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1 INTRODUCTION TO COGNITIVE PSYCHOLOGY

LEARNING OBJECTIVES

1.1 Describe cognitive psychology and its historical origins.

1.2 List the different approaches to the study of cognition.

1.3 Describe the scientific method and how it allows us to test hypotheses about cognition.

1.4 Compare the different research methods used by cognitive psychologists.

1.5 Identify the observable behaviors that are used to understand cognitive processes.

QUESTIONS TO CONSIDER

- What is cognitive psychology?
- How did it develop as a field?
- How have psychologists approached the study of cognition?
- What types of research methods are useful in the study of cognition?
- What behaviors do psychologists observe to study cognition?

INTRODUCTION: COGNITION AND SHOPPING

Last night, as I wandered into the kitchen, I noticed that the lighting looked dim. As I looked up, I realized that three light bulbs had burned out. I also noticed that they were each a different type of bulb. I jumped into the car and headed to the grocery store for more light bulbs. I wandered into the store, grabbed a cart, and headed down the aisle. "While here," I thought to myself, "I may as well pick up some other things that we need." As I passed through the cereal aisle, I noticed a brightly colored sign announcing, "Buy 2, get 30% off" for Fruity O's. Next to it, the price for the generic brand was, "Buy one, get one free." I did some mental math and decided that even though the generic cereal was a better deal, my daughter would only eat brand name Fruity O's, so it would be a bad idea to get the less expensive cereal. Thinking about breakfast, I remembered we also needed milk and orange juice plus bread, butter, and Swiss cheese to make lunches. Since this is the store that I usually shop at, I wandered through quickly, checking things off my mental list. At the checkout counter, I'm asked, "Paper or plastic?" and I hesitated while realizing that I left my reusable bags in the trunk of the car and then replied, "Plastic, please." After paying, I exited the store, drove home, unloaded, and put away the groceries. Afterward, I sat down at the kitchen table and noticed how dim it was. I suddenly realized that I had forgotten the very thing I ran out to the store to get: light bulbs!

WHAT IS COGNITIVE PSYCHOLOGY?

In the shopping story you just read, cognition is involved in many of the tasks described. In fact, cognition is used in most of the tasks that people do every day, from ordinary tasks like grocery shopping to more complex tasks like deciding what to major in or studying for a difficult exam. You may have related the preceding story to things that have happened to you: walking upstairs in your house and then forgetting why you went up there, making a decision about whether an offered deal will really save you money, trying to remember things you have to do or things you need to buy. Cognition is involved in so many things we do that it is difficult to come up with events in our lives that do not involve cognition. In fact, just thinking about what cognitive psychology is involves cognition. As a simple answer, cognition involves thinking and other mental processes. However, as a student of psychology, you probably already know that few questions in psychology have simple answers, and the question of "What is cognitive psychology?" is no exception. A more complete answer to this question is that cognitive psychology includes the following:

- Our perception of the world around us through our senses and how we interpret the sensations brought in by our senses (e.g., noticing that the lights are dim in your kitchen and that there are three different sized light bulbs)
- The attentional processes that allow us to focus on a particular stimulus in our environment (e.g., a brightly colored sign catching our attention in a grocery store)

- How our memory operates to allow us to remember episodes, information, and intentions when we attempt to retrieve them (e.g., remembering—or not remembering—to buy light bulbs at the store)
- Our language processes that help us communicate our thoughts and ideas with others (e.g., being able to read the advertisement for the cereal or understanding the cashier's question of "Paper or plastic?")
- The processes that contribute to our decision making, both helpful and hindering (e.g., trying to decide if the "Buy one, get one free" deal is really going to save you money if no one in your family likes that brand of cereal)
- Being able to monitor your thought processes while you work through the steps of a problem (Which cereal is the better deal? Is paper or plastic better for the environment?)
- The brain activity that controls all the processes described so far

This may seem like a long list, but it only touches briefly on the major areas studied in the field of cognitive psychology. Current research in cognitive psychology also connects cognition with other areas of psychology as well as linguistics, cognitive science, and neuroscience. For example, some cognitive psychologists are interested in the role of consciousness in our cognitive processes and how much conscious choice we actually have in our behaviors. Others consider how brain function might affect our social interactions and be involved in social dysfunction, such as autism spectrum disorders. Cognitive psychology also informs educators about the processes involved in teaching and learning, including the metacognitive strategies that differentiate more and less successful learners. **Metacognition** is being aware of one's own cognitive abilities and processes and will be discussed in the context of different areas of cognition throughout this text. Thus, cognitive psychology is broad and overlaps with many other fields (e.g., social and biological psychology, philosophy), both inside and outside of psychology.

History of Cognitive Psychology

Cognitive psychology in some form has been a field of study for thousands of years. Early philosophers addressed questions about cognition that are still relevant today. For example, Aristotle suggested an early metaphor for the mind to explain how memory processes work. He proposed that our memory could be envisioned as a wax tablet, with memories formed in the tablet like molds in hot wax. The durability of the memory depended on different factors in the same way that the durability of molds in wax can vary; if the wax tablet is heated, the form can become distorted or disappear. As you will read in Chapters 5, 6, and 7, memory researchers still propose, test, and refine theoretical models of memory.

As scientific methods were developed in other fields (e.g., physics, biology, chemistry), researchers began to apply these methods to the study of the mind. The earliest psychological research can be described as physiological studies designed to answer longstanding philosophical questions. Hermann von Helmholtz, a professor of physiology, conducted research on the speed of nerve conduction by isolating the nerve fiber in the leg of a frog. After determining that nerve impulses travel approximately 90 feet per second, he began rudimentary response time experiments with humans. He estimated human nerve conduction to be about 165 to 330 feet per second (Hergenhahn, 1986). Gustav Fechner conducted some of the first experiments in **psychophysics** (described in Chapter 3) with the goal of developing laws of perception.

In 1879, Wilhelm Wundt opened one of the first laboratories dedicated to psychological research at the University of Leipzig. Considered one of the founders of psychology, Wundt studied conscious experience through methods that involved systematic self-reports of a person's thoughts. Wundt and other early psychologists studied how people perceived sounds, colors, and other sensory experiences using **introspection**. Their goal was to study consciousness "as it occurs." Another early psychologist,

Hermann Ebbinghaus, studied the processes of remembering and forgetting by testing his own memory extensively to determine the savings in relearning that can be gained from previous exposures to information. He measured the decline in his memory performance over time and thus mapped out the forgetting curve that researchers still find in current studies measuring memory performance over time (see Chapter 6 for further discussion of the forgetting curve).

