CHAPTER 1

An Introduction to Cognitive Psychology

Chapter Introduction

What Is Cognitive Psychology?

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CHAPTER INTRODUCTION

In the broadest sense, cognitive psychology is a subdiscipline of experimental psychology focused on investigating the mental processes that give rise to our perceptions and interpretations of the world around us. It is the science of the mind.

Even seemingly simple tasks—such as taking a sip from a bottle of soda resting on your desk—are actually quite complex and multi-faceted. You must have access to information about your internal states (e.g., "I'm kind of thirsty and want a little caffeine while studying for this exam"), before then making a decision to take a sip of soda. After this goal is established, you must visually examine your environment until you recognize the bottle of soda in your environment. To satisfy the goal that you've established, you must also execute a motor response that allows you to grasp the bottle and bring it to your mouth.

The goal of research in the field of cognitive psychology is to specify how each of these processes are organized and coordinated by the mind.

In this introductory chapter, we first explore a definition of cognition. Next, we focus on historical developments in the field of psychology. Understanding the historical events that occurred prior to the emergence of cognitive psychology will help you appreciate how a cognitive approach differs from other approaches to the study of human behavior. In the third section, we focus on contributions from multiple fields outside of psychology that have increased our current understanding of how the mind works. As you can imagine, recent advances in the field of neuroscience currently play a key role in specifying how neural systems support mental processes.

To conclude this chapter, I provide an overview of some general themes that you'll encounter throughout this textbook. Additionally, I detail the extensive number of learning features that are built into this textbook. Their design is based on research in areas of cognitive psychology—such as human memory—and they are included here to help you maximize the amount of information that you acquire and retain as you read.

WHAT IS COGNITIVE PSYCHOLOGY?

Cognition, or mental activity, is a term that refers to the acquisition, storage, transformation, and use of knowledge. Certainly, many have argued that nonhuman animals also have cognitive abilities. You will learn more about nonhuman animal cognition in other courses offered by the Psychology and Biology departments at your university. Here, we focus specifically on the inner-workings of the human mind.

A related term, **cognitive psychology**, has two meanings: (1) Sometimes it is a synonym for the word *cognition*, and so it refers to the variety of mental activities we just listed; (2) Sometimes it refers to a particular theoretical approach to psychology. Specifically, the **cognitive approach** is a theoretical orientation that emphasizes people's thought processes and their knowledge. For example, a cognitive explanation of ethnic stereotypes would emphasize topics such as the influence of these stereotypes

on the judgments we make about people from different ethnic groups (Whitley & Kite, 2010).

Cognition is inescapable. At any point that you are awake, your cognitive processes are at work. They grant you the ability to think, to recognize and interpret your environment, and to act (or react) strategically to stimuli in your environment. They give you the ability to plan, to create, to interact with others, and to process all of the thoughts, sensations, and emotions that you experience on a daily basis. Your cognitive abilities operate together in intricate and highly coordinated ways to create your conscious experiences.

In fact, while reading this paragraph, you are actively performing several cognitive tasks at the same time. In order to reach this second sentence of the first paragraph, you used pattern recognition to create words from an assortment of squiggles and lines that form the letters on this page. You also consulted your memory and your knowledge about language to search for word meanings and to link together the ideas in this paragraph into a coherent message. Additionally, right now, as you think about these cognitive tasks, you are engaging in another cognitive task called *metacognition*—you were thinking about your thought processes. Perhaps you made an inference such as, "This book may help me study more effectively." You may also have used decision making, for instance, by saying to yourself, "I'll finish this section of the book before I go to lunch."

If cognition operates every time you acquire some information, place it in storage, transform that information, and use it . . . then cognition definitely includes a wide range of mental processes! This textbook will explore many of these mental processes, such as perception, memory, imagery, language, problem solving, reasoning, and decision making.

I took Introduction to Cognitive Psychology during my junior year of college. I remember quite vividly that I had enrolled for the course because it was required, but I honestly had no idea what the term "cognitive psychology" meant. Even after our brief discussion of a definition of cognition, some of you may still not have a strong sense of what a cognitive psychologist really studies. Below, I provide a brief demonstration that should help you gain a stronger sense of what you're in store for over the course of the semester.

Open up a web browser, pull up a recent episode of a television show or a random video clip, and do the following: (1) Watch 1 minute of the video; (2) Exit your web browser; and (3) In only 2 minutes, write down (or type) everything that you experienced as you watched the TV or video clip for 1 minute. Go ahead . . . give it a shot. It will only take you a total of 3 minutes.

I just did the same demonstration myself. I went online and selected a random music video, and I watched 1 minute of it. Here's what I was able to type in 2 minutes after closing the web browser:

- There was a strong bassline.
- I have never heard this song before.
- A group of about 20 people were standing close together. Music was playing but no one was moving.

- One person at the center of the group of people was female, and she was wearing a turquoise dress that looked kind of fancy.
- The camera moved from left to right but remained focused on the twenty or so people standing in a group.
- Somebody coughed in the adjacent room (not in the video, but in the room next to where I'm sitting and watching this video).
- A female voice started to sing. She's signing in a language that I don't know. It sounds like it could be Swedish but that's just a guess.

Presumably, most of you were able to generate a list of bullet points, and you are likely to observe some similarities between your list and mine (even though we probably watched different videos). Now, focus on the list and think about everything that you had to do in order to produce the list. Or, if you didn't really complete the exercise yourself, think about all of the types of processes that I had to complete in order to produce the list above.

I had to process auditory information (the music), linguistic information (the lyrics, although I couldn't really understand them), and visual information (the visual images that accompanied the music in the video).

Importantly, I had to create a rich internal interpretation of the video in order to truly *experience* that video. In order to do so, I had to use information that is stored in my mind (and thus, in my memory) as a guide for how to interpret the video. Many of you are likely to be in your early 20s. That means that you have had approximately 20 years of experience with the world around you. Based on that experience, you've come to possess *knowledge* about facts (such as, "Brooklyn is one of the five boroughs of New York City") and patterns (the word "the" rarely comes before a verb) that are embedded in the world around you. Crucially, notice how important this stored knowledge is for your ability to interpret and understand the video you watched. In the case of my video, I had to know which physical features of a person are characteristic of males versus females. If I lacked this knowledge, I never would have been able to list in the 4th bullet point above (noting that a female was at the center of the group). I also wouldn't have been able to note that a female voice was singing (as per the 7th bullet point above). Indeed, processing sensory information in the environment isn't enough to allow you to consciously experience and interpret the video. You had to process auditory and visual streams of information, and link the physical characteristics of the auditory and visual streams to knowledge stored in your memory. It is through this linking process that I was able to create an internal interpretation of the video.

I also had to store enough information about the video in my mind in order to report the seven bullet points above. Do you think that I remembered every detail of the video well enough in order to be able to precisely describe it? Probably not. I had to perceive and interpret information from the environment (the video) on a very fast time-scale. Under such time pressure, I had to strategically allocate my attention to elements and events occurring in the video that seemed most relevant and important. I also noted that I heard someone in a nearby room cough. This cough had nothing to

do with the video to which I was supposed to attend, and yet I still processed it (enough to report my perception of it after the video was complete).

And, in order to type the list of bullet points, I had to access my stored memories about the video, transform those memories into a linguistic code, and then decide how to move my fingers around a keyboard in order to type linguistic descriptions of my memories

So, after thinking about your experience with this demonstration, do you have a stronger sense of what is meant by the term "cognition?" Information from the environment was taken in through sensory systems, and it was linked to knowledge that you possess. New memories (of your experiences while watching and interpreting the video) were created. And, they were then accessed at a later point in time in order for you to write out descriptions of your interpretation of the video. In this sense, you acquired, stored, transformed, and used knowledge that you gleaned from experience.

Why should you and other students learn about cognition? One reason is that cognition occupies a major portion of human psychology. In fact, almost everything you have done in the past hour required you to perceive, remember, use language, or think. As you'll soon see, psychologists have discovered some impressive information about every topic in cognitive psychology. Even though cognitive psychology is extraordinarily central in every human's daily life, many college students cannot define this term accurately (Maynard, 2006; Maynard et al., 2004). To demonstrate this point, try Demonstration 1.1.

ⓢ Demonstration 1.1

Awareness about Cognitive Psychology

Locate several friends at your university or college who have not enrolled in any psychology courses. Ask each person the following questions:

1. How would you define the term "cognitive psychology"?
2. Can you list some of the topics that would be included in a course in cognitive psychology?

When Amanda Maynard and her coauthors (2004) asked introductory psychologists to define "cognitive psychology," only 29% provided appropriate definitions. How adequate were the responses that your own friends provided?

A second reason to study cognition is that the cognitive approach has widespread influence on other areas of psychology, such as clinical psychology, educational psychology, and social psychology. Let's consider an example from clinical psychology. One cognitive task asks people to recall a specific memory from their past. People who

are depressed tend to provide a general summary, such as "visiting my grandmother." In contrast, people who are not depressed tend to describe an extended memory that lasts more than one day, such as "the summer I drove across the country" (Wenzel, 2005). Cognitive psychology also influences interdisciplinary areas. For example, a journal called *Cognitive Neuropsychology* examines specific neurological problems, such as an extreme difficulty in recognizing people's faces, when other cognitive skills are normal (e.g., Wilson et al., 2010).

The final reason for studying cognition is more personal. Your mind is an impressively sophisticated piece of equipment, and you use this equipment every minute of the day. If you purchase a new phone, you typically receive a brochure that describes its functions. However, no one issued a brochure for your mind when you were born. In a sense, this textbook is like a brochure or owner's manual, describing information about how your mind works. Understanding cognition = understanding the abilities that provide you with a rich internal mental life.

PRACTICE QUIZ QUESTIONS

1) The cognitive approach is a theoretical orientation that emphasizes a person's:
   a) observable behaviors.
   b) unconscious emotions.
   c) social interactions with other people.
   d) mental processes and knowledge.

