CHAPTER

6

Memory

OVERVIEW

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Most of us remember certain days or moments more distinctly than others. Your first day of school, your first kiss, a special holiday, the loss of a loved one—these experiences may be etched so indelibly on your memory that it seems that they happened just yesterday, rather than many years in the past. But imagine if you had a distinct memory of not only your first day of school, but of the second one, too; as well as the third, fourth, fifth, and so on. Imagine if you recalled not just the most important events of your life, but, in addition, all of the tiny, insignificant details of each and every day: what the weather was like, what you ate for dinner, what you watched on television. Imagine these visions of the past—some ordinary and mundane, some comforting and pleasant, others, terribly painful and sad—ran through your head in a constant loop, a random compilation of all of the moments of your life assaulting your consciousness with ceaseless persistence. Jill Price, a 42-year-old woman who lives in California, need not imagine such a scenario; for Jill Price, this is life.

In her 2008 memoir, *The Woman Who Can't Forget,* Jill Price recounts a life lived with what psychologist James L. McGaugh has diagnosed as hyperthymestic syndrome, or "overdeveloped memory." If given a date over the course of the past thirty years, Price can typically recount what day of the week it was in addition to details about something that happened to her that day. Moreover, according to Price, autobiographical memories, unpredictably summoned by various stimuli—a familiar smell, for example, or a song on the radio—constantly dominate her thoughts in a mechanism beyond her conscious control. As Price contends, her unusual powers of memory are more a burden than a blessing, forcing her to relive every argument, every disappointment, every moment of despair she has ever known at arbitrary intervals. Indeed, as Price's case illustrates, while the ability to remember has its merits, so too, it seems, does the ability to forget.

Accounts of people with extraordinary memories raise many questions about the nature of **memory** itself: Why are some people so much better at remembering things than others? Why is it that remembering may sometimes be so simple (think how effortlessly baseball fans remember the batting averages of their favorite players) and other times so difficult (as when we grope for answers on an exam)? Just how does memory work, and what makes it fail?

Among the first to seek scientific answers to these questions was the 19th-century German psychologist Hermann Ebbinghaus. Using himself as a subject, Ebbinghaus composed lists of "nonsense syllables," meaningless combinations of letters, such as PIB, WOL, or TEB. He memorized lists of 13 nonsense syllables each. Then, after varying amounts of time, he relearned each list of syllables. He found that the longer he waited after first learning a list, the longer it took to learn the list again. Most of the information was lost in the first few hours. Ebbinghaus's contributions dominated memory research for many years.

Many contemporary psychologists, by contrast, perceive memory as a series of steps in which we process information, much as a computer stores and retrieves data (Ashcraft, 2006). Together, these steps form the **information-processing model** of memory. In this chapter you will find terms like *encoding*, *storage*, and *retrieval*, which are convenient ways of comparing human memory with computers. But we will also consider the social, emotional, and biological factors that make us human and that also distinguish our memories from those of computers.

Far more information bombards our senses than we can possibly process, so the first stage of information processing involves selecting some of this material to think about and remember. Therefore, we turn first to the sensory registers and to attention, the process that allows us to select incoming information for further processing.

Enduring Issues in Memory

In this chapter, we will again encounter the "Enduring Issues" in psychology that were introduced in Chapter 1. We will explore the biological bases of memory (mind–body), the ways that memory differs among people and across cultures (diversity–universality), and the ways that memory changes in the first few years of life (stability–change). Finally, we will consider the extent to which memories can be changed by events outside the person as well as the importance of environmental cues in triggering memories (person–situation).

LEARNING OBJECTIVES

- **Describe the role of the sensory registers and the length of time information remains there. Distinguish between the *icon* and the *echo*.**
- **Compare Broadbent and Treisman's theories of attention. Explain what is meant by the "cocktail-party phenomenon" and "inattentional blindness."**

THE SENSORY REGISTERS

What is the role of sensory registers?

Look slowly around the room. Each glance takes in an enormous amount of visual information, including colors, shapes, textures, relative brightness, and shadows. At the same time, you pick up sounds, smells, and other kinds of sensory data. All of this raw information

memory The ability to remember the things that we have experienced, imagined, and learned.

information-processing model A computer-like model used to describe the way humans encode, store, and retrieve information.

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If you were to walk into this room, your eyes and your other sense organs would pick up many impressions of what is to be found here. How much of this information would you remember later?

flows from your senses into the **sensory registers**, which are like waiting rooms in which information enters and stays for only a short time. Whether we remember any of the information depends on which operations we perform on it, as you will see throughout this chapter. Although there are registers for each of our senses, the visual and auditory registers have been studied most extensively.

Visual and Auditory Registers

What would happen if auditory information faded as quickly as visual information fades?

Although the sensory registers have virtually unlimited capacity, information disappears from them quite rapidly (Cowan et al., 2005; Melcher, 2006; Rainer & Miller, 2002). A simple experiment can demonstrate how much visual information we take in—and how quickly it is lost. Bring a digital camera into a darkened room, and then take a photograph with a flash. During the split second that the room is lit up by the flash, your visual register will absorb a surprising amount of information about the room and its contents. Try to hold on to that visual image, or *icon*, as long as you can. You will find that in a few seconds, it is gone. Then compare your remembered image of the room with what you actually saw, as captured in the photograph. You will discover that your visual register took in far more information than you were able to retain for even a few seconds.

Classic experiments by George Sperling (1960) clearly demonstrate how quickly information disappears from the visual register. Sperling flashed groups of letters, organized into three rows, on a screen for just a fraction of a second. When the letters were gone, he sounded a tone to tell his participants which row of letters to recall: A high-pitched tone indicated that they should try to remember the top row of letters, a low-pitched tone meant that they should recall the bottom row, and a medium-pitched tone signaled them to recall the middle row. Using this *partial-report technique*, Sperling found that if he sounded the tone immediately after the letters were flashed, people could usually recall 3 or 4 of the letters in *any* of the three rows; that is, they seemed to have at least 9 of the original 12 letters in their visual registers. But if he waited for even 1 second before sounding the tone, his participants were able to recall only 1 or 2 letters from any single row—in just 1 second, then, all but 4 or 5 of the original set of 12 letters had vanished from their visual registers.

Visual information may disappear from the visual register even more rapidly than Sperling thought (Cowan, 1988; Smithson & Mollon, 2006). In everyday life, new visual information keeps coming into the register; and the new information replaces the old information almost immediately (in about a quarter of a second), a process often called *masking*.

Auditory information fades more slowly than visual information. The auditory equivalent of the icon, the *echo*, tends to last for several seconds, which, given the nature of speech, is certainly lucky for us. Otherwise, "*You* did it!" would be indistinguishable from "You *did* it!" because we would be unable to remember the emphasis on the first words by the time the last words were registered.

Attention

Why does some information capture our attention, whereas other information goes unnoticed?

sensory registers Entry points for raw information from the senses.

attention The selection of some incoming information for further processing.

If information disappears from the sensory registers so rapidly, how do we remember *anything* for more than a second or two? One way is that we select some of the incoming information for further processing by means of attention. (See **Figure 6–1**.) **Attention** is the process of *selectively* looking, listening, smelling, tasting, and feeling (Egeth & Lamy, 2003; Knudsen, 2007). At the same time, we give meaning to the information that is coming in. Look at the

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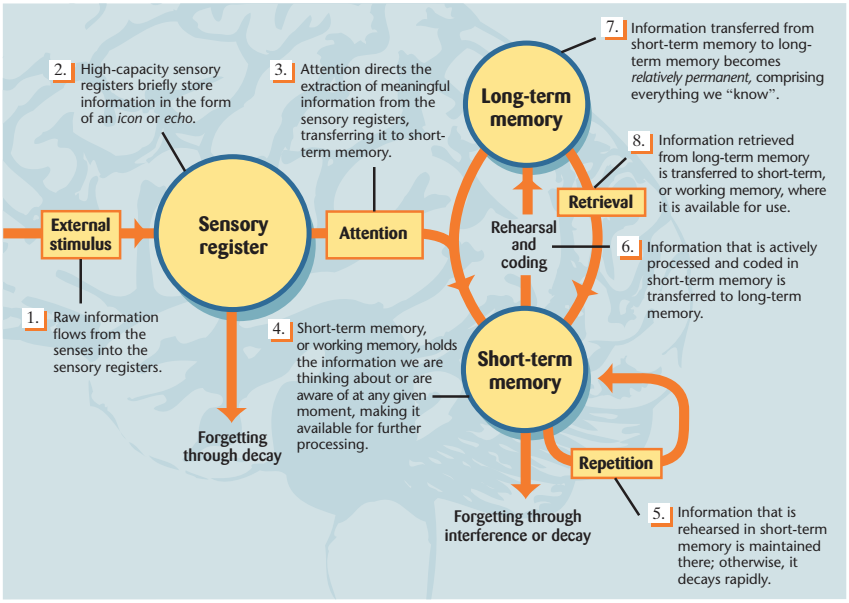

Figure 6–1
The sequence of information processing.

page in front of you. You will see a series of black lines on a white page. For you to make sense of this jumble of data, you process the information in the sensory registers for meaning.

How do we select what we are going to pay attention to at any given moment, and how do we give that information meaning? Donald Broadbent (1958) suggested that a filtering process at the entrance to the nervous system allows only those stimuli that meet certain requirements to pass through. Those stimuli that do get through the filter are compared with what we already know, so that we can recognize them and figure out what they mean. If you and a friend are sitting in a restaurant talking, you filter out all other conversations taking place around you, a process known as the *cocktail-party phenomenon* (Cherry, 1966; Haykin & Chen, 2006). Although you later might be able to describe certain characteristics of those other conversations, such as whether the people speaking were men or women, according to Broadbent, you normally cannot recall what was being discussed, even at neighboring tables. Since you filtered out those other conversations, the processing of that information did not proceed far enough for you to understand what you heard.

Broadbent's filtering theory helps explain some aspects of attention, but sometimes unattended stimuli do capture our attention. To return to the restaurant example, if someone nearby were to mention your name, your attention probably would shift to that conversation. Anne Treisman (1960, 1964, 2004) modified the filter theory to account for phenomena like this. She contended that the filter is not a simple on-and-off switch, but rather a variable control—like the volume control on a radio, which can "turn down" unwanted signals without rejecting them entirely. According to this view, although we may be paying attention to only some incoming information, we monitor the other signals at a low volume. Thus, we can shift our attention if we pick up something particularly meaningful. This automatic processing can work even when we are asleep: Parents often wake up immediately when they hear their baby crying, but sleep through other, louder noises.

At times, however, our automatic processing monitor fails, and we can overlook even meaningful information. In research studies, for example, some people watching a video of a ball-passing game failed to notice a person dressed as a gorilla who was plainly visible for nearly 10 seconds (Mack, 2003). In other words, just because we are *looking* or *listening* to something, doesn't mean we are *attending* to it. Psychologists refer to our failure to attend to something we are looking at as *inattentional blindness*. Research has shown, for example, that attending to auditory information can reduce one's ability to accurately process visual information, which makes driving while talking on a cell phone a distinctly bad idea (Pizzighello & Bressan, 2008)!

This student is working attentively in spite of other activity in the classroom. If the teacher calls her name, though, the student's attention will be quickly diverted.

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CHECK YOUR UNDERSTANDING

1. Indicate whether the following statements are true (T) or false (F):
   a. _____ The sensory registers have virtually unlimited capacity.
   b. _____ Some kinds of information are stored permanently in the sensory registers.
   c. _____ Auditory information fades from the sensory registers more quickly than visual information does.
   d. _____ The filter theory as modified by Treisman holds that attention is like an on-and-off switch.

Answers: 1. a. (T). b. (F). c. (F). d. (F).

APPLY YOUR UNDERSTANDING

1. You are in a large, noisy group in which everyone seems to be talking at once. In order to concentrate on the conversation you are having with one of the people, you "tune out" all the other conversations that are going on around you. A few minutes later, someone nearby turns to you and says, "Did you hear what I was saying to John?" You have to admit that even though you were standing right next to her, you don't know what she said. Your failure to remember that other conversation is an example of
   a. selective attention.
   b. the partial-report technique.
   c. the cocktail-party phenomenon.
   d. masking.
2. A few minutes later in that same group, while talking to someone else, you suddenly hear someone nearby mention your name. This time your attention is immediately drawn to that other conversation. This is an example of
   a. Broadbent's filtering theory.
   b. the partial-report technique.
   c. the cocktail-party phenomenon.
   d. masking.