In the early to mid-twentieth century, the study of cognition fell out of favor in psychology with the rise in popularity of the **behaviorist** perspective. Inspired by the scientific advances in physiology (such as the Nobel prize-winning work on conditioned reflexes by Ivan Pavlov), prominent behaviorists John Watson and B. F. Skinner argued that introspective methods were biased by the perspective of the subject. How did the researcher know that the mental processes of the mind were consciously accessible and could be verbally reported in an accurate way? Instead, behaviorists focused only on behaviors they could directly observe, with the thought processes behind the behaviors of less interest.

Although the behaviorist perspective was common in psychological research in the United States for almost half a century, in Europe, work that acknowledged the existence and importance of mental events was being conducted by the Gestalt psychologists in Germany. In the 1920s and 1930s, the Swiss psychologist Jean Piaget began studying the development of children's thinking. Sir Frederick Bartlett, an English experimental psychologist at the University of Cambridge, published a book entitled *Remembering* in 1932 based on his work with memory for text.

An important event that led to a return to a focus on cognition in psychology was an attack on the behaviorist approach to language learning by the linguist Noam Chomsky. Skinner (1957) proposed that language learning occurs through operant conditioning processes, consistent with the popular behaviorist view at that time. He suggested that language abilities develop through the imitation of speakers around a child and the feedback (reinforcement or punishment) the child's speech elicited. Chomsky (1959) presented a strong counterargument to this proposal; a critical piece of evidence against the behaviorist account of language development was the simple fact that children produce language that has never been produced around them or been reinforced (e.g., original sentences never heard before, incorrect grammar that has never been modeled). Instead, Chomsky suggested that children have the mental capacity to learn the rules of the language(s) spoken around them without explicit feedback on the language they produce. In other words, language abilities result from cognitive processes inherent in humans. From Chomsky's argument, psychologists began to realize that the study of non-observable cognitive processes is an important part of understanding behavior—that understanding the processes behind the overt behaviors would advance our understanding of the mind and behavior in important ways. Still, behaviorism did influence the way we study cognitive processes today. Its focus on the experimental examination of behavior shaped the way researchers approach the study of mental processes. Experimentation is still the focus, but cognitive psychologists examine the behaviors resulting from the mental processes being studied.

Another influential event in the development of cognitive psychology research was the invention of the computer. Herbert Simon recounts in his autobiography that he began a graduate class in 1956 by announcing, "Over the Christmas holiday, Al Newell and I invented a thinking machine" (Simon, 1991, p. 206). Computers presented an information-processing model as an analogous way of thinking about cognitive processes. In this new metaphor for the mind, the brain could be thought of as a biological computer, capable of storing large amounts of information and acting to alter that information as learning takes place. Cognitive processes were the "software" that processed the information (with the brain as the "hardware"). The information-processing model helped psychologists think about cognition in a new way, which spurred research on how information is processed in a way that could be stored in our minds and how that information is acted on as we encounter new information related to what is already stored. This model also provided a universal language that allowed researchers to discuss the processes of the mind and their connection to the brain.

Another milestone in the development of cognitive psychology as a coherent field of study was a 1967 book by Ulric Neisser that integrated such topics as memory, perception, attention, and language as a unified field. Neisser coined the term cognitive psychology (hence the title of this text) and, due to this contribution, is widely viewed as the father of the field. Throughout his career, Neisser conducted research in different areas of *cognitive psychology* with a focus on cognition in everyday behaviors.

PHOTO 1.1 Noam Chomsky; his work in linguistics had a fundamental impact on the early development of cognitive psychology.

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Despite his important contribution, the field of cognitive psychology now differs somewhat from the approach Neisser discussed in his book. For one thing, the topics in this text are broader in scope than those from Neisser when he first described cognitive psychology. For example, in each chapter of this text, you will find a discussion of work in neuroscience, a field that examines the biological underpinnings of cognitive processes. Cognitive neuroscience has become one of the most influential areas of cognitive psychology. It is a topic introduced in Chapter 2 and comes up throughout the book, as research in neuroscience informs theory about many different cognitive processes. Thus, this area of cognitive psychology brings together different topics under the umbrella of a biological approach to the study of cognition. In another example, researchers today take a more holistic approach to memory than was taken in Neisser's book. He discussed memory by modality of information (e.g., "visual memory," "active verbal memory") instead of as one connected topic. In fact, the study of memory has become a large part of the study of cognition in the decades that followed the publication of Neisser's book. A glance at the table of contents of this text shows three chapters (Chapters 5–7) devoted to memory, and this topic is touched on in additional chapters as it connects with other topics (e.g., concepts, imagery). Finally, cognitive psychology is not an isolated field. It has important connections to other fields, such as social psychology, philosophy, biology, economics, and the law. You will see some of these connections illustrated in the text as we discuss the mental processes that make up the field.

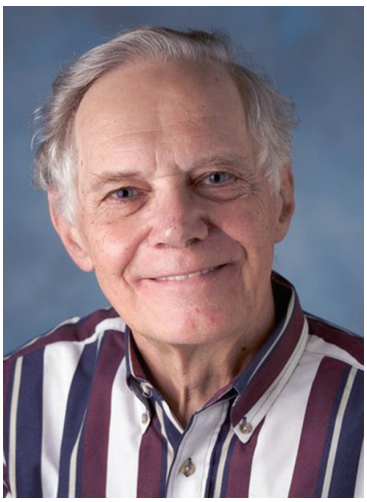

PHOTO 1.2 Ulric Neisser; in addition to his body of research, the publication of his 1967 textbook ***Cognitive Psychology*** led to him being referred to as the "Father of Cognitive Psychology."

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STOP AND THINK

1.1 List four cognitive processes studied by cognitive psychologists.

1.2 What three historical events influenced the development of cognitive psychology?

1.3 From the description of the types of processes studied in cognitive psychology, what processes do you think were involved in generating your responses to the two previous questions?

CURRENT APPROACHES TO THE STUDY OF COGNITION

Cognitive psychology has risen as a major field of study in psychology, with a large number of researchers investigating questions about cognition and its relation to everyday experiences. Current research takes a number of approaches to understanding cognition. We discuss a few of the most influential approaches to allow you to better understand why researchers have focused on some of the research questions we discuss later in this text. These approaches represent some of the ways that researchers think about how cognition works, which in turn influences the way they design research studies to investigate these processes.

PHOTO 1.3 How do you think a concept like "armadillo" is mentally stored in our minds?

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Representationalism

A popular perspective in cognition is to consider information from the world as being represented in some form in our minds. For example, we might store the concept of *armadillo* in various ways. We could represent armadillo as an exemplar of the category of animals or in interconnections with related animals. We might also represent it as a concept with characteristic features (e.g., mammal, hard shell, digs). The basic aspect of the **representationalist** approach is that knowledge about the world is represented in our minds such that cognitive processes can "operate" on the representations. If we read about armadillos or see a documentary about them, we might change or add to this stored information as we learn more about armadillos than we previously knew.