2) Which of the following statements is correct?
   a) A reflex such as a knee-jerk reflex is an example of cognition.
   b) Cognition refers to the acquisition and retrieval of knowledge, but not the use of that knowledge.
   c) "Cognitive psychology" is sometimes used as a synonym for "cognition."
   d) Cognitive psychology emphasizes mental processes that are easily observable.

3) Which of the following statements <u>best</u> captures the scope of cognition?
   a) Cognition includes every internal experience that humans have.
   b) We use cognition when we acquire, store, transform, and use knowledge.
   c) Cognition primarily emphasizes higher mental processes, such as problem solving and decision making.
   d) Cognition is more concerned with visible actions, such as motor activities, than with activities that cannot be seen by an outside observer.

A HISTORICAL PERSPECTIVE ON COGNITIVE PSYCHOLOGY

The cognitive approach to psychology traces its origins to the classical Greek philosophers and to developments that began in the 19th century. As we will also see in this section, however, the contemporary version of cognitive psychology emerged within the last 60 years. In this section, we first consider a set of historical developments that led to the emergence of the field of experimental psychology. We then focus briefly on a series of events that contributed to the emergence of cognitive psychology—a field that is widely viewed as a key subdiscipline of psychology. To conclude this section, we consider a few key points on the nature of cognitive psychology as it exists in present times.

The Origins of Cognitive Psychology

Philosophers and other theorists have speculated about human thought processes for more than 23 centuries. For example, the Greek philosopher Aristotle (384–322 BCE) examined topics such as perception, memory, and mental imagery. He also discussed how humans acquire knowledge through experience and observation (Barnes, 2004; Sternberg, 1999). Aristotle emphasized the importance of **empirical evidence**, or scientific evidence obtained by careful observation and experimentation. His emphasis on empirical evidence and many of the topics he studied are consistent with 21st-century cognitive psychology. In fact, Aristotle can reasonably be called the first cognitive psychologist (Leahey, 2003).

Psychology as a discipline in and of itself did not emerge, however, until the late 1800s. Most scholars who study the history of psychology believe that Wilhelm Wundt (pronounced "Voont") should be considered the founder of experimental psychology (Benjamin, 2009; Pickren & Rutherford, 2010). Wundt lived in Leipzig, Germany, between 1832 and 1920. Students traveled from around the world to study with Wundt, who taught about 28,000 students during the course of his lifetime (Bechtel et al., 1998; Benjamin, 2009; Fuchs & Milar, 2003).

Wundt proposed that psychology should study mental processes, and advocated the use of a technique called introspection in order to do so. In this case, **introspection** meant that carefully trained observers would systematically analyze their own sensations and report them as objectively as possible, under standardized conditions (Blumenthal, 2009; Pickren & Rutherford, 2010; Zangwill, 2004b). For example, observers might be asked to objectively report their reactions to a specific musical chord, and to do so without relying on their previous knowledge about music.

Wundt's introspection technique sounds subjective to most current cognitive psychologists. As you'll see throughout this textbook, our introspections are sometimes inaccurate (Wilson, 2009; Zangwill, 2004b). For example, you may introspect that your eyes are moving smoothly across this page of your textbook. However, cognitive psychologists have determined that your eyes actually move in small jumps—as you'll read in Chapter 3.

One of the earliest (1850–1909) systematic investigations of a cognitive process came from the German psychologist Hermann Ebbinghaus (Baddeley et al., 2009; Schwartz, 2011). Ebbinghaus was interested in human memory. He examined a variety

of factors that might influence performance on memory tasks, such as the amount of time between two presentations of a list of items. He frequently chose nonsense syllables (e.g., DAX), rather than actual words. This precaution reduced the potentially confounding effects of people's previous experience with language on their ability to recall information from their memories (Fuchs & Milar, 2003; Zangwill, 2004a).

Meanwhile, in the United States, similar research was being conducted by psychologists such as Mary Whiton Calkins (1863–1930). Calkins reported a memory phenomenon called the recency effect (Schwartz, 2011). The **recency effect** refers to the observation that our recall is especially accurate for the final items in a series of stimuli (such as a list of words or numbers). In addition, Calkins emphasized that psychologists should study how real people use their cognitive processes in the real world, as opposed to in artificial laboratory tasks (Samelson, 2009). Calkins was also the first woman to be president of the American Psychological Association. In connection with that role, she developed guidelines for teaching college courses in introductory psychology (Calkins, 1910; McGovern & Brewer, 2003). During her career, Calkins also published four books and more than 100 scholarly papers (Pickren & Rutherford, 2010).

Another central figure in the history of cognitive psychology was an American named William James (1842–1910). James was not impressed with Wundt's introspection technique or Ebbinghaus's research with nonsense syllables. Instead, James preferred to theorize about our everyday psychological experiences (Benjamin, 2009; Hunter, 2004a; Pickren & Rutherford, 2010). He is best known for his textbook *Principles of Psychology*, published in 1890.

Principles of Psychology provides clear, detailed descriptions about people's everyday experiences (Benjamin, 2009). It also emphasizes that the human mind is active and inquiring. James's book foreshadows numerous topics that fascinate 21st-century cognitive psychologists, such as perception, attention, memory, understanding, reasoning, and the tip-of-the-tongue phenomenon (Leary, 2009; Pickren & Rutherford, 2010). Consider, for example, James's vivid description of the tip-of-the-tongue experience:

> Suppose we try to recall a forgotten name. The state of our consciousness is peculiar. There is a gap therein but no mere gap. It is a gap that is intensely active. A sort of wraith of the name is in it, beckoning us in a given direction, making us at moments tingle with the sense of our closeness and then letting us sink back without the longed-for term.
> (James, 1890, p. 251)

Now try Demonstration 1.2 before you read further.

An important development in Europe at the beginning of the 20th century was gestalt (pronounced "*geh-shtahlt*") psychology. **Gestalt psychology** emphasizes that we humans have basic tendencies to actively organize what we see, and furthermore, that the whole is greater than the sum of its parts (Benjamin, 2009). Consider, for example, the figure represented in Demonstration 1.2. You probably saw a human face, rather than simply an oval and two straight lines. This figure seems to have unity and organization. It has a **gestalt**, or overall quality that transcends the individual elements (Fuchs & Milar, 2003).

⊙ Demonstration 1.2

An Example of Gestalt Psychology

Quickly look at the figure below and describe what you see. Keep your answer in mind until the next page, when we will discuss this figure.
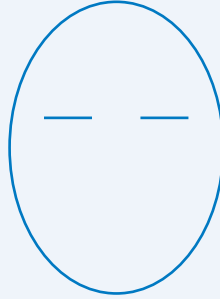
Gestalt psychologists valued the unity of psychological phenomena. They constructed a number of laws that explain why certain components of a pattern seem to belong together. In Chapter 2, we'll consider some of these laws, which help us to quickly recognize visual objects. Gestalt psychologists also emphasized the importance of insight in problem solving (Fuchs & Milar, 2003; Viney & King, 2003). When you are trying to solve a problem, the parts of the problem may initially seem unrelated to each other. However, with a sudden flash of insight, the parts fit together into a solution. Gestalt psychologists conducted most of the early research in problem solving. In Chapter 11 of this textbook, we will examine their concept of insight, as well as more recent developments.

Behaviorism. The work of early memory researchers such as Ebbinghaus and Calkins, and the views of the Gestalt psychologists, all appealed to the notion that information is somehow stored in the mind. Their work suggested that internally stored knowledge about words or objects was one important component of cognitive processing. During the first half of the 20th century, however, behaviorism became the most prominent theoretical perspective in the United States. According to the principles of **behaviorism**, psychology must focus on objective, observable reactions to stimuli in the environment, rather than on introspection (Benjamin, 2009; O'Boyle, 2006).

The most prominent early behaviorist was the U.S. psychologist John B. Watson (1913), who lived from 1878–1958. Watson and other behaviorists emphasized observable behavior, and they typically studied animals (Benjamin, 2009). Most behaviorists believed that it was inappropriate to theorize and speculate about unobservable components of mental life. As a result, the behaviorists did not study concepts such as a mental image, an idea, or a thought (Epstein, 2004; Skinner, 2004). Instead, the

behaviorists focused heavily on learning. That is, they were particularly interested in quantifying the manner in which changes in an organism's environment produced changes in its behavior.

It is possible to objectively quantify how well an organism has learned about properties of its environment. For example, consider placing a rat in a complicated maze—the end of which contains a piece of cheese for the rat to enjoy as a reward for making it through the maze. Rewarding rats for successfully navigating to the end of a maze provides researchers with an opportunity to objectively measure learning. For example, researchers may choose to count the number of errors made by the rat (such as a turn down a dead end path) while completing the maze on each of 30 consecutive days. A decrease in error rate over time, in this case, is interpretable as representing an increase in learning. Because researchers can quantify learning over time, they also have the ability to systematically manipulate properties of the learning task, such as maze complexity, in order to determine what factors influence the speed of learning. Note here, however, that in behaviorist experiments, clear and quantifiable manipulations of the learning environment were implemented in order to examine how they influenced a quantifiable metric of learning. The behaviorists never argued or otherwise appealed to the notion that a rat may be storing information about the spatial layout of the maze (and thus, *internally representing* visual and spatial components of the maze) as they learned about its layout over time.

The lack of a willingness to acknowledge that information about one's environment is stored and can be accessed at some later point in time led to a reaction against strong versions of behaviorist doctrine. In fact, examples of "pure behaviorism" are now difficult to locate. For instance, the Association of Behavioral Therapy is now known as the Association for Behavioral and Cognitive Therapies. Recent articles in their journal, *Cognitive and Behavioral Practice*, have focused on using cognitive behavioral therapy for a variety of clients, including people with eating disorders, elderly adults with post-traumatic stress disorder, and severely depressed adolescents.