Answers: 1. a. 2. c.

LEARNING OBJECTIVES

- **Define short-term memory (STM), explain why it is called "working memory" and describe the way information is encoded in STM.**
- **Describe the capacity of STM including the role of chunking and interference, maintenance of information in STM, and the effect of stress on STM.**

SHORT-TERM MEMORY

What are the two primary tasks of short-term memory?

Short-term memory (STM) holds the information that we are thinking about or are aware of at any given moment. When you listen to a conversation, when you watch a television show, when you become aware of a headache—in all these cases, you are using STM both to hold onto and to think about new information coming in from the sensory registers. Short-term memory has two primary tasks: to store new information briefly and to work on that (and other) information. Short-term memory is sometimes called *working memory*, to emphasize the active or working component of this memory system (Nairne, 2003; Neath, Brown, Poirier, & Fortin, 2005).

short-term memory (STM) Working memory; briefly stores and processes selected information from the sensory registers.

Capacity of STM

How much information can be held in short-term memory?

Chess masters at tournaments demand complete silence while they ponder their next move. You shut yourself in a quiet room to study for final exams. As these examples illustrate, STM can handle only so much information at any given moment. Research suggests

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that STM can hold about as much information as can be repeated or rehearsed in 1.5 to 2 seconds (Baddeley, 1986, 2002).

To get a better idea of the limits of STM, read the first row of letters in the list that follows just once. Then close your eyes, and try to remember the letters in the correct sequence. Repeat the procedure for each subsequent row.

1. C X W
2. M N K T Y
3. R P J H B Z S
4. G B M P V Q F J D
5. E G Q W J P B R H K A

Like most other people, you probably found rows 1 and 2 fairly easy, row 3 a bit harder, row 4 extremely difficult, and row 5 impossible to remember after just one reading.

Now try reading through the following set of 12 letters just once, and see whether you can repeat them:

TJYFAVMCFKIB

How many letters were you able to recall? In all likelihood, not all 12. But what if you had been asked to remember the following 12 letters instead?

TV FBI JFK YMCA

Could you remember them? Almost certainly the answer is yes. These are the same 12 letters as before, but here they are grouped into four separate "words." This way of grouping and organizing information so that it fits into meaningful units is called **chunking** (Cowan & Chen, 2009; Gobet, 2005; Gobet et al., 2001).

By chunking words into sentences or sentence fragments, we can process an even greater amount of information in STM (Baddeley, 1994; T. Carter, Hardy, & Hardy, 2001). For example, suppose that you want to remember the following list of words: *tree*, *song*, *hat*, *sparrow*, *box*, *lilac*, *cat*. One strategy would be to cluster as many of them as possible into phrases or sentences: "The sparrow in the tree sings a song"; "a lilac hat in the box"; "the cat in the hat." But isn't there a limit to this strategy? Would five sentences be as easy to

Chess players demand complete silence as they consider their next move. This is because there is a definite limit to the amount of information STM can handle at any given moment.

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chunking The grouping of information into meaningful units for easier handling by short-term memory.

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remember for a short time as five single words? No. As the size of any individual chunk increases, the number of chunks that can be held in STM declines (Fendrich & Arengo, 2004). STM can easily handle five unrelated letters or words at once, but five unrelated sentences are much harder to remember.

Keep in mind that STM usually has to perform more than one task at a time (Jonides, Lacey, & Nee, 2005). During the brief moments you spent memorizing the preceding rows of letters, you probably gave them your full attention. But normally you have to attend to new incoming information while you work on whatever is already present in short-term memory. Competition between these two tasks for the limited work space in STM means that neither task will be done as well as it could be. Try counting backward from 100 while trying to learn the rows of letters in our earlier example. What happens?

Now turn on some music and try to learn the rows of letters. You'll find that the music doesn't interfere much, if at all, with learning the letters. Interestingly, when two memory tasks are presented in different sensory modalities (for instance, visual and auditory), they are less likely to interfere with each other than if they are in the same modality (Cocchini, Logie, Sala, MacPherson, & Baddeley, 2002; Lehnert & Zimmer, 2008). This suggests the existence of *domain-specific* working memory systems that can operate at the same time with very little interference.

Not surprisingly, stress and worry have also been shown to be a detrimental to the operation of short-term memory (S. Hayes, Hirsch, & Mathews, 2008). This is particularly true when the task at hand involves mathematics, because the worry created by stress competes for working memory space, which would otherwise be allocated to solving the math problem (Beilock, 2008).

Encoding in STM

Do we store material in short-term memory as it sounds or as it looks?

We encode verbal information for storage in STM *phonologically*—that is, according to how it sounds. This is the case even if we see the word, letter, or number on a page, rather than hear it spoken (Inhoff, Connine, Eiter, Radach, & Heller, 2004; Vallar, 2006). We know this because numerous experiments have shown that when people try to retrieve material from STM, they generally mix up items that sound alike (Sperling, 1960). A list of words such as *mad, man, mat, cap* is harder for most people to recall accurately than is a list such as *pit, day, cow, bar* (Baddeley, 1986).

But not all material in short-term memory is stored phonologically. At least some material is stored in visual form, and other information is retained on the basis of its meaning (R. G. Morrison, 2005). For example, we don't have to convert visual data such as maps, diagrams, and paintings into sound before we can code them into STM and think about them. Moreover, research has shown that memory for images is generally better than memory for words because we often store images both phonologically and as images, while words are usually stored only phonologically (Paivio, 1986). The *dual coding* of images accounts for the reason it is sometimes helpful to form a mental picture of something you are trying to learn (Sadoski, 2005; Sadoski & Paivio, 2001). **Explore** on **MyPsychLab**

Explore Encoding, Storage, and Retrieval in Memory at www.mypsychlab.com

Maintaining STM

How can we hold information in STM?

As we have said, short-term memories are fleeting, generally lasting a matter of seconds. However, we can hold information in STM for longer periods through rote rehearsal, also called *maintenance rehearsal*. **Rote rehearsal** consists of repeating information over and over, silently or out loud. Although it may not be the most efficient way to remember something permanently, it can be quite effective for a short time.

rote rehearsal Retaining information in memory simply by repeating it over and over.

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CHECK YOUR UNDERSTANDING

1. _____ memory is what we are thinking about at any given moment. Its function is to briefly store new information and to work on that and other information.
2. _____ enables us to group items into meaningful units.
3. Strings of letters and numbers are encoded _____ in short-term memory.
4. _____ rehearsal, or simply repeating information over and over, is an effective way of retaining information for just a minute or two.

Answers: 1. short-term. 2. chunking. 3. phonologically. 4. rote.

APPLY YOUR UNDERSTANDING

1. You try to remember the letters CNOXNPEHFOBSN, but despite your best efforts you can't seem to remember more than half of them. Then you are told that the letters can be rearranged as CNN FOX HBO ESPN (four TV channels). After that, you are able to remember all the letters even weeks later. Rearranging the letters into groups that are easier to retain in memory is known as
   a. shadowing.
   b. chunking.
   c. rote rehearsal.
   d. cueing.
2. Your sister looks up a phone number in the phone book, but then can't find the phone. By the time she finds the phone, she has forgotten the number. While she was looking for the phone, she apparently failed to engage in
   a. rote rehearsal.
   b. parallel processing.
   c. phonological coding.
   d. categorizing.

Answers: 1. b. 2. a.

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LONG-TERM MEMORY

What types of information are retained in long-term memory?

Our ability to store vast quantities of information for indefinite periods of time is essential if we are to master complex skills, acquire an education, or remember the personal experiences that contribute to our identity. Everything that we learn is stored in **long-term memory (LTM)**: the words to a popular song; the meaning of *justice*; how to roller skate or draw a face; your enjoyment of opera or your disgust at the sight of raw oysters; and what you are supposed to be doing tomorrow at 4:00 P.M.

LEARNING OBJECTIVES

- **Define long-term memory (LTM) including the capacity of LTM and the way information is encoded in LTM. Explain the serial position effect.**
- **Differentiate rote rehearsal from elaborative rehearsal and explain the role of mnemonics and schemata as forms of elaborative rehearsal.**
- **Distinguish between episodic memories, semantic memories, procedural memories, emotional memories, explicit memories, and implicit memories. Explain how priming and the tip-of-the-tongue phenomenon shed light on memory.**

Capacity of LTM

What is the limit of LTM?

We have seen that short-term memory can hold only a few items, normally only for a matter of seconds. By contrast, long-term memory can store a vast amount of information for many years. In one study, for example, adults who had graduated from high school more than 40 years earlier were still able to recognize the names of 75% of their classmates (Lindsay & Read, 2006).

long-term memory (LTM) The portion of memory that is more or less permanent, corresponding to everything we "know."

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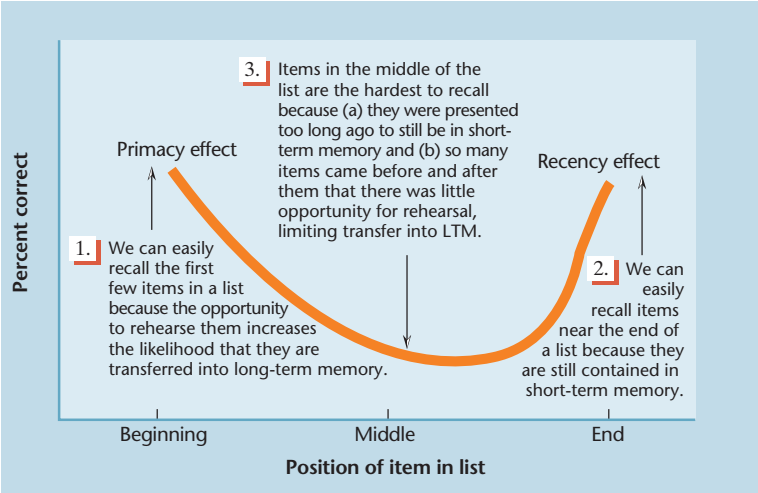

Figure 6–2
The serial position effect.
The serial position effect demonstrates how short- and long-term memory work together.

Encoding in LTM

How are most memories encoded in LTM?

Can you picture the shape of Florida? Do you know what a trumpet sounds like? Can you imagine the smell of a rose or the taste of coffee? Your ability to do most of these things means that at least some long-term memories are coded in terms of nonverbal images: shapes, sounds, smells, tastes, and so on (Cowan, 1988).

Yet, most of the information in LTM seems to be encoded in terms of *meaning*. If material is especially familiar (the words of the national anthem, for example), you may have stored it verbatim in LTM, and you can often retrieve it word for word when you need it. Generally speaking, however, we do not use verbatim storage in LTM. If someone tells you a long, rambling story, you may listen to every word, but you certainly will not try to remember the story verbatim. Instead, you will extract the main points of the story and try to remember those. Even simple sentences are usually encoded in terms of their meaning. Thus, when people are asked to remember that "Tom called John," they often find it impossible to remember later whether they were told "Tom called John" or "John was called by Tom." They usually remember the *meaning* of the message, rather than the exact words (R. R. Hunt & Ellis, 2003).

Information in LTM is highly organized and cross-referenced, like a cataloging system in a library. The more carefully we organize information, the more likely we will be to retrieve it later.

Serial Position Effect

Which items in a list are hardest to remember?

When given a list of items to remember (such as a list of grocery items), people tend to do better at recalling the first items (*primacy effect*) and the last items (*recency effect*) in the list. They also tend to do poorest of all on the items in the middle of the list. (See **Figure 6–2**.)

The explanation for this **serial position effect** resides in understanding how short- and long-term memory work together. The recency effect occurs because the last items that were presented are still contained in STM and thus are available for recall. The primacy effect, on the other hand, reflects the opportunity to rehearse the first few items in the list—increasing their likelihood of being transferred to LTM.