In early representationalist models (Rumelhart & Norman, 1988), information was thought to be stored as symbols that could be operated on in the way that mathematical variable symbols (e.g., *2* and II are both symbols used to represent the concept of two) are operated on (we can manipulate these symbols using operations such as addition or multiplication). This approach allowed researchers to study the operations as processes of cognition. For example, models of perception relied on feature detectors that stored information about features encountered in the world (e.g., lines, curves, colors). We can identify objects when our feature system identifies particular features that we know to be a part of an object. If we detect perpendicular edges on an object, then the feature system can rule out objects with rounded edges and narrow identification down to objects with sharper edges. In this way, the features we see are stored as feature symbols in our minds. As knowledge of cognition has advanced, these symbol systems have become more complex in representing the knowledge stored in our minds.

The representationalist approach arose from the computer and information-processing models of cognition. Information is stored in computers in the form of 0's and 1's that form chains of "off" and "on" signals. This is similar to the way that neurons either fire or do not fire at any given time. In this way, the computer model is analogous to how the brain functions. Seeing this similarity, some cognitive and physiological psychologists have considered information as being represented in the mind through the "on" and "off" firing patterns of groups of neurons. This allows researchers to think of information as being stored in the mind and available for processing as we interpret, analyze, and alter this information in our thinking.

The representationalist perspective connects well with the biological perspective (see later in this section), as it provides a model of cognition in sync with the physiological processes that occur in the brain. However, the primary model for representationalism is the computer metaphor for the mind. The language of computers is typically evoked in describing the representations found in the mind. For example, "concepts" are often described as storage nodes of information in a hierarchical network (see Chapter 9 for further discussion of concepts). Thus, this approach has a different origin and conceptual structure than the biological approach described shortly.

PHOTO 1.4 Researchers who adhere to the embodied cognition approach believe that perception serves as a process to aid interaction with the environment.

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Embodied Cognition

Another approach to the study of cognition views our cognitive processes as providing a means of interacting with the world around us. In this view, our visual sense doesn't simply create representations of objects and scenes from the world for us to interpret and process. Instead, it provides information about the world that allows us to do things in that world, such as walking through a doorway or catching a ball. In other words, our cognitive processes have evolved to allow us to interact with the world (e.g., objects, people, conversations) and should be studied according to the purpose they serve. As such, our motions and interactions with objects and people in the world will influence our cognition. Researchers who adhere to the **embodied cognition** perspective examine cognition as an interaction between humans (and other animals) and their environment. Studies from this area have shown, for example, that memory of a text is better when people act it out as compared with other learning strategies, like rereading the text (Scott et al., 2001); that people will look at the space on an empty screen when recalling information previously presented at that location on the screen (Richardson & Spivey, 2000); and that people with experience wearing the shoulder pads used in American football pass through a small open space in a different way than those without experience playing the sport (Higuchi et al., 2011). These results show that our memory, language, and perception processes depend on our interactions with the world around us. More about this perspective is discussed in each of the topical chapters where this approach has been applied.

Biological Perspective

We have already had some discussion of the role biology plays in the study of cognition as we have considered the area of cognitive neuroscience and its connection to the representationalist approach. However, some researchers have considered a **biological perspective** of cognition, a view beyond just the specific brain activity associated with different cognitive processes. These researchers build theories of cognition using a different metaphor for the mind, one not based on a computer but rather on how the brain works. In other words, they propose theories based not on the manipulation of symbols but rather on networks of connections loosely analogous to networks of neurons. For example, in

attempting to model how our memory system learns new information, researchers have considered the way in which neurons are connected in networks in the brain and simulated such networks in models of memory (McClelland, 1999). Models of this sort, known as connectionist models, have also been developed to explain how we identify language through individual features of letters and spoken words. Thus, our knowledge of the biological architecture of the brain and the neurological functioning of the brain has guided researchers in their attempts to better understand how different cognitive processes work.

STOP AND THINK

1.4 How are the representationalist and biological approaches connected?

1.5 What does embodied cognition mean?

1.6 In what ways are the biological features of the brain important in the study of cognition?

1.7 Given what you know so far about cognitive psychology, which of the approaches described in this section do you think you would follow as a researcher in psychology? Why?

RESEARCH IN COGNITIVE PSYCHOLOGY

One thing is clear from the preceding review of the historical and theoretical perspectives: The field of cognitive psychology relies heavily on research and more broadly on observations of behavior. Throughout this text, you will review research used to develop many of the major theories within cognitive psychology. The following sections briefly review some basics of the scientific method and different research methodologies, and the chapter ends with a review of measurements commonly used in the discipline.

The Scientific Method

The **scientific method** is grounded on four core principles: empiricism, determinism, testability, and parsimony. **Empiricism** is the principle that the key to understanding new things is through systematic observation. In the case of cognitive psychology, the "things" that we want to know are the mental processes that underlie human behavior. This is tricky for most cognitive psychologists because it is difficult to directly observe mental processes. Sometimes, there are observable outcomes of these processes that are readily measured (e.g., remembering or forgetting to do something, buying cereal, selecting plastic instead of paper bags). These outcomes, however, are often assumed to be the result of a string of different mental processes. As a result, much of cognitive psychological theory is based on clever indirect measurements of these processes. **Determinism** is the principle that behaviors have underlying causes and that "understanding" involves the identification of what these causes are and how they are related to the behavior of interest. These sets of cause-and-effect relationships between variables (the "causes" and the "behaviors" that they influence) are what make up theories of behavior. **Testability** is the principle that theories must be stated in ways that allow them to be evaluated through observation. In many respects, the scientific process is a competitive one in which the predictions of different theories are like players pitted against each other and research studies are the playing field. Research consists of systematically collecting observations designed to test the predictions of multiple theories, ruling some out and leaving only those consistent with the data left standing. **Parsimony** is a kind of tiebreaker in this competition. It is the principle to prefer the simple explanations over more complex ones. If there are two or more theories left standing (accounting for the same amount of data), then adopting the least complex one is preferred (at least until further data are collected that refute the simpler theory).

Consider once again the shopping story with which we started the chapter. This story includes many behaviors that we (as cognitive psychologists) may wish to understand. Let's focus on one of them: deciding whether to take the "buy 2, get 30% off" or the "buy one get one free" deal. Our

behavior of interest here is how one makes this and other similar decisions. In the context of research, the behavior of interest is typically referred to as the **dependent variable (or response variable)**. Having identified what we want to explain, the next step is to identify which different variables might affect this dependent variable and how those effects occur. The variable you have control over and can control and manipulate is known as the **independent variable (or explanatory variable)**. The set of variables and how they are hypothesized to be related to each other is what constitutes our theory. For this example, there may be many relevant variables, but for our purposes here, let's keep it simple and just pick two: the type of deal being offered and the starting price of the product. Here, we have the choice of 30 percent off a higher-priced cereal that your family will eat or 50 percent off a lower-priced cereal that your family doesn't like.