Although the behaviorists did not conduct research in cognitive psychology, they did contribute significantly to contemporary research methods. For example, behaviorists emphasized the importance of the **operational definition**, a precise definition that specifies exactly how a concept is to be measured. Similarly, cognitive psychologists in the 21st century need to specify exactly how memory, perception, and other cognitive processes will be measured in an experiment. Behaviorists also valued carefully controlled research, a tradition that is maintained in current cognitive research (Fuchs & Milar, 2003). We must also acknowledge the important contribution of behaviorists to applied psychology. Their learning principles have been used extensively in psychotherapy, business, organizations, and education (Craske, 2010; O'Boyle, 2006; Rutherford, 2009).

The Cognitive Revolution

By the late 1930s and throughout the 1940s, psychologists were becoming increasingly disappointed with the behaviorist outlook that had dominated U.S. psychology in previous decades. It was difficult to explain complex human behavior using only behaviorist

concepts such as observable stimuli, responses, and reinforcement (G. Mandler, 2002; Neisser, 1967). Indeed, research in human memory began to blossom at the end of the 1950s, further increasing the disenchantment with behaviorism. Psychologists proposed models of human memory instead of focusing only on models of animal learning (Baddeley et al., 2009; Bower, 2008). They frequently found that material was altered during memory by an individual's previous knowledge gained through their individual life experiences. Behaviorist principles such as "reinforcement" could not explain these alterations (Bargh & Ferguson, 2000). The behaviorist approach tells us nothing about numerous psychologically interesting processes, such as the thoughts and strategies that people use when they try to solve a problem (Bechtel et al., 1998), or how people access their stored knowledge about language in order to produce a sentence.

Another influential force came from research on children's thought processes. Jean Piaget (pronounced "Pea-ah-*zhay*") was a Swiss theorist who lived from 1896 to 1980. Piaget's books began to attract the attention of U.S. psychologists and educators toward the end of the 1950s, and his perspectives continue to shape developmental psychology (Feist, 2006; Hopkins, 2011; Pickren & Rutherford, 2010). According to Piaget, children actively explore their world in order to understand important concepts (Gregory, 2004b). Children's cognitive strategies change as they mature, and adolescents often use sophisticated strategies in order to conduct their own personal experiments about how the world works.

Research and theory from other academic and intellectual fields also increased the emerging popularity of the study of human cognition (Bermudez, 2014). For example, new developments in linguistics increased psychologists' dissatisfaction with behaviorism (Bargh & Ferguson, 2000; Bower, 2008). The most important contributions came from the linguist Noam Chomsky (1957), who emphasized that the structure of language was too complex to be explained in behaviorist terms (Pickren & Rutherford, 2010; Pinker, 2002). Chomsky and other linguists argued that humans have an inborn ability to master all the complicated and varied aspects of language (Chomsky, 2004). This perspective clearly contradicted the behaviorist perspective that language acquisition can be entirely explained by the same kind of learning principles that apply to laboratory animals.

The growing support for the cognitive approach is often referred to as the "cognitive revolution" (Bruner, 1997; Shiraev, 2011). This term refers to a strong shift away from behaviorist approaches to the study of human behavior. Instead, experimental psychologists began to focus on how organism-internal processes, such as memory, attention, and language, work together to give rise to the human ability to consciously perceive, interpret, and act in the world around them.

We have briefly traced the historical roots of cognitive psychology and provided a brief overview of reasons that psychologists became disenchanted with the behaviorist worldview. But, when was the field of cognitive psychology actually "born"? Cognitive psychologists generally agree that the birth of cognitive psychology can be listed as 1956 (Eysenck & Keane, 2010; G. Mandler, 2002; Thagard, 2005). During this prolific year, researchers published numerous influential books and articles on attention, memory, language, concept formation, and problem solving. In 1967, an influential psychologist named Ulric Neisser (1928–2012) published a booked called *Cognitive*

Psychology. The publication of this book served as one of the first comprehensive treatments of cognitive processing. It is seen as one of the most important factors contributing to the emergence of cognitive psychology as a field. In fact, because Neisser was the first person to use the term "Cognitive Psychology," he has often been called "the father of cognitive psychology" (e.g., American Psychological Science, n.d.).

Cognitive Psychology in Present Times

Since the cognitive revolution and the onset of cognitive psychology as a field, cognitive psychology has had an enormous influence on the discipline of psychology. For example, almost all psychologists now recognize the importance of mental representations, a term that behaviorists would have rejected in the 1950s. Indeed, all areas of psychology incorporate key principles from cognitive psychology in their models of human development and behavior. For instance, psychologists are also studying how cognitive processes operate in our everyday social interactions (e.g., Cacioppo & Berntson, 2005a; Cameron, Payne, & Doris, 2013; Critcher, Inbar, & Pizzaro, 2013; Easton & Emery, 2005; Neel, Neufeld, & Neuberg, 2013; Todd & Burgmer, 2013). Demonstration 1.3 illustrates the important influence of cognitive psychology in many other areas of psychological inquiry.

ⓢ Demonstration 1.3

The Widespread Influence of Cognitive Psychology

Locate a psychology textbook used in some other class. An introductory textbook is ideal, but textbooks in developmental psychology, social psychology, abnormal psychology, etc., are all suitable. Glance through the subject index for terms beginning with *cognition* or *cognitive*, and locate the relevant pages. Depending on the nature of the textbook, you may also find entries under terms such as memory, language, and perception.

Cognitive psychology has its critics, however. One common complaint concerns the issue of ecological validity. Studies are high in **ecological validity** if the conditions in which the research is conducted are similar to the natural setting where the results will be applied.

In contrast, consider an experiment in which participants must memorize a list of unrelated English words, presented at 5-second intervals on a white screen in a barren laboratory room. Half of the people are instructed to create a vivid mental image of each word; the other half receive no instructions. The experiment is carefully controlled. The results of this experiment would tell us something about the way memory operates. However, this task is probably low in ecological validity, because it cannot be applied to the way people learn in the real world (Sharps & Wertheimer, 2000). How often do you try to memorize a list of unrelated words in this fashion?

Most cognitive psychologists prior to the 1980s did indeed conduct research in artificial laboratory environments, often using tasks that differed from daily cognitive activities. However, current researchers frequently study real-life issues. For example, Chapter 3 describes how people are much more likely to make driving errors if they are talking on a handheld cell phone (Folk, 2010). Furthermore, Chapters 5 and 6 discuss numerous methods for improving your memory (e.g., Davies & Wright, 2010a). Chapter 12 provides many suggestions about how to improve your decision-making ability (Kahneman, 2011). In general, most cognitive psychologists acknowledge that the discipline must advance by conducting both ecologically valid and laboratory-based research.

PRACTICE QUIZ QUESTIONS

1) During the first half of the 20th century, some strict behaviorists:
   a) claimed that scientific psychology should rely only on operational definitions of introspective reports.
   b) said that psychology should focus only on objective reactions to environmental stimuli.
   c) advocated research on human cognition instead of on animal cognition and computer cognition.
   d) developed the parallel distributed processing (PDP) approach to understanding behavior.

2) The rise of cognitive psychology was heavily influenced by:
   a) the rise of behaviorism, which provided cognitive psychologists new ways to measure memory and thinking.
   b) the rise of Gestalt psychology, which provided clinical psychologists with new ways to conduct psychoanalysis.
   c) disenchantment with behaviorism and fascination with developments in linguistics, memory, and developmental psychology.
   d) disenchantment with behaviorism and fascination with emerging psychoanalytic studies of human adjustment.

3) All of the following contributed to the rise of cognitive psychology EXCEPT for:
   a) Noam Chomsky's arguments about the inadequacy of behaviorist principles for fully explaining human language acquisition.
   b) the lack of interest in understanding how humans internally store (or represent) information in their minds.
   c) increased interest in human memory.
   d) the publication of Neisser's *Cognitive Psychology*.

4) Gestalt psychology emphasizes:
   a) observable, objective reactions.
   b) the introspective technique.
   c) emotional causes of behavior.
   d) the basic human tendency to organize our perceptions.

5) According to the principle of ecological validity:
   a) experiments should be as carefully controlled as possible, in order to avoid confounding variables.
   b) laboratory settings should be employed whenever possible.
   c) behavior should be initially studied in its simplest, most basic form; more complex kinds of behavior should be studied later on.
   d) experiments should be conducted that will have some application to experience outside the laboratory.

THE RELATIONSHIP BETWEEN MIND, BRAIN, AND BEHAVIOR

By the mid-1970s, the cognitive approach had replaced the behaviorist approach as the dominant theory in psychological research (Robins et al., 1999). But, cognitive psychology as it exists today has become an increasingly interdisciplinary pursuit. The rigorous experimental approach to psychological research that is characteristic of cognitive psychology has become increasingly supplemented by theories and methodologies borrowed from other fields. In this section, we first consider the interdisciplinary field of cognitive science. Indeed, researchers from many different fields have interests in how the human mind works. As we will see, cross-disciplinary research can produce synthetic contributions to our understanding of the human mind that transcend the contributions from members of any individual discipline. Next, we touch on theoretical questions concerning how the concept of "the mind" relates to the human brain. To conclude, we will provide an overview of cognitive neuroscience methodologies. These methodologies allow us to gain insight into how our neural hardware supports different cognitive processes.

Cognitive Science

Cognitive psychology is part of a broad field known as cognitive science. **Cognitive science** is an interdisciplinary field that tries to answer questions about the mind. Cognitive science includes contributions from cognitive psychology, neuroscience, computer science, philosophy, and linguistics. In some cases, researchers in the fields of sociology, anthropology, and economics also make contributions to the field of cognitive science. This field emerged when researchers began to notice connections

among a variety of disciplines, and thus, began to collaborate with one another (Bermúdez, 2010; Sobel, 2001; Thagard, 2005).

According to cognitive scientists, thinking requires us to manipulate our internal representations of the external world. Cognitive scientists focus on these internal representations. Cognitive scientists value interdisciplinary studies, and they try to build bridges among the academic areas. Both the theory and the research in cognitive science are so extensive that no one person can possibly master everything (Bermúdez, 2010; Sobel, 2001; Thagard, 2005). However, if all these different fields remain separate, then cognitive scientists won't achieve important insights and identify relevant connections. Therefore, cognitive science tries to coordinate the information that researchers have gathered throughout each relevant discipline.