Poor performance occurs on the items in the middle of the list because they were presented too long ago to still be in STM, and because so many items requiring attention were presented before and after them that there was little opportunity for rehearsal. The serial position effect has been shown to occur under a wide variety of conditions and situations (Neath, 1993; Suhr, 2002; W. S. Terry, 2005).

serial position effect The finding that when asked to recall a list of unrelated items, performance is better for the items at the beginning and end of the list.

Maintaining LTM

What three processes are used to hold information in LTM?

Rote Rehearsal Rote rehearsal, the principal tool for holding information in STM, is also useful for holding information in LTM. Rote rehearsal is probably the standard method of storing conceptually meaningless material, such as phone numbers, Social Security numbers, security codes, computer passwords, birth dates, and people's names.

Indeed, although everyone hates rote drill, there seems to be no escaping its use in mastering a wide variety of skills, from memorizing the alphabet to playing a work of Mozart on the piano or doing a back flip on the balance beam. Mastering a skill means achieving *automaticity*, or fluid, immediate performance. Expertise in typing, for example, involves the ability to depress the keys quickly and accurately without thinking about it. Automaticity is achieved only through tedious practice.

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Figure 6–3
A penny for your thoughts.
Which of these accurately illustrates a real U.S. penny? The answer is on page 196.

Research suggests, however, that repetition without any intention to learn generally has little effect on subsequent recall (Van-Hooff & Golden, 2002). You can probably prove this phenomenon to yourself: Stop here and try to imagine from memory the front side of a U.S. penny. Now look at **Figure 6–3**, and pick the illustration that matches your memory. For most people, this task is surprisingly difficult: Despite the repetition of seeing thousands of pennies, most people cannot accurately draw one, or even pick one out from among other, similar objects (Nickerson & Adams, 1979).

Elaborative Rehearsal As we have seen, rote rehearsal with the intent to learn is sometimes useful in storing information in LTM. But often, an even more effective procedure is **elaborative rehearsal** (Craik, 2002; Craik & Lockhart, 1972), the act of relating new information to something that we already know. Through elaborative rehearsal, you extract the meaning of the new information and then link it to as much of the material already in LTM as possible. We tend to remember meaningful material better than arbitrary facts; and the more links or associations of meaning you can make, the more likely you are to remember the new information later.

Clearly, elaborative rehearsal calls for a deeper and more meaningful processing of new data than does simple rote rehearsal (Craik & Lockhart, 1972). Unless we rehearse material in this way, we often soon forget it. For example, have you ever been in a group in which people were taking turns speaking up—perhaps on the first day of class when all present are asked to introduce themselves briefly, or at the beginning of a panel discussion when the speakers are asked to do the same in front of a large audience? Did you notice that you forgot virtually everything that was said by the person who spoke just before you did? According to research, you failed to remember because you did not elaboratively rehearse what that person was saying (C. F. Bond, Pitre, & Van Leeuwen, 1991). That person's comments simply "went in one ear and out the other" while you were preoccupied with thinking about your own remarks.

elaborative rehearsal The linking of new information in short-term memory to familiar material stored in long-term memory.

mnemonics Techniques that make material easier to remember.

schema (skee-mah; plural: schemata) A set of beliefs or expectations about something that is based on past experience.

In some situations, special techniques called **mnemonics** (pronounced ni-MON-iks) may help you to tie new material to information already in LTM. Some of the simplest mnemonic techniques are the rhymes and jingles that we often use to remember dates and other facts. *Thirty days hath September, April, June, and November . . .* enables us to recall how many days are in a month. With other simple mnemonic devices, words or sentences can be made out of the material to be recalled. We can remember the colors of the visible spectrum—red, orange, yellow, green, blue, indigo, and violet—by using their first letters to form the acronym ROY G. BIV.

Schemata A variation on the idea of elaborative rehearsal is the concept of **schema** (plural: **schemata**). A schema is a mental representation of an

THINKING CRITICALLY ABOUT . . .

Elaborative Rehearsal

Elaborative rehearsal requires that you relate new material to information already stored in LTM. Sometimes, this requires thinking abstractly, visually, or conceptually about the things you want to remember. How would you use elaborative rehearsal to store the following information?

1. In Japanese, the word for difficult is *muzukashii*.
2. The *p* in pterodactyl is silent.
3. The square root of *pi* is approximately 1.772.

Now try to develop an elaborative rehearsal strategy for something you are trying to learn, say in this or another class you are taking.

Did using an elaborative rehearsal strategy increase your ability to recall the material? What types of elaborative rehearsal strategies did you devise? Which ones seem to work best for you? Why do you think that was the case?

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event, an object, a situation, a person, a process, or a relationship that is stored in memory and that leads you to expect your experience to be organized in certain ways. For example, you may have a schema for eating in a restaurant, for driving a car, or for attending a class lecture. A class lecture schema might include sitting down in a large room with seats arranged in rows, opening your notebook, and expecting the professor or lecturer to come in and address the class from the front of the room.

Schemata such as these provide a framework into which incoming information is fitted. Schemata also may color what you recall by prompting you to form a *stereotype*; that is, to ascribe certain characteristics to all members of a particular group. (We will explore the process of stereotyping in Chapter 14, "Social Psychology.") Thus, becoming aware of your particular schemata is one way to improve your ability to remember. (See "Applying Psychology: Improving Your Memory" for more on improving your memory.)

To summarize, we have seen that the capacity of LTM is immense and material stored there may endure, more or less intact, for decades. By comparison, STM has a sharply limited capacity and information may disappear quickly from it. The sensory registers can take in an enormous volume of information, but they have no ability to process memories. Together, these three stages of memory—the sensory registers, STM, and LTM—comprise the information-processing view of memory, as reviewed in the **"Summary Table:** Memory as an Information-Processing System." (Answer to question on page 195: The accurate illustration of a penny in **Figure 6–3** is the third from the left.)

Types of LTM

How do types of LTM differ?

The information stored in LTM can take many forms. However, most long-term memories can be classified into one of several types: episodic, semantic, procedural, and emotional memories.

Episodic memories (D. C. Rubin, 2006; Tulving, 2002, 2005) are memories for events experienced in a specific time and place. These are *personal* memories, rather than historical facts. If you can recall what you ate for dinner last night or how you learned to ride a bike when you were little, then you are calling up episodic memories. Episodic memory is like a diary that lets you go back in time and space to relive a personal experience (Knierim, 2007). For Jill Price, profiled at the beginning of this chapter, every waking moment is characterized by a barrage of episodic memories.

episodic memories The portion of long-term memory that stores personally experienced events.

SUMMARY TABLE MEMORY AS AN INFORMATION-PROCESSING SYSTEM

System	Means by Which Information Is Stored	Form in Which Information Is Stored	Storage Organization	Storage Duration	Means by Which Information Is Retrieved	Factors in Forgetting
Sensory Register	Visual and auditory registers	Raw sensory data	None	From less than 1 second to only a few seconds	Reconsideration of registered information	Decay or masking
Short-Term Memory	Rote or maintenance rehearsal	Visual and phonological representation	None	Usually 15 to 20 seconds	Rote or maintenance rehearsal	Interference or decay
Long-Term Memory	Rote rehearsal, elaborative rehearsal, schemata	Some nonverbal representations, mostly stored by meaning	Logical frameworks, such as hierarchies or categories	Perhaps for an entire lifetime	Retrieval cues linked to organized information	Retrieval failure or interference

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APPLYING PSYCHOLOGY

Improving Your Memory

What can you do to improve your memory? It's the active decision to get better and the number of hours you push yourself to improve that makes the difference. Regardless of your innate ability, anyone can improve their memory by doing the following.

1. **Develop motivation.** Without a strong desire to learn or remember something, you probably won't. But if you find a way to keep yourself alert and stimulated, you will have an easier time learning and remembering things.
2. **Practice memory skills.** To stay sharp, memory skills, like all skills, must be practiced and used. Memory experts recommend exercises such as crossword puzzles, acrostics, anagrams, Scrabble, Monopoly, Trivial Pursuit, and bridge. Practice testing on the material you want to learn is also helpful. Several studies have shown that repeated testing increases retention of material more than simply studying (A. K. Butler, Karpicke, & Roediger, 2008; Szpunar, McDermott, & Roediger, 2008).
3. **Be confident in your ability to remember.** Self-doubt often leads to anxiety, which, in turn, interferes with the ability to retrieve information from memory. Relaxation exercises, experts agree, may substantially boost your ability to retrieve information from memory.
4. **Minimize distractions.** Although some people can study for an exam and listen to the radio simultaneously, most people find that outside distractions interfere with both learning and remembering. Look for a quiet, even secluded, setting before attempting to commit something to memory.
5. **Stay focused.** Paying close attention to details, focusing on your surroundings, emotions, and other elements associated with an event, will help you remember it clearly.
6. **Make connections between new material and other information already stored in your long-term memory.** The more links you forge between new information and old information already in LTM, the more likely you are to remember the new material. Discuss things you want to remember with other people. Think about or write down ways in which the new information is related to things you already know.
7. **Use mental imagery.** Imagery works wonders as an aid to recalling information from memory. Whenever possible, form mental pictures of the items, people, words, or activities you want to remember. If you have a sequence of stops to make, picture yourself leaving each place and heading for the next. To remember that someone's last name is Glass, you might imagine her holding a glass or looking through a glass.
8. **Use retrieval cues.** The more retrieval cues you have, the more likely it is that you will remember something. One way to establish automatic retrieval cues is to create routines and structure. For example, when you come in the door, put your house and car keys in the same place every time. Then when you ask yourself, "Where did I put my keys?" the fact that you have a special place for the keys serves as a retrieval cue.
9. **Rely on more than memory alone.** Write down the things you need to remember, and then post a note or list of those things somewhere obvious, such as on your bulletin board or refrigerator door. Put all the dates you want to remember on a calendar, and then put the calendar in a conspicuous place.
10. **Be aware that your own personal schemata may distort your recall of events.** People sometimes unknowingly "rewrite" past events to fit their current image or their desired image of themselves and their past decisions (Lyubomirsky & Ross, 1999; Mather, Shafir, & Johnson, 2000). Being on guard against such distortions may help you avoid them.

Semantic memories are facts and concepts not linked to a particular time. Semantic memory is like a dictionary or an encyclopedia, filled with facts and concepts, such as the meaning of the word *semantic*, the location of the Empire State Building, the value of 2 times 7, and the identity of George Washington.

Procedural memories are motor skills and habits (A. Johnson, 2003). They are not memories about skills and habits; they are the skills and habits. Procedural memories have to do with knowing how: how to ride a bicycle, play a violin, make coffee, write your name, walk across a room, or slam on a car's brakes. The information involved usually consists of a precise sequence of coordinated movements that are often difficult to describe in words. Repetition, and in many

semantic memories The portion of long-term memory that stores general facts and information.

procedural memories The portion of long-term memory that stores information relating to skills, habits, and other perceptual-motor tasks.

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THINKING CRITICALLY ABOUT . . .

Types of Memory

Experts disagree about how many different kinds of memory there are. Recently, some psychologists have suggested that the classification of memories into different types is artificial and merely confuses matters. They suggest that we should consider memory a unitary thing.

What arguments can you come up with to support the practice of making distinctions among different kinds of memory?

Once skills such as playing tennis have been stored in our procedural memory, they are seldom lost.

emotional memories Learned emotional responses to various stimuli.

explicit memory Memory for information that we can readily express in words and are aware of having; these memories can be intentionally retrieved from memory.

implicit memory Memory for information that we cannot readily express in words and may not be aware of having; these memories cannot be intentionally retrieved from memory.

cases deliberate practice, are often required to master skills and habits, but once learned, they are rarely completely lost.

Emotional memories are learned emotional responses to various stimuli: all of our loves and hates, our rational and irrational fears, our feelings of disgust and anxiety. If you are afraid of flying insects, become enraged at the sight of a Nazi flag, or are ashamed of something you did, you have emotional memories.

Explicit and Implicit Memory

What are the differences between implicit and explicit memories?

Because of the differences among types of memories, psychologists distinguish between **explicit memory**, which includes episodic and semantic memories, and **implicit memory**, which includes procedural and emotional memories (D. L. Nelson, 1994). These terms reflect the fact that sometimes we are aware that we know something (explicit memory) and that sometimes we are not aware (implicit memory).