Suppose our theory says that people make decisions based on how they frame their potential gains and losses (e.g., Sinha & Smith, 2000; Thaler, 1985). In other words, the shopper's decision may depend on whether he or she is thinking about the deal as either a gain or a reduced loss. How the deal is presented may have an impact on how shoppers view the deal. Imagine that there is a new type of cereal at the store, and you're not sure if you or your family will like it. Consider three ways of presenting what is essentially the same deal: "50% off," "buy one, get one free," and "buy 2, get 50% off" (so if you buy two boxes with an initial price of $1 each, you'll pay only $1 total with all three deals. The first case frames the deal in terms of price savings (a reduced loss), the second in terms of getting extra product (a gain), and the third is a mixture of the two. With a starting price of $1, consumers may view the potential of gaining an extra product as most important. However, if the starting price of the product is larger (e.g., $5), then consumers may change their decision-making processes in favor of reduced losses. These last statements amount to predictions or hypotheses made by the theory. The next step is to design research studies to test the predictions derived from the theory.

PHOTO 1.5 How we make decisions in our daily lives depends on a variety of different variables.

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RESEARCH METHODOLOGIES

While the following chapters describe research and theories across a broad spectrum of behaviors, the methods used can generally be classified into three approaches: case studies, correlational studies, and experimental studies.

Case Studies

A **case study** focuses on intensive analyses of a single individual or more broadly on a single observation unit (e.g., the unit of analysis for the research could be on a couple or on a single institution). Often, the focus of case studies is on unique individuals who display characteristics outside of what is considered the norm. Henry Molaison (H. M.) was one of the most studied individuals of all time. In 1953, to relieve his severe epileptic seizures, H. M. had brain surgery to remove parts of his medial temporal lobe. Following the surgery, it was revealed that H. M. had lost the ability to remember events of his life that occurred after his surgery (anterograde amnesia). H. M. was the subject of intense observation from 1957 to his death in 2008 (Squire, 2009). Theories of how memory is organized are largely based on this work.

Returning to our shopping and decision-making example, you may decide to make a case study of somebody who identifies himself as an "extreme couponer." To investigate his decision-making processes, you systematically observe his behavior over a long period, using a variety of ways to collect the observations. For example, you may directly observe him while he shops, ask him to keep detailed records of his shopping behaviors, and ask him to "think out loud" as he engages in his shopping-related decision processes. The advantage of a case study is the sheer number of intensive observations that may be collected and examined. This allows the researcher to identify many of the variables that may be relevant and to speculate about the relationships between these variables. The major disadvantage of this approach is that it centers on describing and explaining the behavior of a single, often unique, exemplar. As a result, it is often difficult to make broad generalizations of the results to other individuals.

Correlational Studies

A **correlational study** allows researchers to systematically observe groups, recording the frequency and/or intensity of many variables at once. These observations may include indirect measures such as self-report (i.e., asking the participant to report about his or her own behaviors). The key feature of this method is that researchers are attempting to collect the observations with minimal impact on the variables of interest. So in our shopping story, we might set up a camera in the cereal aisles of fifteen grocery stores and record video of customers' buying behaviors over the course of a month. As stores change prices and deals, we might record how frequently people buy the cereal. Additionally, we may wish to systematically observe other potentially relevant variables (e.g., size of boxes, time of day, gender of people). Not surprisingly, correlational studies are often analyzed using correlational procedures. Suppose, in our example, the researchers found a negative correlation between the price of cereal and the amount consumers purchased. This negative correlation simply states that as prices drop, the rate of buying tends to increase (a positive correlation would describe a relationship in which the change in the variables moves in the same direction rather than opposite directions). Data like these may be used for theory testing. For example, if our theory predicts a negative relationship between price (an explanatory variable) and the amount of buying (our response variable), then these data may be considered support for the theory. However, had the result been a positive correlation, that could be used as evidence against the theory. It is important to remember that evidence of a correlation between two variables does not mean that the relationship between them is causal. Because the researchers are just observing things as they naturally occur, determining the causal relationships between variables is extremely difficult. Thus, while correlational studies have the advantage(s) of allowing the observation of many variables at once, within relatively natural contexts, one should not make cause and effect generalizations based on these methods.

Experimental Studies

The majority of the research reviewed in this text uses an experimental approach. An **experimental study** is designed to simplify the contexts surrounding the behavior of interest, allowing for a focused investigation of the impact of a relatively small set of variables on a behavior of interest. In contrast to correlational studies, experiments intentionally involve the manipulation of variables.

Manipulated variables include both independent and control variables. Let's consider a simple example. Suppose that you want to know whether people prefer the taste of cane sugar or a sugar substitute. You design an experiment in which you ask two groups of people to taste one of the types of sweetener and then rate how much they like the taste. Then you compare the ratings of the two groups. In this example, the behavior of interest (our dependent variable) is taste, as measured by the tasters' ratings. The independent variable is which sweetener is presented to each group. However, how something tastes is complex, with many different variables influencing it (e.g., whether in food or drink, what smells are present, how the food looks). To keep your observations focused on the sweetener, you may also manipulate these other variables by keeping them constant for everybody in both groups (e.g., use lemon cookies baked using the same recipe with the only difference being the kind of sweetener used). The logic of controlling variables is to try to ensure that the only difference between the two groups is the independent variable. Thus, if a difference in the dependent variable is found between the two groups, the most likely explanation for this difference is the manipulated independent variable.

Researchers often include more than one independent variable in an experiment to allow for efficiency in examining multiple variables at once but also to be able to see how these variables *interact* to affect the dependent variable. For example, a perception researcher might be interested in how much sweetener should be added to a cola product to optimize flavor. They might manipulate the amount of sweetener and ask people to rate how much they like the cola. But suppose that the amount of sodium in the cola influences how the sweetener affects the taste, such that more sweetener tastes better with less sodium but less sweetener tastes better with more sodium. The only way a researcher will be able to determine this is to manipulate *both* sweetener and sodium in the same study. The researcher can then compare whether the high sweetener/low sodium condition is preferred to the low sweetener/high sodium condition and choose the best one for the cola product to optimize flavor. This is known as a *factorial design*.

Earlier, we described a hypothetical correlational study to examine our decision making in shopping behavior. Imagine designing an experiment to look at the same issues. From the theory outlined earlier, we may predict that the framing (focusing on reduced price or increased product) and the initial price of items will have an impact on the decision making of shoppers. To examine this hypothesis experimentally, we randomly assign people to one of four conditions (see Figure 1.1). We manipulate two different independent variables. To examine the impact of the framing variable, we provide two of the groups with products labeled "50% off" (emphasizing reducing price) and the other two groups with products labeled "buy one, get one free" (emphasizing gaining product). To examine the pricing variable, the products in one group will be given an initial price of $1, and the other group will get items priced at $5.