Below, we examine just one of many examples that highlight the value of interdisciplinary communication when trying to understand the inner-workings of the human mind. More specifically, we look at how interactions between cognitive psychologists and computer scientists have produced deeper insight into cognition than would otherwise be possible.

Artificial Intelligence

Artificial intelligence (AI) is a branch of computer science. It seeks to explore human cognitive processes by creating computer models that show "intelligent behavior" and also accomplish the same tasks that humans do (Bermúdez, 2010; Boden, 2004; Chrisley, 2004). Researchers in artificial intelligence have tried to explain how humans recognize a face, create a mental image, and write a poem, as well as hundreds of additional cognitive accomplishments (Boden, 2004; Farah, 2004; Thagard, 2005).

We need to draw a distinction between "pure AI" and computer simulation. **Pure artificial intelligence (pure AI)** is an approach that designs a program to accomplish a cognitive task as efficiently as possible, even if the computer's processes are completely different from the processes used by humans.

For example, the most high-powered computer programs for chess will evaluate as many potential moves as possible in as little time as possible (Michie, 2004). Chess is an extremely complex game, in which both players together can make about 10128 possible different moves. This is larger than the total number of atoms contained in our universe. Consider a computer chess program named "Hydra." The top chess players in the world make a slight error about every ten moves. Hydra can identify this error—even though chess experts cannot—and it therefore wins the game (Mueller, 2005). Researchers have designed pure AI systems that can play chess, speak English, or diagnose an illness. However, as one researcher points out, "I wouldn't want a chess-playing program speculating as to the cause of my chest pain" (Franklin, 1995, p. 11).

As we have seen, pure AI tries to achieve the best possible performance. In contrast, **computer simulation** or **computer modeling** attempts to take human limitations into account. The goal of computer simulation is to program a computer to perform a specific cognitive task in the same way that humans actually perform this task. A computer simulation must produce the same number of errors—as well as correct responses—that a human produces (Carpenter & Just, 1999; Thagard, 2005).

Computer-simulation research has been most active in such areas as memory, language processing, problem solving, and logical reasoning (Bower, 2008; Eysenck & Keane, 2010; Thagard, 2005). For example, Carpenter and Just (1999) created a classic computer-simulation model for reading sentences. This model was based on the assumption that humans have a limited capacity to process information. As a result, humans will read a difficult section of a sentence more slowly. Consider the following sentence:

The reporter that the senator attacked admitted the error.

Carpenter and Just (1999) designed their computer simulation so that it took into account the relevant linguistic information contained in sentences like this one. The model predicted that processing speed should be fast for the words at the beginning and the end of the sentence. However, the processing should be slow for the awkward two-verb section, "attacked admitted." In fact, Carpenter and Just demonstrated that the human data matched the computer simulation quite accurately.

Surprisingly, people can accomplish some tasks quite easily, even though these tasks are beyond the capacity of computer simulations. For example, a 10-year-old girl can search a messy bedroom for her watch, find it in her sweatshirt pocket, read the pattern on the face of the watch, and then announce the time. However, no current computer can simulate this task. Computers also cannot match humans' sophistication in learning language, identifying objects in everyday scenes, or solving problems creatively (Jackendoff, 1997; Sobel, 2001).

The Computer Metaphor of the Mind and Information Processing. During the 1970s–1990s (and even still today), the computer has been a popular metaphor for the human mind. According to the **computer metaphor**, our cognitive processes work like a computer. That is, computers and human minds are both examples of complex, multipurpose machinery that can process information quickly, accurately, and in a similar fashion.

Of course, researchers acknowledge the obvious differences in physical structure between the computer and the human brain that manages our cognitive processes. However, both human brains and computers may operate according to similar general principles. For example, both humans and computers can compare symbols and can make choices according to the results of the comparison. Furthermore, computers have a processing mechanism with a limited capacity. Humans also have limited attention and short-term memory capacities. For example, the research in Chapter 3 definitely shows that humans cannot pay attention to numerous tasks at the same time.

Computer models need to describe both the structures and the processes that operate on these structures. Thagard (2005) suggests that a computer model resembles a recipe in cooking. A recipe has two parts: (1) the ingredients, which are somewhat like the *structures*; and (2) the cooking instructions for working with those ingredients, which are somewhat like the *processes.* Researchers who favor the computer approach try to design the appropriate "software." With the right computer program and sufficient mathematical detail, researchers hope to imitate the flexibility and the efficiency of human cognitive processes (Boden, 2004).

Beginning in the 1960s, psychologists began to create models of how information flows through cognitive systems. This **information-processing approach** argued that (a) our mental processes are similar to the operations of a computer, and (b) information progresses through our cognitive system in a series of stages, one step at a time (Gallistel & King, 2009; Leahey, 2003; MacKay, 2004). Information processing models of cognitive processes such as memory, visual object recognition, or language comprehension, share a series of general assumptions:

1. Stimuli (maybe a visual object such as a chair or a word from a sentence) occur or are present in one's environment. Information about those stimuli is transported to your sensory receptors (your eyes, your ears, etc.) through a physical medium (light, sound waves). Your sensory receptors process that information, and are responsible for making sure that it gets to your brain. Note that taking in information about your environment through your senses is similar to inputting information into a computer (by, for example, typing a word and pressing the "Enter" key).

2. The information that is provided to your brain via your senses is processed and decoded over the course of multiple processing stages. For example, upon seeing a chair, your visual system seems to first process different features of the chair such as its color, its edges, and its size. After those features are recognized, information progresses to other parts of the visual object recognition system in order for the features to get bound together. Eventually, the visual information reaches a stage at which it has been processed enough in order for you to match it to your stored knowledge about objects in the world. At this stage, you have recognized the object in your environment as a chair. Notice here that under these types of approaches, information is processed in incremental stages. This stage-like processing is similar to how older computers worked. Specific subsystems process input based on rules (or algorithms). After the information gets processed in that subsystem, it is sent to another subsystem so that it can be further processed and interpreted.

3. Eventually, after a stimulus has been processed enough in order for it to be identified and interpreted, a decision must be made about how to respond to the stimulus.

4. If you decide to respond to the stimulus, a motor command is sent to the parts of the system that are responsible for telling your body how to move. You then initiate an action that allows you to respond as strategically as possible to the stimulus that you had just finished processing. This action component is akin to a computer responding to some input (by, for example, displaying a word that you had typed onto your monitor).

A great appreciation for the analogy between the human mind and the computer arose because computer programs must be detailed, precise, unambiguous, and logical (Boden, 2004). Researchers can represent the functions of a computer with a flowchart that shows the sequence of stages in processing information. You will see some examples of these flow charts, which were meant to be models of information flow through the mind, throughout the remainder of this book.

Every metaphor, however, has its limitations. The computer metaphor of the mind, and of information processing more generally, was never intended to be a model of how *the brain* processes information. Back in the 1960s and up until the early 1980s, the scientific community had a very limited sense of how the brain processed and interpreted complex stimuli in the environment. Most of the fancy neuroimaging equipment that we discuss at the end of this section was still in the early phases of development. As a result, these models were designed to capture regularities in how people processed information about different classes of stimuli, such as linguistic, visual, and auditory information. Cognitive psychologists conducted many experiments that served to illuminate the types of environmental information that could be processed by the mind, what types of information seemed to be processed before other types of information, and what factors influenced the ease with which information could be processed. These data were used to create models of information flow through cognitive systems. And, I reiterate here, although those models were motivated by experimental data, they were not intended to serve as models of how the physical brain actually processed information.

The Connectionist Approach. This classical approach described above viewed processing as a series of separate operations; in other words, information processing was considered to be serial. During **serial processing**, the system must complete one step or processing stage before information can proceed to the next step in the flowchart. This one-step-at-a-time approach may capture the leisurely series of operations you conduct when you are thinking about every step in the process. For example, a classical AI model might be appropriate when you are solving a long-division problem (Leahey, 2003).

Classical information processing models have a difficult time accounting for the kinds of cognitive tasks that humans do very quickly, accurately, and without conscious thought. For example, AI models cannot explain how you can instantly perceive a visual scene (Bermúdez, 2010; Leahey, 2003). Glance up from your book, and then immediately return to this paragraph. When you looked at this visual scene, your retina presented about one million signals to your cortex—all at the same time. If your visual system had used serial processing in order to interpret these one million signals, you would still be processing that visual scene, rather than reading this sentence!

In 1986, James McClelland, David Rumelhart, and their colleagues at the University of California, San Diego, published an influential two-volume book entitled *Parallel Distributed Processing* (McClelland & Rumelhart, 1986; Rumelhart et al., 1986). This approach contrasted sharply with the traditional information-processing approach. As previously noted, the classical computer metaphor approach was never intended to appeal to how the brain processed information. Classic information processing models were only meant to serve as abstract flowcharts that captured what we knew at the time about people's performance on cognitive tasks.

In contrast, the **connectionist approach** argues that cognitive processes can be understood in terms of networks that link together neuron-like processing units; in addition, many operations can proceed simultaneously—rather than one step at a time.

In other words, human cognition is often *parallel*, not strictly linear (Barrett, 2009; Gazzaniga et al., 2009). Two other names that are often used interchangeably with connectionism are the **parallel distributed processing (PDP) approach** and the **neural-network approach**.

During the 1970s, neuroscientists developed research techniques that could explore the structure of the cerebral cortex. The **cerebral cortex** is the outer layer of the brain that is essential for your cognitive processes. One important discovery in this research was the numerous connections among neurons, a pattern that resembles many elaborate networks (Bermúdez, 2014; Rolls, 2004; Thagard, 2005).