Serious interest in the distinction between explicit and implicit memory began as a result of experiments with amnesic patients. For example, Brenda Milner (Milner, Corkin, & Teuber, 1968) studied the now-famous case of patient "H. M." (Henry Molaison), a young man who had severe, uncontrollable epileptic seizures. The seizures became life threatening, so that as a last resort, surgeons removed most of the afflicted area of his brain. The surgery greatly reduced the frequency and severity of seizures, but it left behind a new problem: H. M. could no longer form new memories. He could meet someone again and again, but each time it was as if he were meeting the person for the first time. Old memories were intact: He could remember things that he had learned long before the operation, but he could not learn anything new. Or so it seemed!

Then one day Milner asked H. M. to trace the outline of a star while looking in a mirror. This simple task is surprisingly difficult, but with practice most people show steady progress. Surprisingly, so did H. M. Each day he got better and better at tracing the star, just as a person with an undamaged brain would do—yet each day he had no recollection of ever having attempted the task. H. M.'s performance demonstrated not only that he could learn, but also that there are different kinds of memories. Some are explicit: We know things, and we know that we know them. And some are implicit: We know things, but that knowledge is unconscious. (See **Table 6–1** for a summary of implicit and explicit memory.)

Additional support for the distinction between explicit and implicit memory is derived from clinical observations of the ways in which strong emotional experiences can affect behavior years later even without any conscious recollection of the experiences (Kihlström, 1999; Kihlström, Mulvaney, Tobias, & Tobis, 2000; Westen, 1998). In cases of war, abuse, or terrorism, emotional memories are sometimes so overwhelming and painful they can lead to a psychiatric disorder called posttraumatic stress disorder or PTSD (Lasiuk & Hegadoren, 2006; D. C. Rubin, Berntsen, & Bohni, 2008). (We will consider PTSD in more detail in Chapter 11, "Stress and Health Psychology.")

The fact that strong emotional memories can affect behavior without conscious awareness seem at first to give credence to Freud's notion of the unconscious mind—that repressed memories for traumatic incidents can still affect our behavior. But implicit

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Table 6–1 TYPES OF MEMORIES

Explicit		Implicit	
Semantic	**Episodic**	**Procedural**	**Emotional**
Memories of facts and concepts	Memories of personally experienced events	Motor skills and habits	Learned emotional reactions
Example: recalling that Albany is the capital of New York	*Example:* recalling a trip to Albany	*Example:* ice skating	*Example:* recoiling at the sight of a rat

memory research suggests instead that people store emotional experiences separately from the memories of the experience itself. Thus, we may feel anxiety about flying because of a traumatic plane ride in early childhood, yet we may not remember the experience that gives rise to that anxiety. Memory of the event is out of reach, not because (as Freud thought) it has been repressed, but because the episodic and emotional components of the experience were stored separately.

Looking into a bakery window, perhaps smelling the aromas of the cakes inside, may prime the memory, triggering distinct memories associated with those sights and smells, formed many years ago.

Priming Research on a phenomenon called *priming* also demonstrates the distinction between explicit and implicit memory. In priming, a person is exposed to a stimulus, usually a word or picture. Later, the person is shown a fragment of the stimulus (a few letters of a word or a piece of a picture) and is asked to complete it. The typical result is that people are more likely to complete fragments with items seen earlier than they are with other, equally plausible items. For example, you might be shown a list of words, including the word *tour*. Later on, you might be shown a list of word fragments, including __ *ou* __, and be asked to fill in the blanks to make a word. In comparison to others who had not been primed by seeing the word *tour*, you are far more likely to write *tour* than you are *four*, *pour*, or *sour*, all of which are just as acceptable as *tour*. The earlier exposure to *tour* primes you to write that word.

The Tip-of-the-Tongue Phenomenon Everyone has had the experience of knowing a word but not quite being able to recall it. This is called the **tip-of-the-tongue phenomenon** (or **TOT**) (R. Brown & McNeil, 1966; Hamberger & Seidel, 2003; B. L. Schwartz, 2002; Widner, Otani, & Winkelman, 2005). Although everyone experiences TOTs, these experiences become more frequent during stressful situations and as people get older (B. L. Schwartz & Frazier, 2005; K. K. White & Abrams, 2002). Moreover, other words—usually with a sound or meaning similar to the word you are seeking—occur to you while you are in the TOT state and these words interfere with and sabotage your attempt to recall the desired word. The harder you try, the worse the TOT state gets. The best way to recall a blocked word, then, is to stop trying to recall it! Most of the time, the word you were searching for will pop into your head, minutes or even hours after you stopped consciously searching for it (B. L. Schwartz, 2002). (If you want to experience TOT yourself, try naming Snow White's seven dwarfs.)

The distinction between explicit and implicit memories means that some knowledge is literally unconscious. Moreover, as we shall soon see, explicit and implicit memories also seem to involve different neural structures and pathways. However, memories typically work together. When we remember going to a Chinese restaurant, we recall not only when and where we ate and whom we were with (episodic memory), but also the nature of the food we ate (semantic memory), the skills we learned such as eating with chopsticks (procedural memory), and the embarrassment we felt when we spilled the tea (emotional memory). When we recall events, we typically do not experience these kinds of memories as distinct and separate; rather, they are integrally connected, just as

tip-of-the-tongue phenomenon (or TOT) Knowing a word, but not being able to immediately recall it.

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the original experiences were. Whether we will continue to remember the experiences accurately in the future depends to a large extent on what happens in our brain, as we will see in the next section.

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CHECK YOUR UNDERSTANDING

1. The primacy effect accounts for why we remember items at the _____ of a list, while the recency effect accounts for why we remember items at the _____ of the list.
2. If information is learned through repetition, this process is _____ rehearsal; if it is learned by linking it to other memories, this process is _____ rehearsal.
3. A schema is a framework in memory into which new information is fit. Is this statement true (T) or false (F)?
4. Implicit memories consist of _____ and _____ memories, whereas explicit memories consist of _____ and _____ memories.

Answers: 1. beginning; end. 2. rote; elaborative. 3. (T). 4. procedural and emotional; episodic and semantic.

APPLY YOUR UNDERSTANDING

1. You run into an old friend who gives you his phone number and asks you to call. You want to be sure to remember the phone number, so you relate the number to things that you already know. "555" is the same as the combination to your bicycle lock. "12" is your brother's age. And "34" is the size of your belt. This technique for getting information into long-term memory is called
   a. rote rehearsal.
   b. relational rehearsal.
   c. elaborative rehearsal.
   d. episodic rehearsal.
2. *He:* "We've been to this restaurant before."
   She: "I don't think so."
   He: "Didn't we eat here last summer with your brother?"
   She: "That was a different restaurant, and I think it was last fall, not last summer."
   This couple is trying to remember an event they shared and, obviously, their memories differ. The information they are seeking is most likely stored in
   a. procedural memory.
   b. emotional memory.
   c. semantic memory.
   d. episodic memory.

Answers: 1. c. 2. d.

LEARNING OBJECTIVE

- **Define long-term potentiation. Identify the areas of the brain that play a role in the formation and storage of long-term memories. Describe the role of sleep in the formation of new memories.**

THE BIOLOGY OF MEMORY

What role do neurons play in memory?

Research on the biology of memory focuses mainly on the question, *How and where are memories stored?* Simple as the question is, it has proved enormously difficult to answer and our answers are still not entirely complete.

Current research indicates that memories consist of changes in the synaptic connections among neurons (Asrican, 2007; Kandel, 2001). When we learn new things, new connections are formed in the brain; when we review or practice previously learned things, old connections are strengthened. These chemical and structural changes can continue over a period of months or years (Abraham & Williams, 2008; Bekinschtein et al., 2008; Lu, Christian, & Lu, 2008), during which the number of connections among neurons increases as does the likelihood that cells will excite one another through electrical discharges, a process known as **long-term potentiation** (**LTP**).

long-term potentiation (LTP) A long-lasting change in the structure or function of a synapse that increases the efficiency of neural transmission and is thought to be related to how information is stored by neurons.

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Although learning takes place in the brain, it is also influenced by events occurring elsewhere in the body. Two hormones in particular, epinephrine and cortisol, have been shown to affect long-term retention, especially for unpleasant experiences (Korol & Gold, 2007). Another hormone found to influence memory is *ghrelin*. Secreted from the lining of stomach when it is empty, ghrelin travels to the brain where it primarily stimulates receptors in the hypothalamus to signal hunger. However, some ghrelin also finds its way to the hippocampus, where studies with mice have shown it can enhance learning and memory (Diano et al., 2006; Olszewski, Schiöth, & Levine, 2008). As a result, the hungry mice are more likely to remember where they have found food in the past.

ENDURING ISSUES

Mind–Body Effects of Stress on Body and Brain

Epinephrine secretion is part of the "fight or flight" syndrome (see Chapter 11, "Stress and Health Psychology"), and has the effect of arousing the organism to action. However, the effect on memory of epinephrine and other stress-related hormones is not merely the result of general arousal. Apparently these hormones indirectly act on specific brain centers, such as the hippocampus and the amygdala, that are critical for memory formation (Vermetten & Bremner, 2002). Increased blood levels of epinephrine probably also explain improved performance in humans under conditions of mild stress (L. Cahill & Alkire, 2003). Extreme stress, however, often interferes with both the learning and later recall of specific information. For example, research has demonstrated that when people are exposed to highly stressful events, their memory for the emotional aspect of the event may be enhanced (LaBar, 2007) but their ability to recall the nonemotional aspects of the event is disrupted (Payne et al., 2006). If you are studying for an exam, then, a little anxiety will probably improve your performance, but a high level of anxiety will work against you. ■

Where Are Memories Stored?

Are STM and LTM found in the same parts of the brain?

Not all memories are stored in one place. Instead our brains appear to depend on large numbers of neurons distributed throughout the brain working in concert to form and store memories (Tsien, 2007). However, this characteristic does not mean that memories are randomly distributed throughout the brain. In fact, different parts of the brain are specialized for the storage of memories (Rolls, 2000). (See **Figure 6–4**.)

Short-term and working memory, for example, seem to be located primarily in the prefrontal cortex and temporal lobe (Izaki, Takita, & Akema, 2008; Rainer & Miller, 2002; Scheibel & Levin, 2004). Long-term semantic memories seem to be located primarily in the frontal and temporal lobes of the cortex, which interestingly, also play a prominent role in consciousness and awareness. Research shows increased activity in a particular area of the left temporal lobe—for example, when people are asked to recall the names of people. A nearby area shows increased activity when they are asked to recall the names of animals, and another neighboring area becomes active when they are asked to recall the names of tools (H. Damasio, Grabowski, Tranel, Hichwa, & Damasio, 1996). (See **Figure 6–5**.) Destruction of these areas of the cortex (through head injury, surgery, stroke, or disease) results in selective memory loss (e.g., H. Damasio et al., 1996).