For our dependent variable, each participant will be asked to consider the "sale" and rate how likely they are to buy two boxes of the product. This experimental design allows us to examine three separate effects. We can examine the effect of the initial price variable and the effect of the framing of the deal variable on purchasing decisions separately. However, the design also allows us to examine how these two variables interact with one another to influence purchasing decisions. For example, consider the fictional set of data presented in Figure 1.2. We can see that the overall effect of framing was that participants had a higher likelihood of buying two boxes with the 50 percent off deal than the buy one, get one free deal. The overall effect of pricing was that participants were more likely to buy two boxes when the initial price was low. The final graph shows how these two variables interact with one another to form a more complex relationship. Here it becomes apparent that the framing effect really only has an impact when the initial price is high, with participants much more likely to buy two boxes with the 50 percent off deal than the buy one, get one free deal. However, when the initial price was low, there was no difference in likelihood between the two framing conditions.

By virtue of experimental control and the explicit manipulation of independent variables, researchers can be more confident about testing cause and effect relationships between variables. This ability to make causal inferences is the biggest advantage of using experimental approaches. However, this advantage comes at the cost of an ability to generalize to other contexts (also known as *external*

FIGURE 1.1 ■ Possible Variables in Cereal Choice: Ad Framing and Initial Price

Consider how different variables are used to frame products to influence our buying behaviors. This experimental design examines how "deals" may work by looking at the impact of price starting point and how the price change is framed.

Photo credits: Hemera Technologies/PhotoObjects.net/Thinkstock.

FIGURE 1.2 ■ Fictional Data From Framing and Pricing Experiment

The left graph shows that overall, buyers find the 50% off condition more favorable. The center graph shows that overall, buyers are more likely to purchase two boxes if the starting price was low. The right graph shows the interaction of these two effects, such that the framing effect mostly happens when the starting price is high.

validity). Because the experiment is explicitly designed to simplify the context surrounding the behavior of interest, it opens the door to the potential that the results are applicable only to those simplified contexts. In other words, one must be careful in generalizing the conclusions drawn from experiments to the more complex, naturally occurring contexts in which the behavior normally occurs.

Sometimes a complete experimental design isn't possible because we may not be in a position to truly manipulate the independent variable. For example, suppose we think that men and women may differ with respect to their decision-making behaviors when shopping. We would design an experiment like the one described earlier but add gender as an additional variable. In this example, gender is a **quasi-independent variable** because we are not actually able to manipulate our participants' gender (i.e., we can't randomly assign some people to the male condition and others to the female condition). Because gender is a preexisting characteristic, it should be treated like an explanatory variable in a correlational design. As a result, when interpreting any of the results that involve the gender variable, one needs to be appropriately conservative about making causal claims.

STOP AND THINK

1.8 What core principles is the scientific method founded on?

1.9 What are the main differences between a case study, correlational designs, and experimental designs?

1.10 What are the main advantages and disadvantages of each of the different research designs?

1.11 Consider one of the other behaviors described in the shopping example at the beginning of this chapter. Identify potential variables that may impact that behavior and then design a research study to examine how those variables are related.

COMMONLY USED MEASURES WITHIN COGNITIVE PSYCHOLOGY

In most of the examples given, the behavior of interest allowed us to observe how different variables influenced the outcome of the decision processes (how much cereal they bought). However, not all cognitive processes have such obvious, directly observable outcomes or behaviors. And even in the cases where they do, we may be interested in more than just the final outcome; we may also be interested in the mental processes as they occur (i.e., not just after a decision has been made and is then acted on). This section provides a brief introduction and review of some of the most commonly used measures in cognitive psychological research.

Our intuition tells us that we experience the world as it happens. Thinking feels very fast, and until the mid-1850s, it was generally assumed that thought moved at speeds similar to the speed of light. That, combined with the internal nature of thought (as something that goes on inside the head), led most to assume that thought was unmeasurable. That changed when von Helmholtz (1850/1853) began attaching electrical wires to the leg muscles of frogs as described earlier in this chapter. His studies established that the speed of neural transmission is substantially slower than the speed that light travels. Suddenly, the potential to measure mental processes did not seem so out of reach. Following Helmholtz's discovery, researchers began using measures like accuracy (i.e., percentage of correct responses) and response time (i.e., how fast subjects make a response to a stimulus) as indicators of mental processes.

Accuracy

Accuracy measurements are common in research designs in which there are right and wrong responses. For example, when probing how we comprehend language, participants may be asked questions about facts from a passage they read (e.g., in the shopping story, "How many light bulbs were burned out?" "What brand of cereal did the shopper end up buying?"). In a reasoning task, researchers may measure how often participants arrive at the correct solution to a target problem as a function of how similar it is to example problems. Research examining the nature of memory has a long tradition of using accuracy as a measure of mental processing. Without looking back, make a list of all the details that you can recall from our shopping example. After you've made your list, go back and compare your list with the story itself. How many details did you remember? How many details did you leave out? Memory

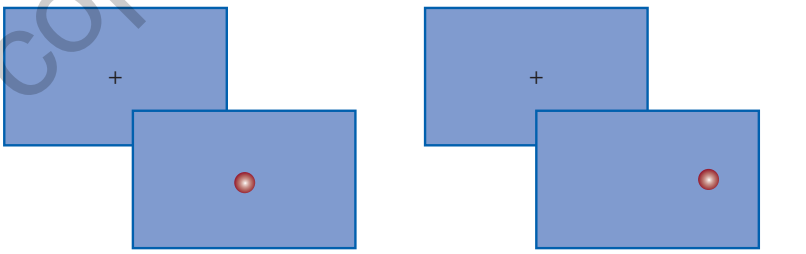
researchers have been using questions like these, about the percentage of correctly remembered details or items, for over 150 years to investigate factors that influence memory (e.g., what kinds of things you are memorizing, the time between learning and testing, what sort of study you do when trying to memorize things).

However, accuracy isn't always just about how many items you can correctly recall; it can also be about the number and kinds of errors you make. Bartlett (1932) reported a series of experiments he conducted in which he presented British students with a brief Native American folktale and later tested their memories for details from the story. Bartlett discovered that their memories were dramatically influenced by their own cultural experiences and stereotypes. This was primarily evidenced by the memory distortion errors his participants made. Consider, too, the case of eyewitness testimony. When witnesses are asked to recall details of an event, some of the details they "remember" are often not accurate. Research examining how and why people have these "false memories" has greatly shaped our theories explaining how memory works.

