitive psychology?** Some of the major issues in the field have centered on how to pursue knowledge. Psychological work can be done:
   - by using both *rationalism* (which is the basis for theory development) and *empiricism* (which is the basis for gathering data);
   - by underscoring the importance of cognitive structures and of cognitive processes;
   - by emphasizing the study of domain-general and of domain-specific processing;
   - by striving for a high degree of experimental control (which better permits causal inferences) and for a high degree of *ecological validity* (which better allows generalization of findings to settings outside of the laboratory);
   - by conducting basic research seeking fundamental insights about cognition and applied research seeking effective uses of cognition in real-world settings.

Although positions on these issues may appear to be diametrical opposites, often apparently antithetical views may be synthesized into a form that offers the best of each of the opposing viewpoints.

Cognitive psychologists study biological bases of cognition as well as attention, consciousness, perception, memory, mental imagery, language, problem solving, creativity, decision making, reasoning, developmental changes in cognition across the life span, human intelligence, artificial intelligence, and various other aspects of human thinking.

Thinking about Thinking: Analytical, Creative, and Practical Questions

1. Describe the major historical schools of psychological thought leading up to the development of cognitive psychology.
2. Describe some of the ways in which philosophy, linguistics, and artificial intelligence have contributed to the development of cognitive psychology.
3. Compare and contrast the influences of Plato and Aristotle on psychology.
4. Analyze how various research methods in cognitive psychology reflect empiricist and rationalist approaches to gaining knowledge.
5. Design a rough sketch of a cognitive-psychological investigation involving one of the research methods described in this chapter. Highlight both the advantages and the disadvantages of using this particular method for your investigation.
6. This chapter describes cognitive psychology as the field is at present. How might you speculate that the field will change in the next 50 years?
7. How might an insight gained from basic research lead to practical uses in an everyday setting?
8. How might an insight gained from applied research lead to a deepened understanding of the fundamental features of cognition?

Key Terms

artificial intelligence (AI), *p. 14*
associationism, *p. 9*
behaviorism, *p. 11*
cognitive psychology, *p. 3*
cognitive science, *p. 33*
cognitivism, *p. 13*
dependent variables, *p. 25*
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