Episodic memories also find their home in the frontal and temporal lobes (Jackson, 2004; Nyberg et al., 2003; Stevens & Grady, 2007). But some evidence shows that episodic and semantic memories involve different portions of these brain structures (Prince, Tsukiura, & Cabeza, 2007). In addition, because episodic memories depend on integrating different sensations (vision, audition, and so on) to create a personal memory experience, they also draw upon several distinct sensory areas of the brain. Thus, episodic memory is

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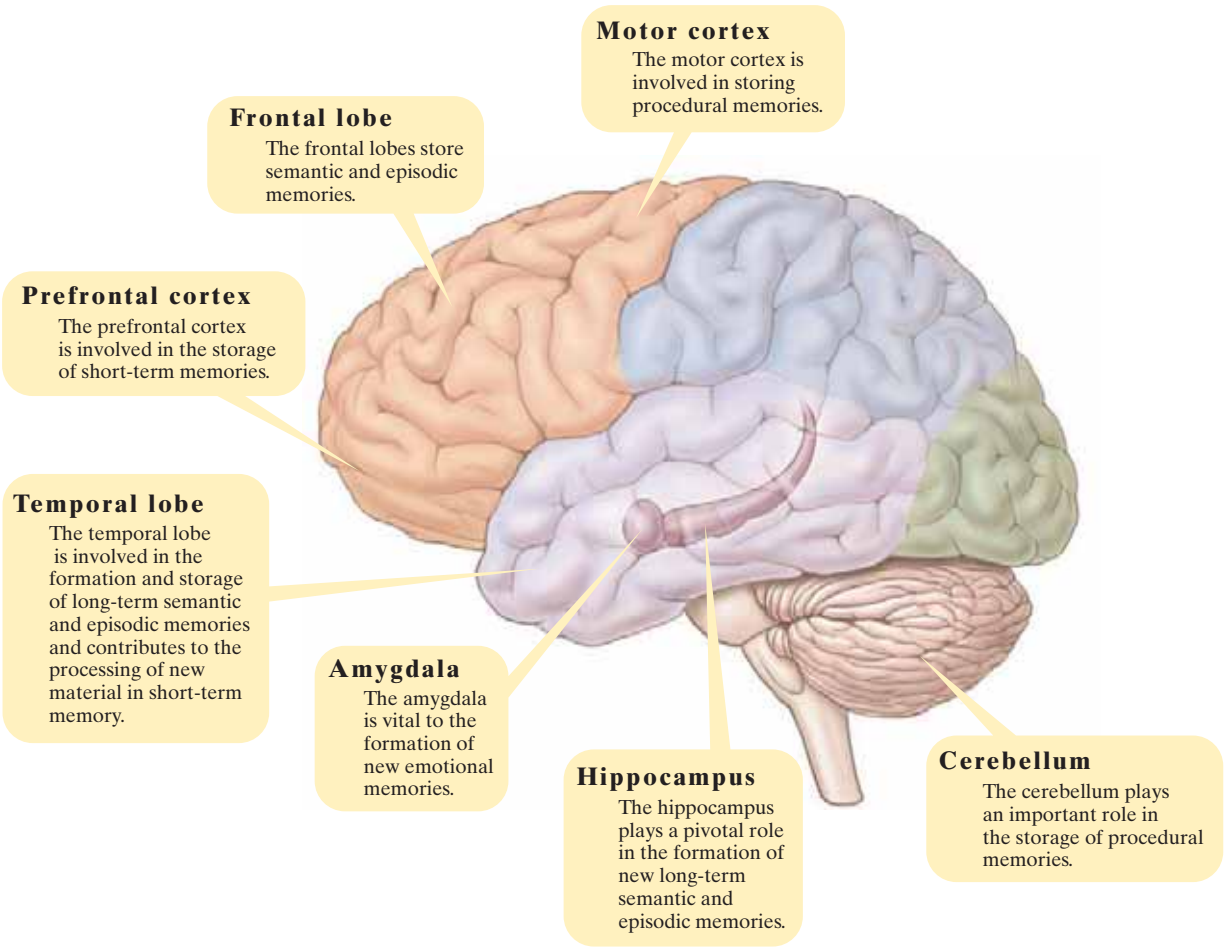

Figure 6–4
The biological basis of memory.
Many different parts of the brain are specialized for the storage of memories.

probably best thought of as the integration of memories that are located throughout the brain into a coherent personal experience (D. C. Rubin, 2006).

Procedural memories appear to be located primarily in the cerebellum (an area required for balance and motor coordination) and in the motor cortex (Gabrieli, 1998; Hermann et al., 2004).

Subcortical structures also play a role in long-term memory. For example, the hippocampus has been implicated in the functioning of both semantic and episodic memory (Eichenbaum & Fortin, 2003; Manns, Hopkins, & Squire, 2003; Rolls, 2000), as well as being involved in the ability to remember spatial relationships (Astur, Taylor, Marnelak, Philpott, & Sutherland, 2002; Bilkey & Clearwater, 2005). If the hippocampus is damaged, people can remember events that have just occurred (and are in STM), but their long-term recall of those same events is impaired. The amygdala, a structure that lies near the

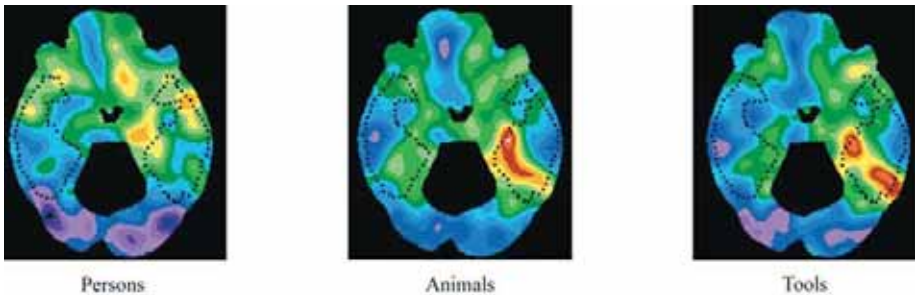

Figure 6–5
PET scanning shows increased activity in different areas of the brain when people are asked to recall the names of people, animals, and tools.

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hippocampus, seems to play a role in emotional memory that is similar to the role the hippocampus plays in episodic, semantic, and procedural memory (LaBar, 2007; Payne et al., 2006; Vermetten & Bremner, 2002). For example, damage to the amygdala reduces the ability to recall new emotional experiences, but it does not prevent the recall of emotional events that occurred prior to the damage, though they are often remembered as neutral facts, devoid of emotional content. This may explain why people with amygdala damage are sometimes unable to "read" facial expressions, even though they recognize the person's face (Pegna, Caldara-Schnetzer, & Khateb, 2008; Pegna, Khateb, & Lazeyras, 2005).

The Role of Sleep

In Chapter 4 ("States of Consciousness"), we noted that sleep appears to play an important role in the formation of new memories. One recent study of adolescents, for example, showed that sleeping less than 8 hours a night negatively impacted working memory (Gradisar, Terrill, Johnston, & Douglas, 2008). Studies like this have prompted neuroscientists to explore precisely how sleep is involved in the formation and storage of new memories (Rasch & Born, 2008). Brain imaging with animals and humans shows that the same hippocampal neurons and patterns of neuron activity that accompany initial learning are reactivated during subsequent deep sleep. Thus, it is not surprising that deep sleep after learning serves to strengthen new memories (M. P. Walker & Stickgold, 2006). Moreover, high levels of neuron reactivation during sleep are associated with the formation of the strongest memories (McNaughton et al., 2003; Peigneux et al., 2004; Rasch, Büchel, Gais, & Born, 2007). Clearly, psychologists have a long way to go before they will fully understand the biology of memory, but progress is being made in this fascinating area.

CHECK YOUR UNDERSTANDING

Match the following types of memory to the location in the brain where they appear to be stored:

1. ___ short-term memories	a. frontal and temporal lobes
2. ___ long-term semantic and episodic memories	b. cerebellum and motor cortex
3. ___ procedural memories	c. amygdala
4. ___ emotional memories	d. prefrontal cortex and temporal lobe

Answers: 1. d. 2. a. 3. b. 4. c.

APPLY YOUR UNDERSTANDING

1. Oliver Sacks, the author of *The Man Who Mistook His Wife for a Hat*, describes Jimmie G., who was an otherwise healthy 49-year-old man whose long-term memory stopped changing when he was 19. New information in his short-term memory simply never got stored in long-term memory. Which part of his brain was most likely not working correctly?
   a. the prefrontal cortex
   b. the hippocampus
   c. Broca's area
   d. the occipital lobe
2. Imagine now that you encounter someone like Jimmie G., but in this case, the person cannot form new emotional memories. He has emotional reactions to things he encountered early in his life, but he has no such reactions to things he encountered more recently—no new loves or hates, no new fears, no new sources of anger or happiness. Which part of his brain is most likely not working correctly?
   a. the amygdala
   b. the temporal lobe
   c. the prefrontal cortex
   d. the cerebellum

Answers: 1. b. 2. a.

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LEARNING OBJECTIVES

- **Describe the biological factors that influence forgetting, including the phenomenon of retrograde amnesia.**
- **Differentiate between retroactive and proactive interference.**
- **Explain what is meant by "state-dependent memory" and the "reconstructive" nature of remembering.**

FORGETTING

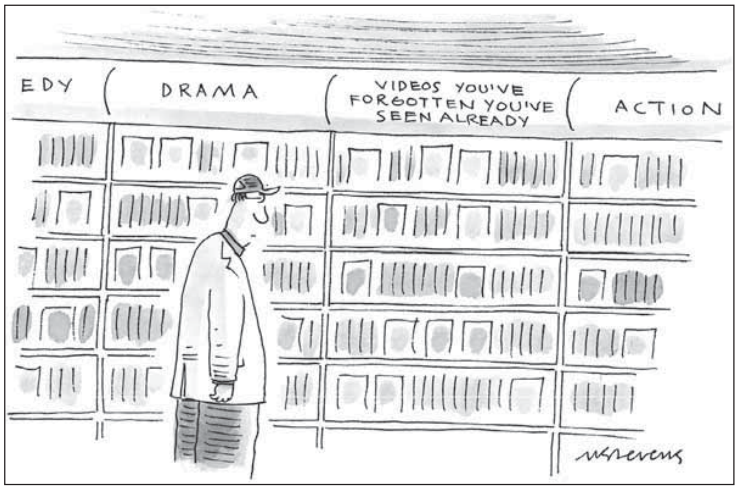
What factors explain why we sometimes forget?

Why do memories, once formed, not remain forever in the brain? Part of the answer has to do with the biology of memory, and another part has to do with the experiences that we have before and after learning.

The Biology of Forgetting

How does the deterioration of the brain help to explain forgetting?

According to the **decay theory**, memories deteriorate because of the passage of time. Most of the evidence supporting decay theory comes from experiments known as *distractor studies*. For example, in one experiment, participants learned a sequence of letters, such as PSQ. Then they were given a three-digit number, such as 167, and asked to count backwards by threes: 167, 164, 161, and so on, for up to 18 seconds (L. R. Peterson & Peterson, 1959). At the end of that period, they were asked to recall the three letters. The results of this test astonished the experimenters. The participants showed a rapid decline in their ability to remember the letters. Because the researchers assumed that counting backwards would not *interfere* with remembering, they could only account for the forgotten letters by noting that they had simply faded from short-term memory in a matter of seconds. Decay, then, seems to be at least partly responsible for forgetting in short-term memory.



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Information in LTM also can be lost if the storage process is disrupted. Head injuries often result in **retrograde amnesia**, a condition in which people cannot remember what happened to them shortly before their injury. In such cases, forgetting may occur because memories are not fully consolidated in the brain.

Severe memory loss is invariably traced to brain damage caused by accidents, surgery, poor diet, or disease (Roncadin, Guger, Archibald, Barnes, & Dennis, 2004). For example, chronic alcoholism can lead to a form of amnesia called *Korsakoff's syndrome* caused by a vitamin deficiency in the nutritionally poor diet that is typical of people who abuse alcohol (Baddeley, 1987; Hildebrandt, Brokate, Eling, & Lanz, 2004). Other studies show the importance of the hippocampus to long-term memory formation. Studies of elderly people who are having trouble remembering new material, for instance, show alterations in hippocampal functioning and connectivity to other areas of the brain (Grady, McIntosh, & Craik, 2003). Brain scans (see **Figure 6–6**) also reveal hippocampus damage in people suffering from *Alzheimer's disease*, a neurological disorder that causes severe memory loss (Rapp et al., 2006; Villain et al., 2008). (See Chapter 9, "Life-Span Development," for more information about Alzheimer's disease.)

decay theory A theory that argues that the passage of time causes forgetting.

retrograde amnesia The inability to recall events preceding an accident or injury, but without loss of earlier memory.

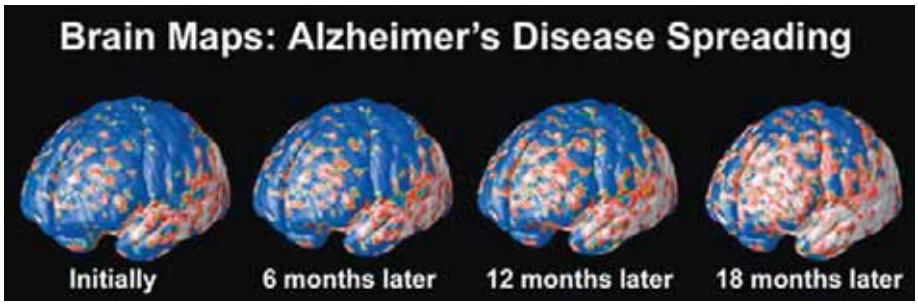

Figure 6–6
The progression of Alzheimer's disease. A computerized brain scan taken of a single patient over time shows the spread of Alzheimer's disease throughout the brain. Diseased tissue is shown as red and white. Notice how the damaged tissue replaces normal brain tissue shown here as blue.

