1 Introduction to Cognitive Psychology

Some Questions We Will Consider

- How is cognitive psychology relevant to everyday experience? (2)
- Are there practical applications of cognitive psychology? (2)
- How is it possible to study the inner workings of the mind, when we can't really see the mind directly? (7)
- What is the field of cognitive psychology? (16)

Sarah is walking across campus. She stops for a moment to talk with a friend about the movie they saw last night. She can't talk for long because she has an appointment to plan her schedule for next term, so she says good-bye and heads off toward her advisor's office.

This minor event in Sarah's life is just one occurrence on a typical day. But if we stop for a moment to consider what's involved in this simple sequence of events, we see that beneath the simplicity lies mental processes such as the following:

- *Perception.* Sarah is able to find her way through campus, recognize her friend, and hear her speak.
- *Attention.* As she walks across campus, she focuses on only a portion of her environment, but seeing her friend captures her attention.
- *Memory.* Sarah remembers her friend's name, that she has an appointment, and how to find her way to her advisor's office. She finds it interesting that although she and her friend saw the same movie, they remember different things about it.
- *Language.* She talks with her friend about the movie they saw last night.
- *Reasoning and decision making.* Sarah needs to decide which courses to take and, soon, what to do after graduation. Should she go to graduate school or start looking for a job?

Not only is it easy to provide examples of cognition in everyday experience, but it is also easy to find examples in the news.

- *Perception.* Thousands of deaf people have had a cochlear implant operation that enables them to hear. Researchers are also working to develop devices that would provide sight to the blind.
- *Attention.* Researchers testify at a hearing of the New York State legislature that cell phones distract attention from driving. The legislature agrees and bans the use of cell phones while driving in New York (see http://www.nysgtsc.state.ny.us/ts-place.htm).
- *Memory.* Memory researchers search for ways to prevent the memory losses that are associated with aging. Also, research studies show that a large number of innocent people have been convicted of crimes based on faulty memory by eyewitnesses at crime scenes.
- *Problem solving and reasoning.* Experts ponder evidence to determine the cause of the disintegration of the space shuttle *Columbia* as it reentered the atmosphere on February 1, 2003.

Each of the items on the preceding lists are aspects of **cognition**—the mental processes that are involved in perception, attention, memory, problem solving, reasoning, and making decisions. **Cognitive psychology** is the branch of psychology concerned with the scientific study of cognition.

The Challenge of Cognitive Psychology

How can we go beyond simply labeling different aspects of cognition, as we did for Sarah's walk across campus and the examples of cognition in the news? One approach would be to apply common sense and everyday observation to cognitive phenomena. This might lead to observations about things such as techniques that work for studying, for remembering what to do later in the day, or for solving certain types of problems. It might also lead us to conclude that cognitive tasks that we carry out almost effortlessly, such as perceiving forms or colors or paying attention to important things in the environment, are so straightforward and simple that there is little to study about how they operate. But before we decide that cognition is either obvious or simple, we should consider the following observation by memory researcher Endel Tulving (2001): "Much of science begins as exploration of common sense, and much of science, if successful, ends if not in rejecting it, then at least going far beyond it" (p. 1505).

Tulving's statement is what this book is about—how science has refined and expanded on our everyday explanations of cognition based on common sense. As we explore this idea, we will see that many of the processes involved in cognition are complex and often hidden from view.

The Complexity of Cognition

Many of the cognitions we listed to describe Sarah's behavior occurred without much effort on her part. She easily perceived the scene around her and recognized her friend. It took a little more effort to remember some of the details of the movie she saw the night before, but she also accomplished this without much difficulty. However, when cognitive psychologists look more closely at processes such as these, they find that beneath this ease and apparent simplicity lie complexities that may not be initially obvious.