Response Time

Another widely used method to examine cognitive processes is to measure how long it takes to respond to a stimulus. One of the earliest and most influential sets of experiments was conducted by Franciscus Donders (1969/1868). Donders developed a response time technique called the subtractive method to examine cognitive processing (Figure 1.3). His technique combined two measurements from two slightly different tasks. In the first task (simple response time procedure), he measured the time it took for a person to respond to a simple stimulus (e.g., push the button when you see a light). The second task was similar, but instead of having a single button to press, there were multiple lights and buttons. If the left light came on, the person was to press the left button, and if the right light came on, then the right button (choice response time procedure). Having multiple lights and buttons required the same set of processes needed in the simple response time procedure but also required discrimination (left or right light) and decision (left or right button) processes. Donders's methodology assumes that components of mental processes are strictly discrete and serial. That is, each stage operates separately and in sequence. With these assumptions, one may subtract the response times of the first task from the response times of the second task, leaving a measurement of the time required to perform discrimination and choice.

FIGURE 1.3 ■ Donders's (1969/1868) Subtraction Methodology



Simple Reaction Time
Press the button when you see the light.

Choice Reaction Time
Press a button when you see the light, which button depends on where the light was located ("a" for left, "l" for right).

In the years since Donders's experiments, response time procedures have become more sophisticated. Not all of the underlying assumptions of his task have turned out to be true. However, the same basic underlying logic that mental processes are measurable is still present in the bulk of cognitive psychology research. Consider two popular paradigms currently used in cognitive psychology laboratories: priming and eye movement studies.

Priming tasks are pervasive in the field of cognitive psychology (typing "priming" into the search field of an article database yields thousands of articles). In a typical priming task, participants respond to a series of stimuli (e.g., "Press the right button if the string of letters is a real word. Press the left button if the string of letters is not a real word."). Embedded within the list of stimuli are sets of paired trials, the first of which is called the "prime" and the second the "target." Researchers are typically interested in how quickly participants respond to the target stimuli when it follows a related prime compared to when it follows an unrelated prime. For example, suppose the target is the word DOCTOR and it is preceded by either the word NURSE (related) or BREAD (unrelated). Typically, participants would respond faster to DOCTOR when NURSE precedes it than when it is preceded by BREAD (Meyer & Schvaneveldt, 1971). Following logic similar to that proposed by Donders, this difference in reaction time between the two conditions is thought to reflect cognitive processing differences.

After reading the previous examples, you might have the impression that all response time studies focus on button pressing. That isn't the case. Throughout this textbook, you'll see a wide variety of response time measurements involving other behaviors (e.g., naming times, reaching times, recognition judgments). Recently, monitoring eye movements has become a popular behavioral measurement in cognitive psychology. Our eyes are constantly jumping around, moving from one fixation (keeping still with one thing in focus for 200–350 milliseconds) to another. The fundamental assumption with this methodology is that there is a tight coupling between the eyes and the mind. In other words, we think about what we look at, and how long we look at something reflects underlying mental processing. Initial interest in using eye movements to measure cognition focused on attempts to understand the processes involved in reading. However, recent technological advancements have led to an explosion of the use of eye movements to address research questions across a wide range of cognitive psychology subdomains (e.g., spoken language comprehension, language production, attention and visual search, scene perception). Similar to the work with the button-pressing method discussed earlier, researchers typically compare how long participants fixate on stimuli from different experimental conditions to test their theories.

Beyond Accuracy and Response Time

While much of the research that you will read about in the following chapters reports dependent variables using either response time or accuracy alone, many other measures are used as well. Think of your own experiences. When you try to do something very quickly, your error rate increases; as a task gets harder, your performance may get slower and you make more errors. Some research focuses on this tight tradeoff between speed and accuracy (e.g., Kahana & Loftus, 1999; Meyer et al., 1988). Other research focuses not on the time taken to initiate a response but rather on other characteristics (e.g., duration, velocity, direction of movement) of responses (e.g., Abrams & Balota, 1991).

Within the rapidly growing field of cognitive neuroscience, recent technological advances in brain imaging techniques have led to the development of brain visualization measures. For example, using methods like electroencephalography (EEG) and functional magnetic resonance imaging (fMRI), researchers are able to "watch" the neural activity of the brain while it is processing information. We describe some of these procedures in greater detail in Chapter 2. Often these new techniques are combined with the old standbys of accuracy and response time to gain new insights into the nature of mental processing (e.g., Posner, 2005).

One thing to keep in mind with nearly all these measures is that they are indirect measurements. Regardless of whether we are examining response times (e.g., to push a button, read a sentence, or stare at an object), accuracy measures (e.g., how often we arrive at the correct solution to a problem or remember all the items from a list), or brain activity within a particular region, in all cases, we are measuring something we assume to be correlated with the cognitive processes, not the processes themselves. Given this, you should always critically evaluate the assumed connection between the behavior measured and the cognitive process being tested.

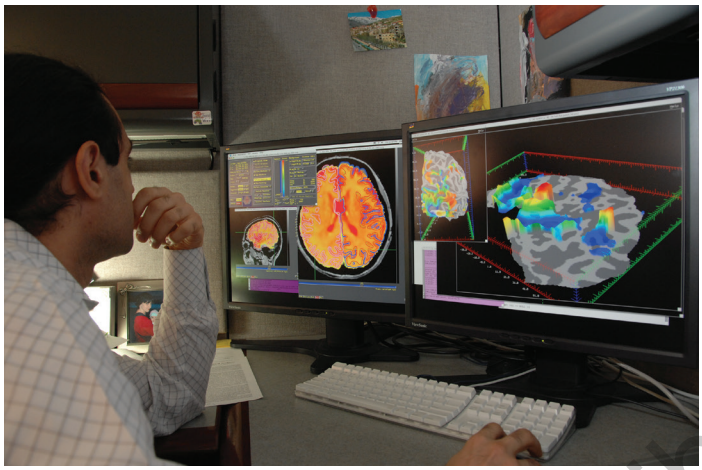


PHOTO 1.6 Brain imaging techniques like fMRI allow researchers to observe areas of the brain as they function during experiments.

National Institute of Mental Health

STOP AND THINK

1.12 What are two commonly used dependent measures in cognitive psychology?

1.13 Briefly explain the logic used in Donders's subtractive method.

1.14 Think back to the shopping story that started the chapter. Suppose that you were interested in studying how the shopper understood the bagger's question, "Paper or plastic?" How might you design a study to investigate this issue?

THINKING ABOUT RESEARCH

As you read the following summary of a research study in psychology, think about the following questions:

1. Which approach to the study of cognition is being used in this study?
2. What type of research design are the researchers using in this study?
3. What is the independent variable in this study?
4. What is the dependent variable in this study?

Study Reference

Ward, E. V., Berry, C. J., Shanks, D. R., Moller, P. L., & Czsiser, E. (2020). Aging predicts decline in explicit and implicit memory: A life-space study. *Psychological Science, 31*, 1071–1083.