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Alzheimer's may also involve below-normal levels of the neurotransmitter acetylcholine in the brain. Indeed, some research suggests that drugs and surgical procedures that increase acetylcholine levels may serve as effective treatments for age-related memory problems (Coyle, Geerts, Sorra, & Amatniek, 2007; McIntyre, Marriott, & Gold, 2003). Watch on MyPsychLab

Watch What Happens with Alzheimer's at www.mypsychlab.com

Experience and Forgetting

What environmental factors contribute to our inability to remember?

Although sometimes caused by biological factors, forgetting can also result from inadequate learning. A lack of attention to critical cues, for example, is a cause of the forgetting commonly referred to as absentmindedness (D. L. Schacter, 1999). For example, if you can't remember where you parked your car, most likely you can't remember because you didn't pay attention to where you parked it.

Forgetting also occurs because, although we attended to the matter to be recalled, we did not rehearse the material enough. Merely "going through the motions" of rehearsal does little good. Prolonged, intense practice results in less forgetting than a few, halfhearted repetitions. Elaborative rehearsal can also help make new memories more durable. When you park your car in space G-47, you will be more likely to remember its location if you think, "G-47. My uncle George is about *47* years old." In short, we cannot expect to remember information for long if we have not learned it well in the first place.

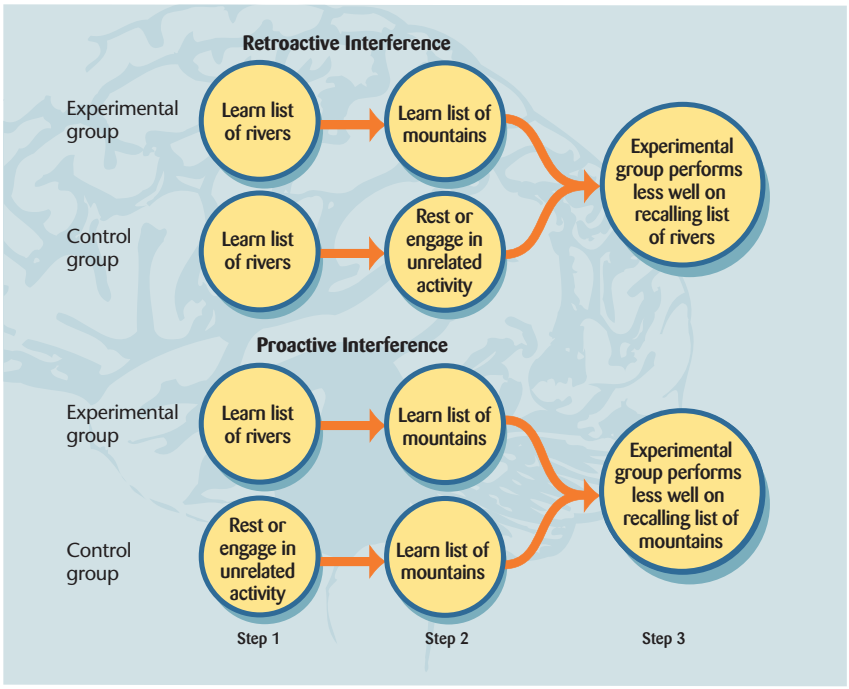

Figure 6–7
Diagram of experiments measuring retroactive and proactive interference.
In retroactive interference, the experimental group usually does not perform as well on tests of recall as those in the control group, who experience no retroactive interference from a list of words in Step 2. In proactive interference, people in the experimental group suffer the effects of proactive interference from the list in Step 1. When asked to recall the list from Step 2, they perform less well than those in the control group.

Interference Inadequate learning accounts for many memory failures, but learning itself can cause forgetting. This is the case because learning one thing can interfere with learning another. Information gets mixed up with, or pushed aside by, other information and thus becomes harder to remember. Such forgetting is said to be due to *interference*. As portrayed in **Figure 6–7**, there are two kinds of interference. In **retroactive interference**, new material interferes with information already in long-term memory. Retroactive interference occurs every day. For example, once you learn a new telephone number, you may find it difficult to recall your old number, even though you used that old number for years.

In the second kind of interference, **proactive interference**, old material interferes with new material being learned. Like retroactive interference, proactive interference is an everyday phenomenon. Suppose you always park your car in the lot behind the building where you work, but one day all those spaces are full, so you have to park across the street. When you leave for the day, you are likely to head for the lot behind the building—and may even be surprised at first that your car is not there. Learning to look for your car behind the building has interfered with your memory that today you parked the car across the street.

The most important factor in determining the degree of interference is the similarity of the competing items. Learning to swing a golf club may interfere with your ability to hit a baseball, but probably won't affect your ability to make a free throw on the basketball courts. The more dissimilar something is from other things that you have already learned, the less likely it will be to mingle and interfere with other material in memory (G. H. Bower & Mann, 1992).

retroactive interference The process by which new information interferes with information already in memory.

proactive interference The process by which information already in memory interferes with new information.

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Situational Factors Whenever we try to memorize something, we are also unintentionally picking up information about the context in which the learning is taking place. That information becomes useful when we later try to retrieve the corresponding information from LTM. If those environmental cues are absent when we try to recall what we learned, the effort to remember is often unsuccessful. Context-dependent memory effects tend to be small, so studying in the same classroom where you are scheduled to take an exam will probably not do too much to improve your grade. Nevertheless, contextual cues are occasionally used by police who sometimes take witnesses back to the scene of a crime in the hope that they will recall crucial details that can be used to solve the crime.

Our ability to accurately recall information is also affected by internal cues, a phenomenon known as *state-dependent memory*. Researchers have found that people who learn material in a particular physiological state tend to recall that material better if they return to the same state they were in during learning (de-l'Etoile, 2002; Kelemen & Creeley, 2003; Riccio, Millin, & Gisquet-Verrier, 2003). For example, if people learn material while under the influence of caffeine, recall of the material is slightly improved when they are again under the influence of caffeine (Kelemen & Creeley, 2003).

The Reconstructive Process Forgetting also occurs because of what is called the "reconstructive" nature of remembering. Earlier, we talked about how schemata are used in storing information in long-term memory. Bartlett proposed that people also use schemata to "reconstruct" memories (Bartlett, 1932; D. L. Schacter, Norman, & Koutstaal, 1998). This reconstructive process can lead to huge errors. Indeed, we are sometimes more likely to recall events that never happened than events that actually took place (Brainerd & Reyna, 1998)! The original memory is not destroyed; instead, people are sometimes unable to tell the difference between what actually happened and what they merely heard about or imagined (Garry & Polaschek, 2000; S. R. Schmidt, 2004; S. E. Taylor, Pham, Rivkin, & Armor, 1998).

We may also reconstruct memories for social reasons or personal self-defense (Feeney & Cassidy, 2003). Each time you tell someone the story of an incident, you may unconsciously make subtle changes in the details of the story. Consequently, these changes become part of your memory of the event. When an experience doesn't fit our view of the world or ourselves, we tend, unconsciously, to adjust it or to blot it out of memory altogether (Bremner & Marmar, 1998). Such distortions of memory become critically important in criminal trials, in which a person's guilt or innocence may depend on the testimony of an eyewitness—a topic we will return to later in this chapter.

SUMMARY TABLE

FACTORS THAT AFFECT FORGETTING

Factor	Effect
Decay	Information in memory deteriorates with the passage of time
Retrograde amnesia	Storage of new information is disrupted; most often due to injury
Hippocampal damage	Damage to the hippocampus interferes with the formation of new memories; often caused by brain injury, advanced aging or Alzheimer's disease
Retroactive interference	Learning new material interferes with information already stored in memory
Proactive interference	Information already stored in memory interferes with learning new material
Situational factors	Attempting to remember something in a different situation or internal state may negatively impact memory
Reconstruction	Memories are reconstructed or replaced with incorrect information which is often more consistent with a current image or perception

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CHECK YOUR UNDERSTANDING

Match the following terms with their appropriate definitions:

1. ___ retrograde amnesia
2. ___ retroactive interference
3. ___ proactive interference

a. forgetting because new information makes it harder to remember information already in memory
b. forgetting because old information in memory makes it harder to learn new information
c. can result from head injury or electroconvulsive therapy

Answers: 1. c. 2. a. 3. b.

APPLY YOUR UNDERSTANDING

1. You are trying to explain to someone that "forgetting" sometimes occurs because of the reconstructive nature of long-term memory. Which of the following would be an example that you might use to support your position?
   a. People can distinguish between real and fictional accounts in narratives.
   b. People who learn material in a particular setting tend to recall that material better if they return to that same setting.
   c. Rote rehearsal with no intention to remember has little effect on long-term memory.
   d. People often rewrite their memories of past events to fit their current view or desired view of themselves.
2. You are given a chance to earn $10 if you can correctly learn a list of 20 words. You have 5 minutes to learn the entire list. At the end of that time, you can recite the list perfectly. But before you are given a chance to show what you have learned, you are required to learn a second list of similar words. When it comes time to show how well you learned the first list, to your dismay, you discover that you have forgotten half the words that you once knew perfectly! What is the most likely cause of your forgetting the words on the first list?
   a. negative transfer
   b. retroactive interference
   c. retroactive facilitation
   d. proactive interference

Answers: 1. d. 2. b.

SPECIAL TOPICS IN MEMORY

What factors can influence how well you remember a specific incident?

Now that we have reviewed the various types of memory and how our memory for different events is stored in the brain, we will turn our attention to some special factors that affect memory.

LEARNING OBJECTIVES

- **Describe the influence of culture on memory.**
- **Define autobiographical memory and describe the several theories that attempt to explain childhood amnesia.**
- **Describe examples of extraordinary memory (including eidetic imagery and flashbulb memories).**
- **Discuss the accuracy of eyewitness testimony and recovered memories.**

Cultural Influences

Are the memory tasks in Western schools different from those in cultures that pass on traditions orally?

Remembering has practical consequences for our daily life and takes place within a particular context. It's not surprising, then, that many researchers believe that the values and customs of a given culture have a profound effect on what and how easily people remember (Confino & Fritzsche, 2002; Shebani, van de Vijver, & Poortinga, 2008). In many Western cultures, for example, being able to recite a long list of words or numbers, to repeat the details of a scene, and to provide facts and figures about historical events are all signs of a "good memory." In fact, tasks such as these are often used to test people's memory abilities.

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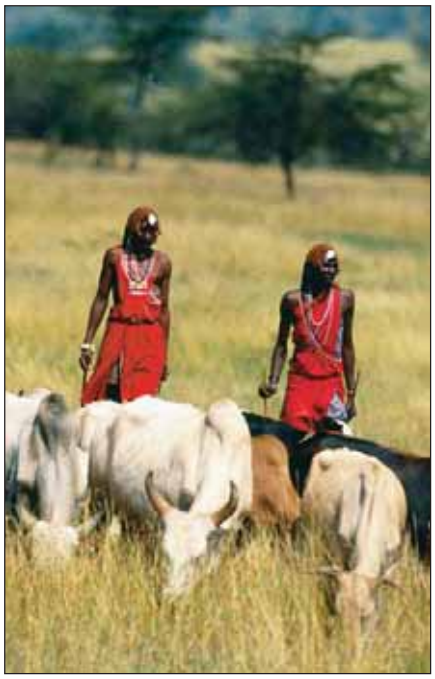

Look carefully at these cows and try to notice significant distinguishing characteristics of each animal. Is this task difficult for you? It probably is, unless you have been working closely with cattle all your life, as these two people have.

However, these kinds of memory tasks do not necessarily reflect the type of learning, memorization, and categorization skills taught in non-Western schools. Members of other cultures often perform poorly on such memory tests because the exercises seem so odd to them.