This network pattern suggests that an item stored in your brain cannot be localized in a specific pinpoint-sized location of your cortex (Barrett, 2009; Fuster, 2003; Woll, 2002). Instead, the neural activity for that item seems to be *distributed* throughout a section of the brain. For example, researchers cannot pinpoint one small portion of your brain that stores the name of your cognitive psychology professor. Instead, that information is probably distributed throughout numerous neurons in a region of your cerebral cortex. Notice that the term "parallel *distributed* processing" captures the distributed characteristic of the neurons in your brain.

The researchers who developed the connectionist approach proposed a model that simulates many important features of the brain (Bermúdez, 2010; Levine, 2002; Woll, 2002). Most importantly, these networks are designed based on the basic principles associated with how neurons pass electrical signals to each other. Naturally, the model captures only a fraction of the brain's complexity. However, like the brain, the model includes simplified neuron-like units, numerous interconnections, and neural activity distributed throughout the system.

Many psychologists welcomed the connectionist approach as a groundbreaking new framework. It was ground-breaking in that it provided a way to understand how populations of neurons worked together in order to represent knowledge gained through learning. Thus, unlike the classic information processing perspective, researchers who operate under a connectionist modeling approach create computational models of neural processing that do appeal to how the brain actually works. They have developed models in areas as unrelated to one another as college students' stereotypes about a group of people and children's mastery of irregular verbs (Bermúdez, 2014; Christiansen & Chater, 2001). Researchers continue to explore whether the PDP approach can adequately account for the broad range of skills demonstrated by our cognitive processes.

Keep in mind that the connectionist approach uses the human brain—rather than the serial-computer—as the basic model (Woll, 2002). This more sophisticated design allows the connectionist approach to achieve greater complexity, flexibility, and accuracy as it attempts to account for human cognitive processes.

Cognitive Neuroscience

The sophistication of neuroimaging technology has increased in recent times. Additionally, given advances in computer hardware, we have an ever increasing ability to process large datasets more quickly than ever before. As a result, data collected from

cognitive neuroscientific methodologies are becoming a substantially more valuable tool in understanding how multiple neural systems contribute to our processing and interpretation of the world around us. **Cognitive neuroscience** combines the research techniques of cognitive psychology with various methods for assessing the structure and function of the brain (Marshall, 2009).

In recent decades, researchers have examined which structures in the brain are activated when people perform a variety of cognitive tasks (Gazzaniga et al., 2009). Furthermore, psychologists now use neuroscience techniques to explore the kind of cognitive processes that we use in our interactions with other people; this new discipline is called **social cognitive neuroscience** (Cacioppo, 2007; Cacioppo & Berntson, 2005a; Easton & Emery, 2005). For example, researchers have identified a variety of brain structures that are active when people look at a photograph of a face and judge whether the person is trustworthy (Winston et al., 2005). However, neurological explanations for some cognitive processes are elusive. For example, take several seconds to stand up and walk around the room in which you are reading. As you walk, notice what you see in your environment. This visual activity is actually extremely complicated, requiring billions of neurons and more than fifty regions of the surface of your brain (Emery & Easton, 2005).

Because the brain is so complex, we need to be very cautious when we read summaries of cognitive neuroscience research in the popular media. For example, I discovered a newspaper article that claimed "Scientists Find Humor Spot in the Brain." In reality, numerous parts of the brain work together to master the complicated task of appreciating humor. This observation is not unique to humor. Instead, all cognitive processing tasks that we face on a daily basis are complex, and multiple neural systems must work together for us to perform them.

Let's examine several neuroscience techniques that provide particularly useful information for cognitive psychologists.

Brain Lesions.   In humans, the term **brain lesions** refers to the destruction of an area in the brain, most often by strokes, tumors, blows to the head, and accidents. The formal research on lesions began in the 1860s, but major advances came after World War II, when researchers examined the relationship between damaged regions of the brain and cognitive deficits (Farah, 2004; Kolb & Whishaw, 2009). Tragically, neurologists continue to learn more about specific cognitive deficits from the thousands of U.S. soldiers with brain lesions from the Iraq and Afghanistan wars (e.g., Department of Veterans Affairs, 2010; Oakie, 2005).

The study of brain lesions has definitely helped us understand the organization of the brain. However, the results are often difficult to interpret. For example, a brain lesion is not limited to just one specific area. As a result, researchers typically cannot associate a cognitive deficit with a specific brain structure (Gazzaniga et al., 2009; Kalat, 2009). In this textbook, we will occasionally discuss research on people with brain lesions. However, other neuroscience techniques provide better-controlled information about the neural structures involved in cognitive processing (Hernandez-García et al., 2002).

Positron Emission Tomography (PET Scan).   When you perform a cognitive task, your brain needs chemicals such as oxygen to support the neural activity. The brain does not store oxygen. Instead, the blood flow increases in the activated part of the brain in order to carry oxygen to that site. Brain-imaging techniques measure brain activity indirectly. These techniques are based on the following logic: By measuring certain properties of the blood in different regions of the brain while people perform a cognitive task, we can determine which brain regions contribute to performance on that cognitive task (Coren et al., 2004; Szpunar, 2010).

In a **positron emission tomography (PET) scan**, researchers measure blood flow in the brain by injecting the participant with a low dose of a radio-active chemical just before this person works on a cognitive task. This chemical travels through the bloodstream to the parts of the brain that are activated during the tasks. While the person works on the task, a special camera makes an image of the accumulated radioactive chemical in various regions of the brain. For example, the participant might perform two slightly different cognitive tasks. By comparing the two brain images, researchers can determine which parts of the brain are activated when the participant works on each task (Kolb & Whishaw, 2011; Szpunar, 2010). PET scans can be used to study such cognitive processes as attention, memory, and language.

PET scans require several seconds to produce data, so this method does not provide useful information about the time-course of processing a stimulus in the environment. If the activity in a specific brain region increases and then decreases within this brief period, the PET scan will record an average of this activity level (Hernandez-García et al., 2002). For example, you can scan an entire room in 2 or 3 seconds, so an average activity level for this entire scene would not be meaning-ful. Furthermore, in the current era, PET scans are used less often than some other imaging techniques, because they are expensive and they expose people to radioactive chemicals (Kalat, 2009).

Functional Magnetic Resonance Imaging.   More specifically, **functional magnetic resonance imaging (fMRI)** is based on the principle that oxygen-rich blood is an index of brain activity (Cacioppo & Berntson, 2005b; Kalat, 2009; Szpunar, 2010). The research participant reclines with his or her head surrounded by a large, doughnut-shaped magnet. This magnetic field produces changes in the oxygen atoms. A scanning device takes a "photo" of these oxygen atoms while the participant performs a cognitive task. For exam-ple, researchers have used the fMRI method to examine regions of the brain that process visual information. They found that specific locations in the brain respond more to letters than to numbers (Polk et al., 2002).

The fMRI technique was developed during the 1990s, based on the magnetic resonance imaging (MRI), which is used in medical settings. In general, an fMRI is preferable to a PET scan because it is less invasive, with no injections and no radioac-tive material (Gazzaniga et al., 2009). In addition, an fMRI can measure brain activity that occurs fairly quickly—in about 1 second (Frith & Rees, 2004; Huettel et al., 2004; Kalat, 2009).

The fMRI technique is more precise than a PET scan in that it provides a more detailed image of an individual's brain. It also produces more robust illustrations of the parts of the brain that are involved in processing a stimulus. The fMRI technique can also detect subtle differences in the way that the brain processes language. For example, Gernsbacher and Robertson (2005) used this technique to discover a different pattern of brain activation when students read sentences like, "The young child played in a backyard," as opposed to "A young child played in a backyard." Notice the subtle difference in meaning between "A child" and "The child." Would you have thought that your brain responded differently to these almost identical phrases?

PET scans and functional magnetic resonance imaging provide information about location. That is, they provide information about which parts of the brain contribute to processing a certain type of stimuli. fMRIs are much more common today than PET scans because fMRIs do not use radioactive material, and because they provide better resolution (Bermúdez, 2010; Bernstein & Loftus, 2009). Neither of these techniques, however, provides insight into questions associated with time-course. fMRI and PET are not able to provide information about when, or how quickly, certain processes occur. In addition, neither PET scans nor fMRIs can tell us precisely what a person is thinking. For instance, some news commentators have suggested using brain scans to identify terrorists. The current technology for this precise kind of identification is clearly inadequate.

Event-Related Potential Technique.   As we've seen, PET scans and the fMRI technique are too slow to provide precise information about the timing of brain activity. In contrast, the **event-related potential (ERP) technique** records the very brief fluctuations in the brain's electrical activity, in response to a stimulus such as an auditory tone or a visual word (e.g., Bernstein & Loftus, 2009; DeLong, Urbach, & Kutas, 2005; Gazzaniga et al., 2009; Kolb & Whishaw, 2011; Molinaro, Barraza, & Carreiras, 2013).

To use the event-related potential technique, researchers place electrodes on a person's scalp (usually 32 or 64 electrodes, depending on the system). Each electrode records the electrical activity generated by populations of neurons located in the brain. The ERP technique cannot identify the response of a single neuron. However, it can identify electrical changes over a very brief period produced by populations of neurons in some region of the brain (Kutas & Federmeier, 2011).

For example, suppose that you are participating in a study that examines how humans respond to facial movement. Specifically, you have been instructed to watch a video that lasts 1 second. One video shows a woman opening her mouth; a second video shows her closing her mouth. The electrodes are fastened to your scalp, and you watch numerous presentations of both the mouth-opening and the mouth-closing videos. Later, the researchers will average the signal for each of the two conditions, to eliminate random activity in the brain waves (Puce & Perrett, 2005).

The ERP technique provides a reasonably precise picture about changes in the brain's electrical potential while people perform a cognitive task. Consider the research on mouth movement, for example. If you were to participate in this study, your brain

would show a change in electrical potential about half of a second after you saw each mouth movement. However, your brain would respond more dramatically when you watch her mouth open than when you watch a mouth close (Puce & Perrett, 2005).