Purpose of the study: Because methods and results have differed in past studies that examined implicit (automatic) and explicit (intentional) memory across the lifespan, the purpose of this study was to measure these forms of memory for a large sample of individuals with ages ranging from 12 to 82 years. Memory tasks were chosen such that instructions differed across the two types of memory test but the tests were otherwise very similar. The researchers' goal was to clarify past results showing declines in explicit memory and unclear changes in implicit memory across the lifespan.

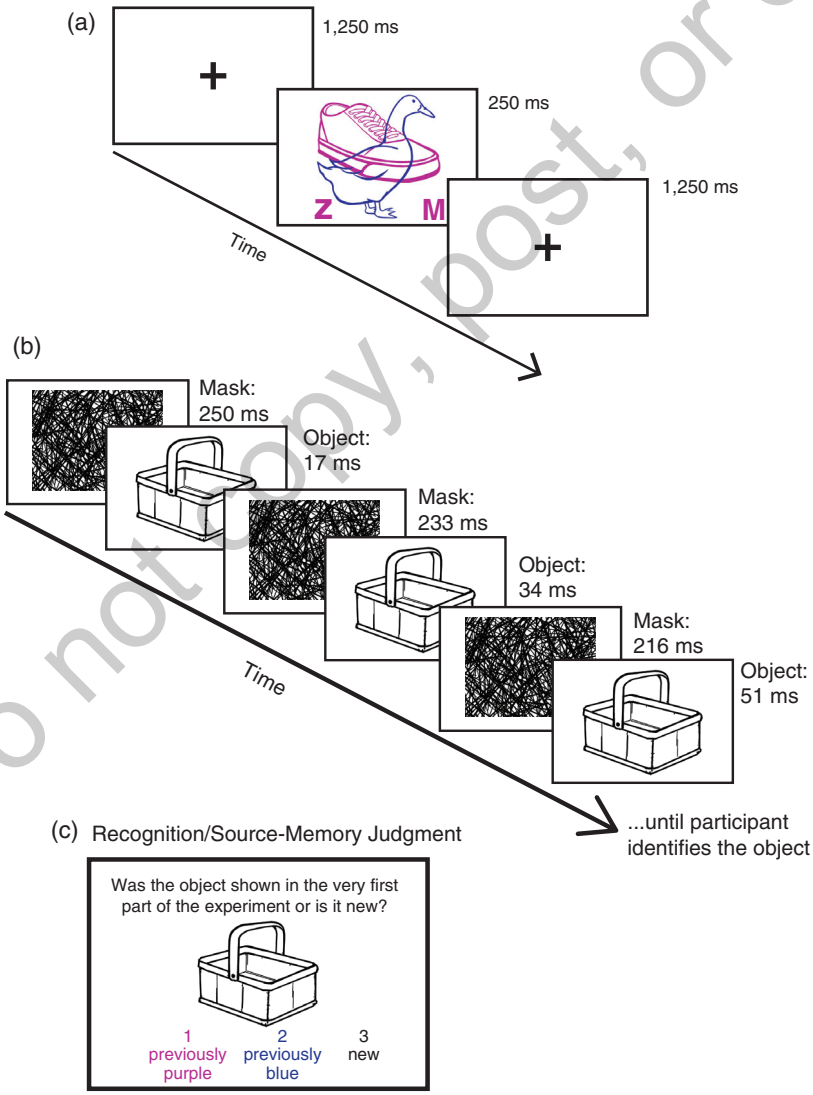
Method of the study: Participants were 1,072 visitors to a science museum in the United Kingdom. They were classified by age into six groups: 12–17 years, 18–24 years, 25–34 years, 35–49 years, 50–64 years, and 65–82 years. Participants studied sets of overlapping objects, with each object in the set presented in a different color (see top panel of Figure 1.4). They were told to pay attention to one of the colors (either purple or blue) and ignore objects presented in the other color during presentation. They also performed one of two tasks during the presentation: (a) Decide if the attended to object was natural or manufactured (press Z key for natural; M key for manufactured) or (b) determine if the attended to object was angled or round. In Figure 1.4a, a blue goose and a purple shoe are presented at the same time.

About 3 minutes after the study presentation, the participants began the test trials. On each test trial, they completed identification (implicit memory task), recognition (explicit memory task), and source (explicit memory task) judgments. For the identification judgments, an object was shown (either studied or new) for a very brief time (17 milliseconds) followed by a jumbled screen (also called a "mask") to prevent afterimages. The object was displayed again for a slightly longer period of time (34 milliseconds) and then the jumbled screen appeared. This process continued (with the object displayed for increasing periods of time) until the participant indicated they could identify the object (see the middle panel of Figure 1.4). Then they judged whether the object had been seen in the study portion (it could have been attended to not attended to) and then which color the object was presented in if it was an object they had studied (see the bottom panel of Figure 1.4).

Results of the study: The results showed that memory performance declines in older age for both implicit and explicit tasks, particularly for the participants over age 50 years (as shown in Figure 1.5). These results apply to the attended to objects during a study. Unattended to objects had memory scores similar to chance across all age groups, suggesting that these objects were not encoded when attention was not paid to them during a study. The study task (natural vs. manufactured or angled vs. round) did not affect memory scores.