In contrast, consider the memory skills of a person living in a society in which cultural information is passed on from one generation to the next through a rich oral tradition. Such an individual may be able to recite the deeds of the culture's heroes in verse or rattle off the lines of descent of families, larger lineage groups, and elders. Or perhaps the individual has a storehouse of information about the migration of animals or the life cycles of plants that help people to obtain food and to know when to harvest crops.

ENDURING ISSUES

Diversity–Universality Memory and Culture

Frederic Bartlett, whose work on memory was discussed earlier in this chapter, anticipated the intertwining of memory and culture long ago. Bartlett (1932) related a tale of a Swazi cowherd who had a prodigious memory for facts and figures about cattle. The cowherd could recite, with virtually no error, the selling price, type of cattle bought, and circumstances of the sale for purchases dating back several years. These skills are not surprising when you know that in Swazi culture the care and keeping of cattle are very important in daily life, and many cultural practices focus on the economic and social importance of cattle. In contrast, Bartlett reported, Swazi children did no better than his young European participants in recalling a 25-word message. Stripped of its cultural significance, their memory performance was not exceptional. More recent research showed that college students in Ghana, a culture with a strong oral tradition, were much better than college students in New York at remembering a short story they had heard (Matsumoto, 2000). ■

Autobiographical Memory

What kinds of events are most likely to be remembered?

Why do we have so few memories from the first 2 years of life?

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Autobiographical memory refers to our recollection of events that happened in our life and when those events took place (Koriat, Goldsmith, & Pansky, 2000; K. Nelson & Fivush, 2004); as such, it is a form of episodic memory. As Martin Conway (1996, p. 295) contends, "autobiographical memory is central to self, to identity, to emotional experience, and to all those attributes that define an individual." Explore on MyPsychLab

In general, recent life events are, of course, easier to recall than earlier ones. In a classic study of autobiographical memory, researchers asked young adults to report the earliest personal memory that came to mind when they saw each of 20 words and then to estimate how long ago each event had occurred. The words were all common nouns, such as *hall* and *oven*, for which people can easily create images. In general, most personal memories concerned relatively recent events: The longer ago an event occurred, the less likely people were to report it (Crovitz & Schiffman, 1974). Other research, however, shows that people over age 50 are more likely than younger people to recall events from relatively early in life, probably because many of the most critical choices we make in our lives occur in late adolescence and early adulthood (Janssen, Chessa, & Murre, 2005; Mackavey, Malley, & Stewart, 1991).

Exactly how the vast amount of autobiographical information stored in memory is organized is not fully understood, but research in this area has supported two interesting theories. It may be that we store autobiographical information according to important events in our lives, such as beginning college, getting married, or experiencing the death of a loved one. This view explains why we can usually remember when events occurred relative to these major landmarks in our lives (Shum, 1998). We may also store autobiographical

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memories in *event clusters*, which are groups of memories on a related theme or that take place close together in time (N. R. Brown, 2005; N. R. Brown & Schopflocher, 1998). However, it is important to remember that like all memory, autobiographical memory is not always accurate, though its accuracy does increase when distinctive cues are present to help elicit the recall of information (McDonough & Gallo, 2008).

ENDURING ISSUES

Stability–Change Childhood Amnesia

Despite the richness of our autobiographical memories, research shows that people rarely if ever recall events that occurred before they were 2 years old (Howe, 2003). This phenomenon is sometimes called **childhood amnesia**, or *infantile amnesia*.

Exactly why people have difficulty remembering events from their first years of life is not well understood, although several explanations have been advanced (Q. Wang, 2003). One hypothesis holds that childhood amnesia is a result of the child's brain not being fully developed at birth. Consistent with this line of reasoning, Patricia Bauer and her colleagues (Bauer, 2008; Bauer, Burch, Scholin, & Güler, 2007) found that memories formed early in life may not consolidate properly because the specific regions of the brain devoted to memory consolidation are not yet fully developed, and as such remain vulnerable to interference. Childhood amnesia may also be linked to language skills: Young children do not have the language skills necessary to strengthen and consolidate early experiences (Hudson & Sheffield, 1998; Simcock & Hayne, 2002). Other research suggests that age-related changes in encoding, retention, and retrieval processes that accompany the transition from infancy to early childhood account for childhood amnesia (Hayne, 2004). Still other researchers contend appropriate cues and repetition are the primary influences on efficient recall, not age (Bauer, 1996). Further research is needed before we can evaluate each of these alternative explanations. ■

Extraordinary Memory

What is photographic memory?

Some people are able to perform truly amazing feats of memory. From time to time, the newspaper will carry a report of a person with a "photographic memory." This phenomenon, called **eidetic imagery**, enables people to see the features of an image in minute detail, sometimes even to recite an entire page of a book they read only once.

One study screened 500 elementary schoolchildren before finding 20 with eidetic imagery (Haber, 1969). The children were told to scan a picture for 30 seconds, moving their eyes to see all its various parts. The picture was then removed, and the children were told to look at a blank easel and report what they saw in an eidetic image. They needed at least 3 to 5 seconds of scanning to produce an image, even when the picture was familiar. In addition, the quality of eidetic imagery seemed to vary from child to child. One girl in this study could move and reverse images and recall them several weeks later. Three children could produce eidetic images of three-dimensional objects; and some could superimpose an eidetic image of one picture onto another and form a new picture. However, the children with eidetic imagery performed no better than their noneidetic classmates on other tests of memory.

One of the most famous documented cases of extraordinary memory comes from the work of the distinguished psychologist Alexander Luria (Luria & Solotaroff, 1987). For over 20 years, Luria studied a Russian newspaper reporter named Shereshevskii ("S"). In *The Mind of a Mnemonist* (1968), Luria described how "S" could recall masses of senseless trivia as well as detailed mathematical formulas and complex arrays of numbers. He could easily repeat lists of up to 70 words or numbers after having heard or seen them only once.

childhood amnesia The difficulty adults have remembering experiences from their first two years of life.

eidetic imagery The ability to reproduce unusually sharp and detailed images of something one has seen.

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Millions of people will forever have a vivid flashbulb memory of planes flying into the twin towers of the World Trade Center in New York City on September 11, 2001.

"S" and other people with exceptional memories were not born with a special gift for remembering things. Rather, they have carefully developed memory techniques using certain principles. For example, Luria discovered that when "S" studied long lists of words, he would form a graphic image for every item. When reading a long and random list of words, for example, "S" might visualize a well-known street, specifically associating each word with some object along the way. When asked to recite the lists of words, he would take an imaginary walk down that street, recalling each object and the word associated with it. By organizing his data in a way that was meaningful to him, he could more easily link them to existing material in his long-term memory.

Developing an exceptional memory takes time and effort (Ericsson, Delaney, Weaver, & Mahadevan, 2004; Wilding & Valentine, 1997). **Mnemonists** (pronounced nee-MON-ists), people who are highly skilled at using memory techniques, frequently have compelling reasons for developing their memories. "S" used his memory skills to his advantage as a newspaper reporter. As we will see in the next chapter, chess masters also sometimes display astonishing recall of meaningful chessboard configurations (Campitelli, Gobet, & Parker, 2005; Haberlandt, 1997).

Flashbulb Memories

Are flashbulb memories always accurate?

A **flashbulb memory** is the experience of remembering vividly a certain event and the incidents surrounding it even after a long time has passed. We often remember events that are shocking or otherwise highly significant in this way (Cubelli & Della Sala, 2008; Wooffitt, 2005). The death of a close relative, a birth, a graduation, or a wedding day may all elicit flashbulb memories. So can dramatic events in which we were not personally involved, such as the attacks on the World Trade Center and the Pentagon on September 11, 2001 (Edery & Nachson, 2004; Talarico & Rubin, 2003): 97% of Americans surveyed 1 year after the September 11 attacks claimed they could remember exactly where they were and what they were doing when they first heard about the attacks (Pew Research Center for the People and the Press, 2002).

The assumptions that flashbulb memories are accurate, that they form at the time of an event, and that we remember them better because of their highly emotional content have all been questioned (Talarico & Rubin, 2007). First, flashbulb memories are certainly not always accurate. Although this is a difficult contention to test, let's consider just one case. Psychologist Ulric Neisser vividly recalled what he was doing on the day in 1941 when the Japanese bombed Pearl Harbor. He clearly remembered that he was listening to a professional baseball game on the radio, which was interrupted by the shocking announcement. But professional baseball is not played in December, when the attack took place, so this sharp flashbulb memory was simply incorrect (Neisser, 1982).

Even if an event is registered accurately, it may undergo periodic revision, just like other long-term memories (Cubelli & Della Sala, 2008). We are bound to discuss and rethink a major event many times, and we probably also hear a great deal of additional information about that event in the weeks and months after it occurs. As a result, the flashbulb memory may undergo reconstruction and become less accurate over the years until it sometimes bears little or no resemblance to what actually happened.

mnemonists People with highly developed memory skills.

flashbulb memory A vivid memory of a certain event and the incidents surrounding it even after a long time has passed.

Eyewitness Testimony

How much can we trust eyewitness testimony?

I know what I saw! When an eyewitness to a crime gives evidence in court, that testimony often overwhelms evidence to the contrary. Faced with conflicting or ambiguous testimony,

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jurors tend to put their faith in people who saw an event with their own eyes. However, there is now compelling evidence that this faith in eyewitnesses is often misplaced (Sporer, 2008; D. B. Wright & Loftus, 2008).

For more than 20 years, Elizabeth Loftus (1993; Loftus & Pickrell, 1995; D. B. Wright & Loftus, 2008) has been the most influential researcher into eyewitness memory. In a classic study, Loftus and Palmer (1974) showed experimental participants a film depicting a traffic accident. Some of the participants were asked, "About how fast were the cars going when they hit each other?" Other participants were asked the same question, but with the words *smashed into*, *collided with*, *bumped into*, or *contacted* in place of *hit*. The researchers discovered that people's reports of the cars' speed depended on which word was inserted in the question. Those asked about cars that "smashed into" each other reported that the cars were going faster than those who were asked about cars that "contacted" each other. In another experiment, the participants were also shown a film of a collision and then were asked either "How fast were the cars going when they hit each other?" or "How fast were the cars going when they smashed into each other?" One week later, they were asked some additional questions about the accident that they had seen on film the week before. One of the questions was "Did you see any broken glass?" More of the participants who had been asked about cars that had "smashed into" each other reported that they had seen broken glass than did participants who had been asked the speed of cars that "hit" each other. These findings illustrate how police, lawyers, and other investigators may, often unconsciously, sway witnesses and influence subsequent eyewitness accounts. On the basis of experiments like these, Loftus and Palmer concluded that eyewitness testimony is unreliable.

Why do eyewitnesses make mistakes? Some research suggests that the problem may be *source error*: People are sometimes unable to tell the difference between what they witnessed and what they merely heard about or imagined (Garry & Polaschek, 2000; Hekkanen & McEvoy, 2005; Kleider, Pezdek, Goldinger, & Kirk, 2008; Reyna & Titcomb, 1997). This is especially true for young children (Shapiro, 2002; K. L. Thierry & Spence, 2002). Indeed, studies have shown that imagining an event sometimes makes people believe it actually happened (Garry & Polaschek, 2000; Henkel, Franklin, & Johnson, 2000; Mazzoni & Memon, 2003). Similarly, if you hear information about an event you witnessed, you might later confuse your memory of that information with your memory of the original event. For instance, studies have shown that if an eyewitness receives confirming feedback after picking a suspect out of a police lineup, or has the opportunity to meet with a co-witness who shares their memory for the event, their confidence in the accuracy of their memory increases (Mori & Mori, 2008; Neuschatz et al., 2005; D. B. Wright & Skagerberg, 2007). The impact of subsequent information seems to be particularly strong when it is repeated several times (Zaragoza & Mitchell, 1996), as is often the case with extensive media coverage, or when it comes from an authority figure such as a police officer (Roper & Shewan, 2002). Other studies have shown that simply describing the perpetrator shortly after the incident occurs actually interferes with memories of what the person actually looked like, thus making it more difficult for the eyewitness to pick the correct person out of a lineup at a later date (B. Bower, 2003a; Fiore & Schooler, 2002).