Why does this fine-grained ERP analysis show that your brain responds differently to these two situations? Puce and Perrett propose that a mouth-opening movement is more important, because it signals that a person is about to say something. You therefore need to be attentive, and this exaggerated ERP reflects this attentiveness. In contrast, it's less important to notice that someone has finished talking.

A detailed investigation of cognitive neuroscience techniques is beyond the scope of this book. However, these techniques will be mentioned further in the chapters on perception, memory, and language. You can also obtain more information from other resources (e.g., Gazzaniga et al., 2009; Kalat, 2009; Kolb & Whishaw, 2011; Luck, 2014). However, it's important to point out that neuroscientists have not developed a detailed explanation for any human cognitive process, despite the claims in the popular media (Gallistel & King, 2009). In any event, the increased ease and accessibility of these cognitive neuroscientific techniques mean that more integrative and neutrally grounded theories of mind and brain are on the horizon.

PRACTICE QUIZ QUESTIONS

1) In the information-processing approach:
   a) principles of Gestalt psychology are applied to the scientific study of overt behavior.
   b) a mental process can be understood by comparison with the operations of a computer.
   c) introspection, one of the oldest techniques in psychology, is the best research technique.
   d) a mental process always involves conscious problem solving and decision making.

2) The distinction between whether or not cognitive activities are performed as a sequence of separate operations or as a simultaneous processing of many signals involves the issues of:
   a) serial processing and parallel processing.
   b) serial processing and pure AI.
   c) computer simulation and pure AI.
   d) computer simulation and parallel distributed processing.

3) Which of the following statements best describes cognitive science?
   a) Cognitive science is the interdisciplinary study of internal representations involved in thinking.
   b) Cognitive science is a subdiscipline of psychology that focuses on observable stimuli and external responses.

    c) Cognitive science declined in popularity as cognitive psychology increased in popularity.

    d) Cognitive science is a subdiscipline of computer science that uses pure AI and computer simulation methods.

4) An important characteristic of the connectionist approach to cognition is that:

    a) it handles information by processing it one step at a time.

    b) it first analyzes an object's shape, then its size, and finally its color.

    c) it can perform many operations at the same time.

    d) it predicts that humans perform cognitive tasks much more accurately than they actually do.

5) A research team is trying to identify the cognitive deficits of a man who had a stroke that affected a small portion in the left temporal lobe of his brain. This approach to studying the brain examines:

    a) the single-cell recording technique.

    b) brain lesions.

    c) parallel distributed processing.

    d) the event-related potential technique.

6) A researcher wants to study how people's attention shifts when they see a visual stimulus in an unexpected portion of a screen that they are viewing; this attention shift occurs in just a fraction of a second. Which of the following techniques is this researcher most likely to use?

    a) The neural-network approach

    b) A positron emission tomography (PET) scan

    c) The functional magnetic resonance imaging technique (fMRI)

    d) The event-related potential technique (ERP)

OVERVIEW OF YOUR TEXTBOOK

This textbook examines many different kinds of mental processes. We'll begin with perception, attention, and memory—three processes that contribute to all other cognitive tasks. We'll then consider language, which is probably the most challenging cognitive task that humans need to master. Later chapters discuss "higher-order" processes. As the name suggests, these higher-order cognitive processes depend upon the more basic processes introduced in earlier chapters. The final chapter examines cognition across the life span, from infancy to old age. Let's preview Chapters 2 through 13. Then we'll explore five themes that can help you appreciate some general characteristics of cognitive processes. Our final section provides hints on how you can use your book more effectively.

Preview of the Chapters

Visual and auditory recognition (**Chapter 2**) are perceptual processes that require linking the stimuli that are registered by your senses to the stored knowledge that you have about the world. For example, visual recognition allows you to recognize each letter on this page, whereas auditory recognition allows you to recognize the words you hear when a friend is talking to you.

Attention is a process that helps you determine which stimuli in the environment you choose to focus on (**Chapter 3**). The last time you tried to follow a friend's story—while simultaneously reading your biology textbook—you probably noticed the limits of your attention. This chapter also examines a related topic, called *consciousness*. **Consciousness** is your awareness of the external world, as well as your thoughts and emotions about your internal world.

Memory is the process of maintaining information over time. Memory is such an important part of cognition that it requires several chapters. **Chapter 4** describes working memory (short-term memory). You're certainly aware of the limits of working memory when you forget someone's name that you heard less than a minute earlier.

Chapter 5, the second of our memory chapters, focuses on long-term memory. We'll explore the factors that influence your ability to recall information stored in your long-term memory. We'll also investigate the factors, such as emotion, that can influence your ability to remember information. We'll then explore memory for everyday life events, as well as people's accuracy during eyewitness testimony.

Chapter 6, the last of the general memory chapters, provides suggestions for how to improve your memory. In particular, we focus on cognitive strategies that you can use in order to improve exam performance. This chapter also considers **metacognition**, which is your knowledge about your own cognitive processes. For instance, do you know whether you could remember the definition for *metacognition* if you were to be tested tomorrow?

Chapter 7 examines **imagery**, which is the mental representation of things that are not physically present. One important controversy in the research on imagery is whether your mental images truly resemble perceptual images. Another important topic concerns the mental images we have for physical settings. For example, the cognitive map you have developed for your college campus may show several buildings lined up in a straight row, even though their actual positions are much more random.

Chapter 8 concerns how we store and organize general knowledge. One area of general knowledge is **semantic memory**, which includes factual knowledge about the world as well as knowledge about word meanings. General knowledge also includes schemas (pronounced "*skee*-mahz"). **Schemas** are generalized kinds of information about situations. For example, you have a schema for the typical sequence of events that happen during the first day of a new course.

Chapter 9 is the first of two chapters on language, and it examines language *comprehension*. For example, you may hear someone that you have never met before

mumble a sentence, and yet you can easily arrive at an understanding of the intended message. Reading is the second topic in Chapter 9; you'll see that reading is much more complex than you might think! We'll also explore how people process **discourse**, which refers to a long passage of spoken or written language.

Chapter 10, the second of the language chapters, examines language *production*. One component of speaking is its social context. For example, when you describe an event to some friends, you probably check to make certain that they have the appropriate background knowledge. Writing requires some cognitive processes that are different from those necessary for speaking, but both of them require working memory and long-term memory. Our final language topic is bilingualism. Even though learning a single language is challenging, many people can speak two or more languages fluently.

Chapter 11 considers problem solving. Suppose you want to solve a problem, such as how to complete a course assignment if you do not understand the instructions. You may solve the problem by using a strategy such as dividing the problem into several smaller problems. Chapter 11 also explores creativity. As you'll see, people are often less creative if they have been told that they will be rewarded for their creative efforts.

Chapter 12 addresses deductive reasoning and decision making. Reasoning tasks require you to draw conclusions from several known facts. In many cases, your background knowledge interferes with drawing accurate conclusions. In decision making, you make a judgment about uncertain events. For example, people often cancel an airplane trip after reading about a recent plane accident, even though statistics clearly show that driving is more dangerous.

Chapter 13 examines cognitive processes in infants, children, and elderly adults. People in these three age groups are more competent than you might guess. For example, 6-month-old infants can recall an event that occurred 2 weeks earlier. Young children are also very accurate in remembering events from a medical procedure in a doctor's office. Furthermore, elderly people are competent on many memory tasks, and they actually perform better than younger adults on some tasks, such as crossword puzzles (Salthouse, 2012).

Themes in the Book

This book emphasizes certain themes and consistencies in cognitive processes. The themes are designed to guide you and offer you a framework for understanding many of the complexities of our mental abilities. The themes are as follows:

Theme 1: *Cognitive processes are active, rather than passive.* The behaviorists viewed humans as passive organisms. They wait for a stimulus to arrive from the environment before they respond. In contrast, the cognitive approach proposes that people seek out information. Attentional and perceptual systems work together to facilitate your ability to strategically seek out and process information that is most relevant for your current goals. In addition, memory is a lively process that requires you to continually synthesize and transform information. When you read, you actively draw

inferences that were never directly stated. In summary, your mind is not a sponge that passively absorbs information leaking out from the environment. Instead, you continually search and synthesize.

Theme 2: *Cognitive processes are remarkably efficient and accurate.* For example, the amount of material in your memory is astonishing. Just think about all the facts, names, and phone numbers that you know. And consider language comprehension. Speech unfolds at an extremely fast rate that a speaker controls, and yet most of the time, your interpretation of the speech signal is highly accurate.

Furthermore, your cognitive systems are designed in such a way that they can limit the amount of information to which you have access at some point in time. Although at face value these limitations may sound like a bad thing, many of the limitations on human information processing are actually helpful. Consider a situation in which you are eating lunch with friends at a busy restaurant. Your attentional abilities allow you to direct your attention to the speech of your friends. At the same time, they also provide you with the ability to filter out all of the background noise in the restaurant. Imagine how difficult life would be if you had to process every bit of information about every environmental stimulus at the same point in time. It would be overwhelming.

Before you read further, try Demonstration 1.4, which is based on a Demonstration by Hearst (1991).

🌀 **Demonstration 1.4**

Looking at Unusual Paragraphs

How fast can you spot what is unusual about this paragraph? It looks so ordinary that you might think nothing is wrong with it at all, and, in fact, nothing is. But it is atypical. Why? Study its various parts, think about its curious wording, and you may hit upon a solution. But you must do it without aid; my plan is not to allow any scandalous misconduct in this psychological study. No doubt, if you work hard on this possibly frustrating task, its abnormality will soon dawn upon you. You cannot know until you try. But it is commonly a hard nut to crack. So, good luck!

I trust a solution is conspicuous now. Was it dramatic and fair, although odd? Author's hint: I cannot add my autograph to this communication and maintain its basic harmony.