To illustrate some of these complexities, let's consider attention. As Sarah walked through campus, her eyes were flooded with images, but she attended closely to just a few. Thus, as she waved to her friend (Figure 1.1), she was hardly aware of the woman with the scarf, even though she was clearly visible. This situation enables us to pose the following question: Even though both people are clearly present in Sarah's field of view, what causes her to be very aware of her friend, but hardly aware of the other person?

Here's another example from everyday experience: Have you ever returned to a place after many years away, and remembered things you hadn't thought about for years? When I asked students in my class to write about an experience that involved memory, one of my students related the following experience.

> When I was eight years old, both of my grandparents passed away. Their house was sold, and that chapter of my life was closed. Since then I can remember general things about being there as a child, but not the details. One day I decided to go for a drive. I went to my grandparents' old house, and I pulled around to the alley and parked. As

■ **Figure 1.1** As Sarah waves to her friend, she is only slightly aware of the woman wearing the scarf, even though that woman is clearly visible.


Bruce Goldstein

> I sat there and stared at the house, the most amazing thing happened. I experienced a vivid recollection. All of a sudden, I was eight years old again. I could see myself in the backyard, learning to ride a bike for the first time. I could see the inside of the house. I remembered exactly what every detail looked like. I could even remember the distinct smell. So many times I tried to remember these things, but never so vividly did I remember such detail. (Angela Paidousis)

Angela's experience demonstrates that although it is sometimes difficult to remember things, returning to the place where the memories were originally formed can reveal memories that were there all along. These examples illustrate that experiences such as attention and memory (and other cognitions, as well) involve "hidden" processes we may not be aware of. One way of thinking about these hidden processes is to draw an analogy between what happens as an audience watches a play at the theater and how the mind works. At a play, the audience's attention is focused on the drama being created by the actors, but there is a great deal of activity backstage that the audience is unaware of. Some actors are changing costumes, others are listening for their cues, and stagehands are moving sets into place for the next scene change. Just as a great deal of activity occurs backstage in a play, a great deal of "backstage" activity occurs in your mind.

One of the goals of this book is to show you how cognitive psychologists have revealed the hidden processes that occur "behind the scenes." This chapter tells the beginning of a story of cognitive psychology research that began over 100 years ago, even before the field of psychology was formally founded. To give us perspective on where cognitive psychology is today, it is important to see where it came from, and so we will begin by describing some of the pioneering research on the mind that began in the 19th

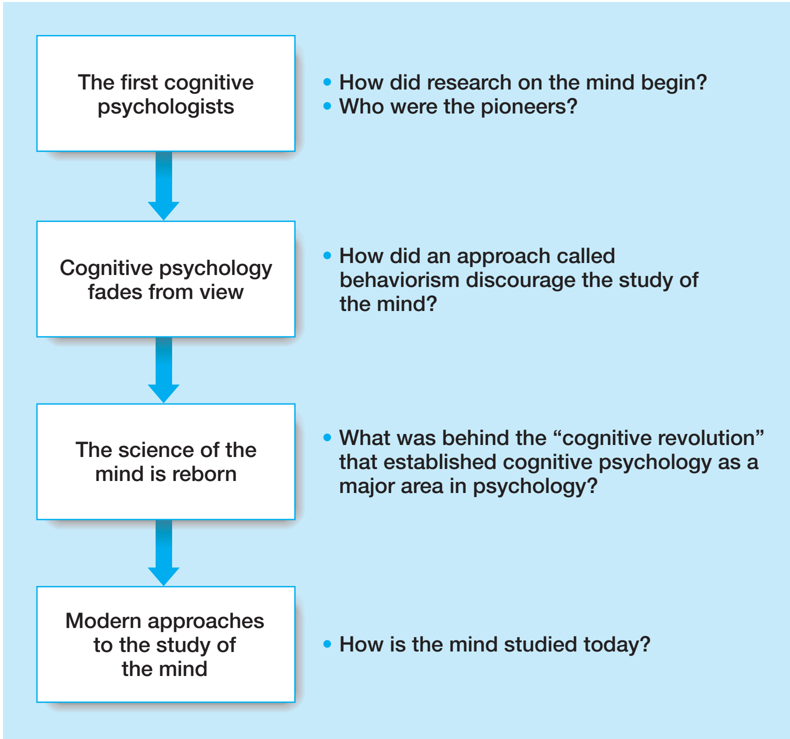


Figure 1.2 Flow diagram for this chapter.