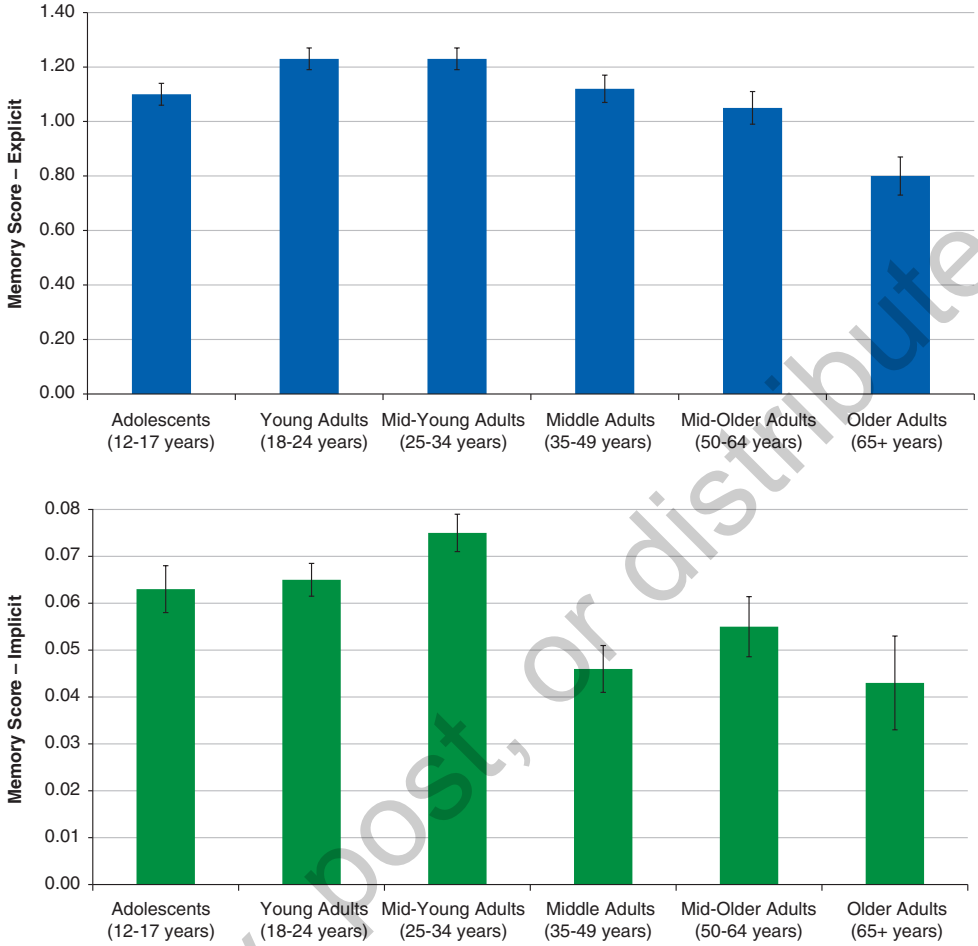
Conclusions of the study: The results of the study clarified mixed findings from past studies in showing clear age-related declines in implicit memory performance in older age. These results suggest that implicit and explicit memory have more similarities with respect to change over the lifespan than previously thought.

FIGURE 1.4 ■ Stimulus Materials Used by Ward et al.



Source: Adapted from Ward et al. (2020, Figure 1). Licensed under CC-BY 4.0, https://creativecommons.org/licenses/by/4.0/.

FIGURE 1.5 ■ Mean Memory Scores as a Function of Type of Test and Age Group



Source: Adapted from Ward et al. (2020, Figure 2). Licensed under CC-BY 4.0, https://creativecommons.org/licenses/by/4.0/.

CHAPTER REVIEW

- **What is cognitive psychology? How did it develop as a field?**

  Cognitive psychology is the study of how our minds receive, store, and use information. This includes theory and research about perception, attention, memory, language use, decision making, and problem solving. The roots of the discipline may be traced to philosophy and physiology before the twentieth century. However, modern cognitive psychology primarily developed since the mid-twentieth century. This was in part a reaction to the behaviorist tradition within psychology but also is a reflection of developments within other disciplines, including biology, linguistics, and computer science.

- **How have psychologists approached the study of cognition?**

  Explanations of cognitive processes have been developed within three general approaches: representationalist, embodied, and biologically motivated. Representationalist theories of cognition generally view the mind as a symbolic processor, similar to a computer. In these views, information is conceptualized as abstract representations that may be acted on by mental operations. Embodied approaches envision the mind as something situated within a body and an environmental context. These approaches examine cognition as interactions between individuals

and their environment. Biologically motivated approaches to cognition focus on theories based on neurologically inspired elements.

- **What types of research methods are useful in the study of cognition?**

  Three main types of research designs are employed in research in cognition: (1) case studies that focus on the behaviors of a distinct individual or group, (2) correlational studies that examine relationships between sets of dependent (or response) variables, and (3) experiments that test causal relationships between variables through the manipulation of independent variables and control of the conditions under which the dependent (or response) variables are measured. Researchers may also use quasi-independent variables (group subjects based on a particular characteristic, such as gender or age) to compare groups for the dependent variable when manipulation of a variable is not possible.

- **What behaviors do psychologists observe to study cognition?**

  There is a range of behaviors studied by cognitive psychologists. A common measure is accuracy for a task (such as memory or perceptual judgments). Another common measure is the speed to complete a task (such as identify a word or solve a problem). There are also behaviors specific to an area of cognitive psychology (such as the measurement of brain activity in cognitive neuroscience).

CHAPTER QUIZ

1. Enter the letter for the approach to the study of cognition next to its corresponding definition below:
   - **a.** representationalism
   - **b.** embodied cognition
   - **c.** biologically motivated models

   ___ describe cognitive processes in a similar fashion to the physiological functioning of the brain

   ___ describe cognitive processes as operating on knowledge concepts represented in our minds

   ___ describe cognitive processes as the interplay between the body and the environment

2. Which core principle of the scientific method involves the identification of the underlying causes of behavior?
   - **a.** empiricism
   - **b.** determinism
   - **c.** parsimony
   - **d.** testability

3. Which core principle of the scientific method involves the assumption that simpler explanations of behavior are preferred?
   - **a.** empiricism
   - **b.** determinism
   - **c.** parsimony
   - **d.** testability

   Use the following study description to answer questions 4 through 7:

   A researcher is interested in examining the relationship between one's actual memory abilities and one's perception of how good his or her memory abilities are. Subjects in this study are given a study list of words and asked to remember these words after a short delay. They are also given a questionnaire and asked how good the subject thinks his or her memory is, where a high score means the subject thinks he or she has high memory abilities. The researcher finds a small but positive relationship between the memory test scores and the questionnaire scores.

4. What type of research design is used in this study?
   a. experiment
   b. case study
   c. correlational study
5. Explain how you know which research design is being used.
6. Which of the following are dependent (response) variables in this study? (Choose all that apply.)
   a. The delay between the study list and the memory test
   b. The score on the questionnaire
   c. The score on the memory test
   d. The number of words in the study list
7. *The results indicated a positive relationship between the variables that were measured*. Explain what this means.
8. In what way does an experiment differ from other research designs?
9. What is the key difference between an independent variable and a quasi-independent variable?
10. The measure used by researchers that indicates the speed with which someone completes a task is known as
    a. accuracy
    b. reaction time
    c. self-report
    d. an independent variable
11. What are two "metaphors of the mind" that have influenced the development of theories of cognition?
12. What are two developments that led to a rapid expansion of the field of cognitive psychology after the mid-twentieth century?
13. Describe Donders's experiments and explain how they propose to measure cognitive processes.

KEY TERMS

Behaviorist (p. 4)
Biological perspective (p. 7)
Case study (p. 10)
Correlational study (p. 10)
Dependent variable (response variable) (p. 9)
Determinism (p. 8)
Embodied cognition (p. 7)
Empiricism (p. 8)
Experimental study (p. 10)
Independent variable (explanatory variable) (p. 9)
Introspection (p. 3)
Metacognition (p. 3)
Parsimony (p. 8)
Priming (p. 15)
Psychophysics (p. 3)
Quasi-independent variable (p. 13)
Representationalist (p. 6)
Scientific method (p. 8)
Testability (p. 8)