Theme 3: *Cognitive processes handle positive information better than negative information.* We understand sentences better if they are worded in the affirmative— for example, "Mary is honest," rather than the negative wording, "Mary is not dishonest." In addition, we have trouble noticing when something is missing, as illustrated in Demonstration 1.4 (Hearst, 1991) (see page 38 for the answer to this demonstration,

as well as for the credit for this quotation). We also tend to perform better on a variety of different tasks if the information is emotionally positive (that is, pleasant), rather than emotionally negative (unpleasant). In short, our cognitive processes are designed to handle *what is*, rather than *what is not* (Hearst, 1991; Matlin, 2004).

Theme 4: *Cognitive processes are interrelated with one another; they do not operate in isolation.* This textbook discusses each cognitive process in one or more separate chapters. However, this organizational plan does not imply that every process can function by itself, without input from other processes. For example, decision making typically requires perception, memory, general knowledge, and language. In fact, all higher mental processes require careful integration of our more basic cognitive processes.

Theme 5: *Many cognitive processes rely on both bottom-up and top-down processing.* **Bottom-up processing** emphasizes the importance of information from the stimuli registered on your sensory receptors. Bottom-up processing uses only a low-level sensory analysis of the stimulus. In contrast, top-down processing emphasizes how our concepts, expectations, and memory influence our cognitive processes. This **top-down processing** requires higher-level cognition, for example, the kind of processes we will emphasize in Chapters 5 and 8 of this textbook. Both bottom-up and top-down processing work simultaneously to ensure that our cognitive processes are typically fast and accurate.

Consider pattern recognition. You recognize your aunt partly because of the specific information from the stimulus—information about your aunt's face, height, shape, and so forth. This bottom-up processing is important. At the same time, however, you must possess stored knowledge about the physical characteristics of your aunt. The reliance on stored knowledge about the physical identity of your aunt—knowledge that is necessary in order to recognize a person as your aunt and not as a stranger—is an example of the top-down knowledge-driven component of visual recognition. Furthermore, consider the role of context. There is a higher likelihood of seeing your aunt in her house than seeing your best friend from college in your aunt's house. This top-down knowledge may speed up the visual recognition of your aunt in her house. It may also, however, slow down the recognition of your best friend from college should that person happen to be at your aunt's house when you arrive. Assuming that your aunt and your best friend from college don't know each other, and you know that they don't know each other, do you have the sense that you would be slightly confused upon encountering your best friend from college at your aunt's house? As we'll see throughout this book, knowledge and context work together to shape the way that we access and process information in our environments.

How to Use Your Book Effectively

Your textbook includes several features that are specifically designed to help you understand and remember the material. As you read the list that follows, figure out how to use each feature most effectively.

Chapter Outline. Notice that each chapter begins with an outline. When you start to read a new chapter, first examine the outline so that you can appreciate the general structure of a topic. For example, notice that Chapter 1 has four main topics, each appearing in large boldface print, starting with **What Is Cognitive Psychology?** Each appears in text under a solid line that denotes a new main section of the chapter. The second-level headings are smaller, such as **The Origins of Cognitive Psychology** here in Chapter 1. The third-level headings are the smallest, and appear in text at the beginning of relevant subsections in italics.

Chapter Introductions. Each chapter begins by an introductory section that encourages you to think about how your own cognitive experiences are related to the material in the chapter. They are designed to emphasize the central components of the cognitive process discussed in each chapter. By combining the material from the outline and the opening paragraph, you'll be better prepared for the specific information about the research and theories in each chapter. You may be tempted to skip the chapter outline and the chapter introductions. However, this organizational structure will help you understand the major groupings of topics throughout the chapter before you begin to read.

Demonstrations. I designed the demonstrations in this book to make the research more meaningful. The informal experiments in these demonstrations require little or no equipment, and you can perform most of them by yourself. Students have told me that these demonstrations help make the material more memorable, especially when they try to picture themselves performing the tasks in a research setting. As you will see in our multiple discussions of memory systems, we remember information more accurately when we try to relate the material to ourselves.

Individual Differences Focus. The term **individual differences** refers to the systematic variation in the way that groups of people perform on the same cognitive task. Prior to about 1995, cognitive psychologists rarely studied how individual differences could influence people's thought processes. Instead, they focused quite strongly on measuring the behavior of multiple participants in an experiment, and then calculating the statistical mean (average) performance per each condition of an experiment. But, average estimates of performance do not provide information about variability in participant performance. Some participants may have performed really well on a task whereas others may have exhibited more difficulty. And, in many cases, understanding why certain individuals performed better or worse on a task can provide deeper insight into the cognitive process that one is investigating.

The exploration of individual differences in cognitive performance is consistent with a relatively new approach that makes connections among the various disciplines within psychology. John T. Cacioppo (2007) wrote about this important issue when he was the president of the Association for Psychological Science. APS is an organization that focuses on psychology research in areas such as cognitive psychology, social psychology, and biopsychology.

Cacioppo emphasized that psychology can make major advances by combining each of these areas with one of three specific perspectives. These three perspectives are abnormal psychology, individual differences, and developmental psychology. For instance, a group of researchers could combine one area (e.g., cognitive psychology) with a perspective (e.g., abnormal psychology).

Consider individuals who have major depression. **Major depression** is a psychological disorder in which feelings of sadness, discouragement, and hopelessness interfere with the ability to perform daily mental and physical functions. In an earlier era, psychologists seldom studied whether depressed individuals might differ from other people when performing cognitive tasks. This situation is puzzling, because therapists—and the individuals themselves—frequently noticed these problems on cognitive tasks. Fortunately, many contemporary psychologists now conduct research on the relationship between psychological disorders and cognitive performance (e.g., Hertel & Matthews, 2011).

This kind of interdisciplinary research is important, from both practical and theoretical standpoints. As you know, Theme 4 emphasizes that our cognitive processes are interrelated. Therefore, cognitive aspects of psychological problems—such as major depression—could certainly be related to attention, memory, and other cognitive processes. And, if depressed individuals underperform nondepressed individuals on a memory task, the next most reasonable question to ask is "Why?" Perhaps individuals with depression do not encode information into memory in the same way as those without depression. Or, perhaps attentional differences between the two groups explain why they differed in memory performance. Pursuing either of these two potential explanations for the group difference will likely yield more information not only about cognitive processing in depressed individuals, but also about memory systems more generally.

Other researchers who investigate individual differences choose to compare groups of people who differ on a demographic characteristic. For example, you may have heard from someone at some point in your life that men and women differ in their language or spatial abilities. In Chapter 7, however, we'll see that women and men are actually similar in most kinds of spatial abilities. Indeed, although gender differences may be an important area of inquiry in some other areas of psychology, men and women tend to demonstrate extremely similar patterns of performance on most cognitive psychology experiments.

In order to increase your awareness of the emerging focus on individual differences research in cognitive psychology, each chapter contains an overview of research that highlights some type of individual differences effect. For example, Chapter 2 contains a discussion of how individuals with a schizophrenia diagnosis perform more slowly than a control group (without schizophrenia or other significant mental health problems) on facial recognition tasks. Chapter 5 contains a discussion of the manner in which the presence of an anxiety disorder can influence performance on different types of memory tasks. I hope that you come to see the importance of examining how individual difference variables can influence cognitive processing.

Applications. As you read each chapter, notice the numerous applications of cognitive psychology. Indeed, research in cognition has important applications to areas

such as education, medicine, business, and clinical psychology. For example, understanding the factors that can increase the accurate retrieval of information from memory is not only interesting for theoretical reasons. People recall information better if it is concrete, rather than abstract, and if they try to determine whether the information applies to themselves (Paivio, 1995; Rogers et al., 1977; Symons & Johnson, 1997). Each time that you take an exam, you must access information that is stored in your memory. As a result, the scientific study of memory can provide valuable information that you can apply to your own study strategies and test-taking behaviors in order to increase your exam performance.

End-of-Section Practice Quiz Questions.　In your high school or college experience, have you ever had the sense that you understood a topic better after you took as test on the topic? It turns out that people do experience increases in memory for material after they have been tested on it—a phenomenon called the **testing effect**. At the end of each section in each chapter, 3–7 multiple choice quiz questions appear. Try to answer each question. If you have difficulty doing so, immediately go back to the corresponding text and try to figure out the correct response. These mock quizzes provide you with a quick way to test yourself for understanding. Completing these questions should provide you with the information you need in order to identify weaknesses in your understanding of the material. This information will be very valuable in allowing you to strategize about which topics you should spend more time studying when preparing for upcoming exams.

Section Summaries.　As we will discuss in the chapters on memory, repeated exposures to information increases accurate memory for that information. The practice quiz questions provide you with a second exposure to key concepts after you already encountered them in text. In order to provide you with a third opportunity to think about key concepts in each chapter, section summaries appear for each section at the end of the chapter. When you reach the end of the chapter, cover the summary points provided for each section and see which important points you remember. Then, read the section summary and notice which items you remembered incorrectly or incompletely. Take extra care to revisit the text associated with the points on which you experienced difficulty.

End of Chapter Review Questions.　At the end of each chapter, you will find a set of essay-style review questions. These questions provide you with yet another opportunity to quiz yourself, in a different format, on the material contained in the chapter. Many review questions ask you to apply your knowledge to an everyday problem. Other review questions encourage you to integrate information from several parts of the chapter. Thinking about each question will provide you with another opportunity to identify the areas in which you may have difficulty with the material.

Keywords.　Notice that each new term in this book appears in boldface type (e.g., **cognition)** when it is first discussed. I have included the definition in the same sentence as the term, so you do not need to search an entire paragraph to discover

the term's meaning. Also, notice that phonetic pronunciation is provided for a small number of words that are often mispronounced. Students tell me that they feel more comfortable using a word during class discussion if they are confident that their pronunciation is correct. (I also included pronunciation guides for the names of several prominent theorists and researchers, such as Wundt and Piaget).

Keywords List and Glossary. A list of new terms appears at the end of each chapter. Check each item to see whether you can supply a definition and an example. You can consult the chapter for a discussion of the term. Your textbook also includes a glossary at the end of the book. The glossary will be helpful when you need a precise definition for a technical term. It will also be useful when you want to check your accuracy while reviewing the list of new terms in each chapter.