century (Figure 1.2). We then consider the first half of the 20th century, when studying the mind became unfashionable; the second half of the 20th century, when the study of the mind began to flourish again; and how psychologists and researchers in other fields approach present-day research on the mind.

The First Cognitive Psychologists

Cognitive psychology research began in the 19th century before there was a field called cognitive psychology—or even, for that matter, psychology. In 1868, eleven years before the founding of the first laboratory of scientific psychology, Franciscus Donders, a Dutch physiologist, did one of the first cognitive psychology experiments.

Donders' Reaction-Time Experiment Donders conducted research on what today would be called **mental chronometry**, measuring how long a cognitive processes takes. Specifically, he was interested in how long it took for a person to make a decision. He determined this by using a measure called *reaction time*.

Method

Reaction Time

Reaction time—the interval between presentation of a stimulus and a person's response to the stimulus—is one of the most widely used measures in cognitive psychology. One reason for its importance is that measuring the speed of a person's reaction can provide information about extremely rapid processes that occur in the mind.

Reaction time is typically measured by presenting a stimulus and having a participant respond by pressing a button or a key on a computer keyboard as soon as the participant has completed a task. Tasks can range from simply indicating that the stimulus was presented ("Press the button when you see the light"), to making a decision about stimuli ("Press the key if the letters you see form a word" or "Press Key #1 if the statement is true and Key #2 if it is false"). In each of these cases, reaction time can provide insights into the nature of mental processing involved in these tasks.

Donders measured the reaction time to perceiving a light. In the **simple reaction-time** task there was one location for the light, and participants pushed a button as quickly as possible after the light was illuminated (Figure 1.3a). In the **choice reaction-time** task, the light could appear on the left or on the right, and the participants were to push one button if the light was illuminated on the left, and the other button if the light was illuminated on the right (Figure 1.3b).

The rationale behind the simple reaction-time experiment is shown in Figure 1.4a. Presenting the stimulus (the light) causes a mental response (perceiving the light), which leads to a behavioral response (pushing the button). The reaction time (dashed line) is the time between presentation of the stimulus and the behavioral response.

(a) Press J when light goes on.

(b) Press J for left light, K for right.

Figure 1.3 A modern version of Donders' (1868) reaction-time experiment: (a) the simple reaction-time task; and (b) the choice reaction-time task. For the simple reaction-time task, the participant pushes the J key when the light goes on. For the choice reaction-time task, the participant pushes the J key if the left light goes on, and the K key if the right light goes on. The purpose of Donders' experiment was to determine the time it took to decide which key to press for the choice reaction-time task.

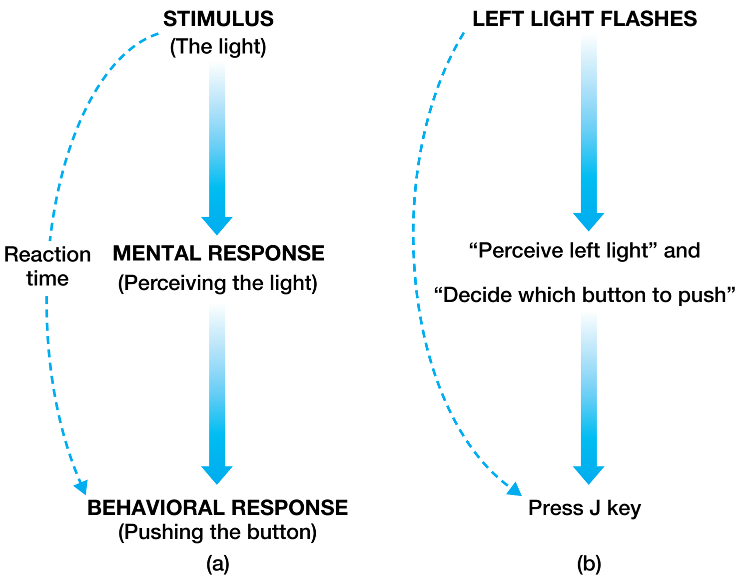
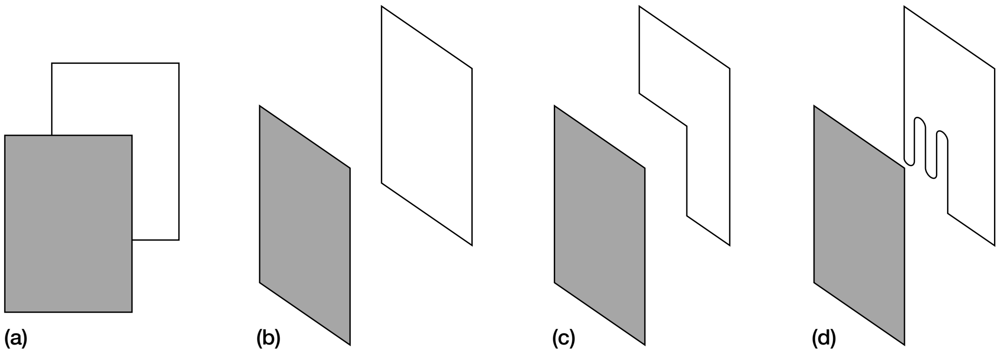


Figure 1.4 Sequence of events between presentation of the stimulus and the behavioral response in Donders' experiment. The dashed line indicates that Donders measured reaction time, the time between presentation of the light and the participant's response. (a) Simple reaction-time task; (b) choice reaction-time task.

In Figure 1.4b, a similar diagram for the choice reaction-time experiment, the mental response includes not only perceiving the light but also deciding which light was illuminated and then which button to push. Donders reasoned that choice reaction time would be longer than simple reaction time because of the time it takes to make the decision. Thus, the difference in reaction time between the simple and choice conditions would indicate how long it took to make the decision. Because the choice reaction time took one-tenth of a second longer than simple reaction time, Donders concluded that it took one-tenth of a second to decide which button to push.

Donders' experiment is important both because it was one of the first cognitive psychology experiments, and because it illustrates something extremely important about studying the mind—mental responses (perceiving the light and deciding which button to push, in this example) cannot be measured directly, but must be inferred from the participants' behavior. We can see why this is so by noting the dashed lines in Figure 1.4. These lines indicate that when Donders measured the reaction time, he was measuring the relationship between the presentation of the stimulus and the participant's response. He did not measure the mental response directly, but inferred how long it took from the reaction times. The fact that mental responses can't be measured directly, but must be inferred from observing behavior, is a principle that holds not only for Donders' experiment, but for all research in cognitive psychology.

Helmholtz's Unconscious Inference Hermann von Helmholtz was another 19th-century researcher who was concerned with studying the mind. Helmholtz, who was professor of physiology at the University of Heidelberg (1858) and professor of physics at the



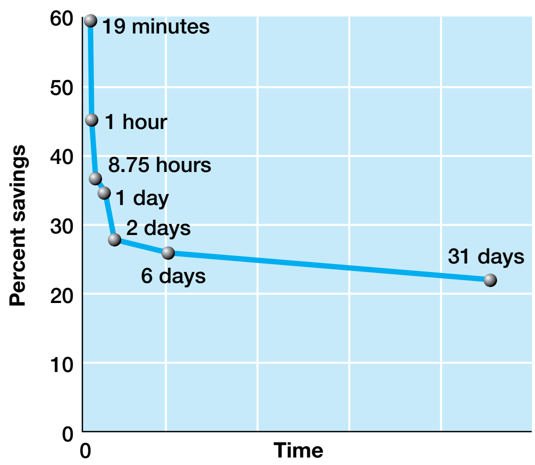
■ **Figure 1.5** The display in (a) looks like (b) a gray rectangle in front of a light rectangle; but it could be (c) a gray rectangle and a six-sided figure that are lined up appropriately or (d) a gray rectangle and a strange-looking figure that are lined up appropriately.