Recommended Readings. Each chapter features a list of recommended readings. This list can supply you with resources if you want to write a paper on a particular topic or if an area is personally interesting. In general, I tried to locate books, chapters, and articles that provide more than an overview of the subject but are not overly technical.

One unusual aspect of cognitive psychology is that you are actually using cognition to learn about cognition! These learning aids, combined with the material on memory improvement in Chapter 6, should help you use your cognitive processes even more efficiently.

PRACTICE QUIZ QUESTIONS

1) Which of the following statements is <u>true</u> about cognition, in connection with the themes of this textbook?
   a) Most cognitive processes can be studied in isolation, without reference to other processes.
   b) Although some cognitive processes are active, most are passive.
   c) Most cognitive theories propose that humans actively examine the world for information.
   d) Cognitive processes handle neutral information better than positive information.

2) Suppose that you are accustomed to a certain bus stopping on a specific corner near your college campus. A bus stops, and you think that it's your customary bus. You fail to notice that the side of the bus has a totally different company name. The process that led to your misidentifying the bus is called:
   a) serial processing.
   b) parallel processing.
   c) bottom-up processing.
   d) top-down processing.

3) The kind of processing that emphasizes how your sensory receptors register information is called:

   a) serial processing.

   b) parallel processing.

   c) bottom-up processing.

   d) top-down processing.

4) One of the themes of your textbook focuses on bottom-up and top-down processing. According to this theme:

   a) the phrase "top-down processing" points out the importance of the information contained in the stimulus.

   b) bottom-up processing is almost always more important than top-down processing.

   c) top-down processing is more important in childhood, but bottom-up processing is more important in adulthood.

   d) both top-down processing and bottom-up processing operate at the same time, so that our cognitive processes can operate efficiently.

5) According to the discussion of individual differences in Chapter 1 of your textbook:

   a) behaviorists pay more attention to individual differences than cognitive psychologists do.

   b) cognitive psychologists now emphasize individual differences more than in earlier decades.

   c) cognitive psychologists have always studied psychological disorders more than they have studied developmental psychology.

   d) cognitive psychologists believe that research about individual differences has some practical applications, but individual differences are not theoretically interesting.

Section Summary Points

WHAT IS COGNITIVE PSYCHOLOGY?

1. The term *cognition* refers to the acquisition, storage, transformation, and use of knowledge; *cognitive psychology* is sometimes used as a synonym for cognition, and sometimes it refers to a theoretical approach to psychology.

2. Multiple systems and processes contribute to your conscious interpretation of the world around you.

3. It's useful to study cognitive psychology because (a) cognitive activities are a major part of human psychology, (b) the cognitive approach influences other important areas of psychology, and (c) you can learn how to use your cognitive processes more effectively.

A HISTORICAL PERSPECTIVE ON COGNITIVE PSYCHOLOGY

1. Many historians maintain that Wilhelm Wundt is responsible for creating the discipline of psychology; Wundt also developed the introspection technique.
2. Hermann Ebbinghaus and Mary Whiton Calkins conducted early research on human memory.
3. William James examined numerous everyday psychological processes, and he emphasized the active nature of the human mind.
4. Gestalt psychology emphasized that people use organization to perceive patterns, and they often solve problems by using insight.
5. Beginning in the early 20th century, behaviorists such as John B. Watson rejected the study of mental processes; the behaviorists helped to develop the research methods used by current cognitive psychologists.
6. Cognitive psychology began to emerge in the mid-1950s. This new approach was stimulated by disenchantment with behaviorism, as well as a growing interest in linguistics, human memory, and developmental psychology.

THE RELATIONSHIP BETWEEN MIND, BRAIN, AND BEHAVIOR

1. Cognitive science examines questions about the mind; it includes disciplines such as cognitive psychology, neuroscience, artificial intelligence, philosophy, linguistics, anthropology, sociology, and economics.
2. Theorists who are interested in artificial intelligence (AI) approaches to cognition typically try to design computer models that accomplish the same cognitive tasks that humans do.
3. The approach called "pure artificial intelligence" attempts to design programs that can accomplish cognitive tasks as efficiently as possible.
4. The approach called "computer simulation" attempts to design programs that accomplish cognitive tasks the way that humans do.
5. According to the computer metaphor, human cognitive processes work like a computer that can process information quickly and accurately.
6. According to the information-processing approach, mental processes operate like a computer, with information flowing through a series of storage areas.

7. Enthusiasm for the classic information processing approach has declined, because cognitive psychologists now realize that human thinking requires more complex models.

8. Cognitive psychology has had a major influence on the field of psychology. In the current era, cognitive psychologists are more concerned about ecological validity than in previous decades.

9. According to the connectionist approach, cognitive processes can be represented in terms of networks of neurons; furthermore, many operations can proceed at the same time, in parallel, rather than one step at a time.

10. The area of cognitive neuroscience combines the research techniques of cognitive psychology with a variety of methods for assessing the brain's structure and function.

11. Brain lesions, PET-scans, and the functional magnetic resonance imaging (fMRI) are cognitive neuroscientific methodologies that provide information about which brain structure are involved in cognitive processing; fMRI is now more commonly used than PET scans.

12. The event-related potential technique uses electrodes to track the very brief changes in the brain's electrical activity, in response to specific stimuli. It does not provide information about where in the brain the processing occurred, but it gives very precise estimates of the time-course of cognitive processing.

CHAPTER REVIEW QUESTIONS

1. Define the terms *cognition* and *cognitive psychology*. Now think about your ideal career, and suggest several ways in which the information from cognitive psychology would be relevant to this career.

2. Compare the following approaches to psychology, with respect to their specific emphasis on human thinking: (a) William James's approach, (b) behaviorism, (c) gestalt psychology, and (e) the cognitive approach.

3. This chapter addresses the trade-off between ecological validity and carefully controlled research. Define these two concepts. Then compare the following approaches in terms of their emphasis on each concept: (a) Ebbinghaus's approach to memory, (b) James's approach to psychological processes, (c) the behaviorist approach, (d) the cognitive psychology approach from several decades ago, and (e) current cognitive psychology research.

4. List several reasons for the increased interest in cognitive psychology and the decline of the behaviorist approach. In addition, describe the field of cognitive science, noting the disciplines that are included in this field.

5. The section on cognitive neuroscience described four different research techniques. Answer the following questions for each technique: (a) What are its strengths? (b) What are its weaknesses? (c) What kind of research questions can it answer?

6. What is artificial intelligence, and how is the information-processing approach relevant to this topic? Select three specific cognitive processes that might interest researchers in artificial intelligence. Then provide examples of how pure AI and the computer-simulation investigations of these cognitive processes would differ in their focus.

7. How does connectionism differ from the classical artificial-intelligence approach? List three characteristics of the PDP approach. In what way is this approach based on discoveries in cognitive neuroscience?

8. Theme 4 emphasizes that your cognitive processes are interrelated. Think about a problem you have solved recently, and point out how the solution to this problem depended upon perceptual processes, memory, and other cognitive activities.

9. As you'll see in Chapter 6, your long-term memory is more accurate if you carefully think about the material you are reading; it is especially accurate if you try to relate the material to your own life. Review the section called "How to Use Your Book" and describe how you can use each feature to increase your memory for the material in the remaining chapters of this book.

10. Review each of the five themes of this book. Which of them seem consistent with your own experiences, and which seem surprising? From your own life, think of an example of each theme.

KEYWORDS

cognition
cognitive psychology
cognitive approach
empirical evidence
introspection
recency effect
behaviorism
operational definition
gestalt psychology
gestalt
information-processing
   approach
ecological validity
cognitive neuroscience
social cognitive
   neuroscience
brain lesions
positron emission
   tomography
   (PET scan)

functional magnetic
   resonance
   imaging (fMRI)
event-related potential (ERP)
technique
artificial intelligence
   (AI)
computer metaphor
pure AI
computer simulation
computer modeling
connectionist approach
parallel distributed
   processing
   (PDP) approach
neural-network approach
cerebral cortex
serial processing
parallel processing
cognitive science

consciousness
memory
metacognition
imagery
semantic memory
schemas
discourse
Theme 1
Theme 2
Theme 3
Theme 4
Theme 5
bottom-up processing
top-down processing
individual differences
major depression
testing effect

RECOMMENDED READINGS

Bermúdez, J. L. (2014). *Cognitive science: An introduction to the science of the mind*. New York: Cambridge University Press. Cognitive science is an interdisciplinary area, and this textbook does a good job of explaining how multiple field, including psychology, contributed to a more interdisciplinary understand of how the mind works.

Clark, A. (2013). *Mindware: An introduction to the philosophy of cognitive science*. Oxford University Press, Inc. Written by a leading philosopher in the field of cognitive science, this book provides a very accessible overview of multiple approaches to modeling the complexities of the human mind.

Kalat, J. W. (2009). *Biological psychology* (10th ed.). Belmont, CA: Cengage Wadsworth. Kalat's textbook provides an interesting, clear description of biopsychology and neuropsychology; the illustrations are especially helpful.

Pickren, W. E., & Rutherford, A. (2010). *A history of modern psychology in context*. Hoboken, NJ: Wiley. I highly recommend this clearly written, well-organized overview of the history of psychology.

Spivey, M. (2007). *The continuity of mind. Oxford University Press*. Although this book is a bit advanced, it provides a very clear and concise critique of the classical information processing approach to cognitive psychology. The author then argues for a newer perspective on the relationship between perception, cognition, and action.

ANSWER TO DEMONSTRATION 1.4

The letter *e* is missing from this entire passage. The letter e is the most frequent letter in the English language. Therefore, a long passage—without any use of the letter *e*—is highly unusual. The exercise demonstrates the difficulty of searching for something that is not there (Theme 3).

Quotation on page 25 from: Hearst, E. (1991). Psychology and nothing. *American Scientist*, **79**, 432–443.