University of Berlin (1871), was one of the preeminent physiologists and physicists of his day. He made basic discoveries in physiology and physics, and also developed the ophthalmoscope (the device that an optometrist or ophthalmologist uses to look into your eye) and proposed theories of object perception, color vision, and hearing.

One of the conclusions Helmholtz reached from his research on perception is a principle called the theory of **unconscious inference**, which states that some of our perceptions are the result of unconscious assumptions that we make about the environment. For example, consider Figure 1.5a. This display could be caused by one rectangle overlapping another (Figure 1.5b), or by a six-sided shape positioned to line up with the upper-right corner of the gray rectangle (Figure 1.5c), or a rectangle overlapping a strange shape (Figure 1.5d). However, according to the theory of unconscious inference, we infer that we are seeing a rectangle covering another rectangle because of experiences we have had with similar situations in the past. This inference is called unconscious because it occurs without our awareness or any conscious effort. Helmholtz's idea that we infer much of what we know about the world was an early statement of what is now considered to be a central principle of modern cognitive psychology.

Ebbinghaus's Memory Experiments Hermann Ebbinghaus (1885) performed his classic experiments on memory by learning lists of nonsense syllables like DAX, QEH, LUH, and ZIF. He used nonsense syllables so that his memory would not be influenced by the meaning of a particular word. He read lists of these syllables out loud to himself over and over and determined how many repetitions it took to repeat the lists with no errors. This initial learning is the first step in the **savings method**.

Ebbinghaus then waited a period of time and relearned the list using the same procedure. For short intervals between initial learning and relearning, it usually took fewer repetitions to relearn the list than it had taken him to initially learn it. For example, if Ebbinghaus had to repeat the list 9 times to initially learn it, it might take only 3 repeti-



■ **Figure 1.6** Ebbinghaus's retention curve, determined by the method of savings. (Based on data from Ebbinghaus, 1885.)

tions to relearn the list after a short interval. Based on this data, he calculated a savings score, using the following formula:

Savings = [(Initial repetitions) − (Relearning repetitions)] / Initial repetitions.

Multiplying the result by 100 converts the savings to a percentage, so for the example above,

Savings = [(9 − 3) / 9] × 100 = 67 percent.

By learning many different lists at retention intervals ranging from 19 minutes to 31 days, Ebbinghaus was able to plot the "forgetting curve" in Figure 1.6, which shows savings as a function of retention interval. Ebbinghaus's experiments were important because they provided a way to quantify memory and therefore plot functions like the forgetting curve that describe the operation of the mind. Notice that although Ebbinghaus's savings method was very different from Donders' reaction-time method, they have something in common: They both measure *behavior* to determine a property of the *mind*.

The First Psychology Laboratories People like Donders, Helmholtz, and Ebbinghaus, who were investigating the mind in the 19th century, were usually based in departments of physiology, physics, or philosophy, because there were no psychology departments at the time. But in 1879 Wilhelm Wundt founded the first laboratory of scientific psychology at the University of Leipzig, with the goal of studying the mind scientifically. He and his students carried out reaction-time experiments and measured basic properties of the senses, particularly vision and hearing.

The theoretical approach that dominated psychology in the late 1800s and early 1900s was called **structuralism**. According to structuralism, our overall experience is determined by combining basic elements of experience called sensations. Thus, just as