Whatever the reason for eyewitness errors, there is good evidence that such mistakes can send thousands of innocent people to jail each year in the United States (Pezdek, 2007). For example, based almost entirely on the eyewitness identification testimony of a single individual, Steven Avery was convicted of brutally attacking, raping, and nearly killing a woman in 1985 and was sentenced to 32 years in prison. Although Avery offered alibis from 14 witnesses and documentation showing he wasn't at the scene of the crime, it took repeated legal challenges and new advances in DNA testing for him to overcome the conviction. Finally, on September 11, 2003, Mr. Avery was exonerated of all charges and released from prison. Increasingly, courts are recognizing the limits of eyewitness testimony (Kassin, Tubb, Hosch, & Memon, 2001; E. Rubinstein, 2008).

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Recovered Memories

Can people be persuaded to "create" new memories about events that never occurred?

In recent years, a controversy has raged, both within the academic community and in society at large, about the validity of *recovered memories* (Boag, 2007; Cerri, 2005; Geraerts & McNally, 2008; Geraerts, McNally, Jelicic, Merckelbach, & Raymaekers, 2008; Gerkens, 2005; Loftus, Garry, & Hayne, 2008). The idea is that people experience an event, then lose all memory of it, and then later recall it, often in the course of psychotherapy or under hypnosis. Frequently, the recovered memories concern physical or sexual abuse during childhood. The issue is important not only for theoretical reasons, but also because of the fact that people have been imprisoned for abuse solely on the basis of the recovered memories of their "victims" (Geraerts, Raymaekers, & Merckelbach, 2008). Adding to this confusion is research that shows children's memories are particularly influenced by negative emotions. Thus, when recalling events associated with an uncomfortable experience, such as abuse, children are more likely to make factual errors than when recalling neutral or positive events (Brainerd, Stein, Silveira, Rohenkold, & Reyna, 2008). No one denies the reality of childhood abuse or the damage that such experiences cause. But are the recovered memories real? Did the remembered abuse really occur? **Simulate** on **MyPsychLab**

Simulation on Creating False Memories at www.mypsychlab.com

The answer is by no means obvious. There is ample evidence that people can be induced to "remember" events that never happened (S. M. Smith et al, 2003). Research confirms that it is relatively easy to implant memories of an experience merely by asking about it. Sometimes these memories become quite real to the participant. In one experiment, 25% of adults "remembered" fictitious events by the third time they were interviewed about them. One of the fictitious events involved knocking over a punch bowl onto the parents of the bride at a wedding reception. At the first interview, one participant said that she had no recollection whatsoever of the event; by the second interview, she "remembered" that the reception was outdoors and that she had knocked over the bowl while running around. Some people even "remembered" details about the event, such as what people looked like and what they wore. Yet, the researchers documented that these events never happened (Hyman, Husband, & Billings, 1995).

The implication of this and similar research is that it is quite possible for people to "remember" abusive experiences that never happened. And some people who have "recovered" abuse memories have later realized that the events never occurred. Some of these people have brought suit against the therapists who, they came to believe, implanted the memories. In one case, a woman won such a suit and was awarded $850,000 (Imrie, 1999; also see Geraerts, Raymaekers, & Merckelbach, 2008).

However, there is reason to believe that not all recovered memories are merely the products of suggestion. There are numerous case studies of people who have lived through traumatic experiences, including natural disasters, accidents, combat, assault, and rape, who then apparently forgot these events for many years, but who later remembered them (Arrigo

THINKING CRITICALLY ABOUT . . .

Eyewitness Testimony

T. R. Benton, Ross, Bradshaw, Thomas, and Bradshaw (2006) studied 111 jurors drawn from a jury pool in Hamilton County, Tennessee. Using a questionnaire with 30 statements about eyewitness testimony (Kassin et al., 2001), they found that jurors significantly disagreed with eyewitness experts on more than 85% of the items. For example, 98% of the experts agreed that "Police instructions can affect an eyewitness's willingness to make an identification," but only 41% of the jurors agreed. Eighty-one percent of the experts agreed that "Eyewitnesses sometimes identify as a culprit someone they have seen in another situation or context"; only 30% of the jurors agreed. And while 91% of the experts agreed that "Hypnosis increases suggestibility to leading and misleading questions," only 24% of the jurors agreed with that statement. The authors concluded that jurors "exhibit important limitations in their knowledge of eyewitness issues; their knowledge diverges significantly from expert opinion, and it is not high in overall accuracy" (p. 126).

1. What questions might you raise about the authors' conclusion? For example, do you think that their sample of jurors is representative of jurors throughout the United States? If so, why do you think so? If not, in what ways do you think it differed significantly and how do you think that might have affected their results?
2. The authors note that ". . . it is not surprising to find numerous and varied reasons offered by courts across the country for excluding testimony from eyewitness experts. One of the most commonly cited reasons is that eyewitness memory is common sense to jurors, and thus an eyewitness expert is simply not necessary." Do you agree that testimony from eyewitness experts "is simply not necessary"? Why or why not? Are there some circumstances when such testimony might be more valuable than others? How might you go about determining whether, in fact, expert testimony is valuable at least sometimes?

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& Pezdek, 1997). For example, Wilbur J. Scott, a sociologist, claimed to remember nothing of his tour of duty in Vietnam during 1968–1969, but during a divorce in 1983, he discovered his medals and souvenirs from Vietnam, and the memories then came back to him (Arrigo & Pezdek, 1997).

What is needed is a reliable way of separating real memories from false ones, but so far no such test is available (Gleaves, Smith, Butler, & Spiegel, 2004). The sincerity and conviction of the person who "remembers" long-forgotten childhood abuse is no indication of the reality of that abuse. We are left with the conclusion that recovered memories are not, in themselves, sufficiently trustworthy to justify criminal convictions. There must also be corroborative evidence, since without corroboration, there is no way that even the most experienced examiner can separate real memories from false ones (Loftus, 1997).

CHECK YOUR UNDERSTANDING

Is each of the following statements true (T) or false (F)?

1. Retrograde amnesia is the phenomenon that we seldom remember events that occurred before our second birthday.
2. A long-lasting and vivid memory for a certain event and the incidents surrounding it is called a flashbulb memory.
3. Research demonstrates that it is nearly impossible to change a person's memory once that memory has been stored.

Answers: 1. (F). 2. (T). 3. (F).

APPLY YOUR UNDERSTANDING

1. You are talking with someone from a different culture who is not very good at remembering long lists of random words or numbers, but who can recite from memory all of his ancestors going back hundreds of years. What is the most likely explanation for this difference in memory skills?
   a. The values and customs of a given culture have a profound effect on what people remember.
   b. The person's autobiographical memory is stronger than his semantic memory.
   c. The list of his ancestors has been stored in flashbulb memory.
   d. The list of his ancestors is an example of a "recovered memory."
2. Your mother is reminiscing about your first birthday party and asks you, "Do you remember when Aunt Mary dropped her piece of cake in your lap?" Try as you might, you can't recall that incident. This is most likely an example of
   a. memory decay.
   b. retrograde amnesia.
   c. infantile amnesia.
   d. proactive interference.

Answers: 1. a. 2. c.

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KEY TERMS

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information-processing model, *p. 187*

The Sensory Registers
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THE SENSORY REGISTERS

What is the role of sensory registers? Many psychologists view **memory** as a series of steps in which we encode, store, and retrieve information, much as a computer does. This is called the **information-processing** model of memory. The first step in the model is inputting data through our senses into temporary holding bins, called **sensory registers**. These registers give us a brief moment to decide whether something deserves our attention.

What would happen if auditory information faded as quickly as visual information fades? Information entering a sensory register disappears very quickly if it isn't processed further. Information in the visual register lasts for only about a quarter of a second before it is replaced by new information. If sounds faded from our auditory register as rapidly as this, spoken language would be more difficult to understand. Luckily, information in the auditory register can linger for several seconds.

Why does some information capture our attention, while other information goes unnoticed? The next step in the memory process is **attention**—selectively looking at, listening to, smelling, tasting, or feeling what we deem to be important. The nervous system filters out peripheral information, allowing us to zero in on what is essential at a particular time. Unattended information receives at least some processing, however, so that we can quickly shift attention to it if it suddenly strikes us as significant.

SHORT-TERM MEMORY

What are the two primary tasks of short-term memory? How much information can be held in short-term memory? **Short-term memory** (**STM**), also called *working memory*, holds whatever information we are actively attending to at any given time. Its two primary tasks are to store new information briefly and to "work" on information that we currently have in mind. We can process more information in STM by grouping it into larger meaningful units, a process called **chunking**.

Do we store material in short-term memory as it sounds or as it looks? Information can be stored in STM according to the way it sounds, the way it looks, or its meaning. Verbal information is encoded by sound, even if it is written rather than heard. The capacity for visual encoding in STM is greater than for encoding by sound.

How can we hold information in STM? Through **rote rehearsal**, or maintenance rehearsal, we retain information in STM for a minute or two by repeating it over and over again. However, rote memorization does not promote long-term memory.

LONG-TERM MEMORY

What types of information are retained in long-term memory? **Long-term memory** (**LTM**) stores everything we learn.

What is the limit of LTM? Long-term memory can store a vast amount of information for many years.

How are most memories encoded in LTM? Most of the information in LTM seems to be encoded according to its meaning.

Which items in a list are hardest to remember? Short- and long-term memory work together to explain the **serial position effect**, in which people tend to recall the first and last items in a list better than items in the middle. The *recency effect* explains that items at the end are still held in STM, whereas the *primacy effect* describes the extra LTM rehearsal given to items early in the list.

What three processes are used to hold information in LTM? The way in which we encode material for storage in LTM affects the ease with which we can retrieve it later on. Rote rehearsal is particularly useful for holding conceptually meaningless material, such as phone numbers, in LTM. Through the deeper and more meaningful mechanism of **elaborative rehearsal**, we extract the meaning of information and link it to as much material as possible that is already in LTM. Memory techniques such as **mnemonics** rely on elaborative processing.

A **schema** is a mental representation of an object or event that is stored in memory. Schemata provide a framework into which incoming information is fitted. They may prompt the formation of stereotypes and the drawing of inferences.

How do types of LTM differ? **Episodic memories** are personal memories for events experienced in a specific time and place. **Semantic memories** are facts and concepts not linked to a particular time. **Procedural memories** are motor skills and habits. **Emotional memories** are learned emotional responses to various stimuli.

What are the differences between implicit and explicit memories? **Explicit memory** refers to memories we are aware of, including episodic and semantic memories. **Implicit memory** refers to memories for information that either was not intentionally committed to LTM or is retrieved unintentionally from LTM, including procedural and emotional memories. This distinction is illustrated by research on *priming*, in which people are more likely to complete fragments of stimuli with items seen earlier than with other, equally plausible items.

THE BIOLOGY OF MEMORY

What role do neurons play in memory? Memories consist of changes in the chemistry and structure of neurons. The process by which these changes occur is called **long-term potentiation** (**LTP**).

Are STM and LTM found in the same parts of the brain? Different parts of the brain are specialized for the storage of memories. Short-term memories seem to be located primarily in the prefrontal cortex and temporal lobe. Long-term memories seem to involve both subcortical and cortical structures. Semantic and episodic memories seem to be located primarily in the frontal and temporal lobes of the cortex, and procedural memories appear to be located primarily in the cerebellum and motor cortex. The hip-

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pocampus seems especially important in the formation of semantic, episodic, and procedural memories. Emotional memories are dependent on the amygdala.

What role does sleep play in memory? During deep sleep, the same hippocampal neurons and patterns of neuron activity that accompany initial learning are reactivated. As a result, new memories are further strengthened.

FORGETTING

What factors explain why we sometimes forget? Both biological and experiential factors can contribute to our inability to recall information.

How does the deterioration of the brain help to explain forgetting? According to the **decay theory**, memories deteriorate because of the passage of time. Severe memory loss can be traced to brain damage caused by accidents, surgery, poor diet, or disease. Head injuries can cause **retrograde amnesia**, the inability of people to remember what happened shortly before their accident. The hippocampus may have a role in long-term memory formation. Below-normal levels of the neurotransmitter acetylcholine may be implicated in memory loss seen in Alzheimer's disease.

What environmental factors contribute to our inability to remember? To the extent that information is apparently lost from LTM, researchers attribute the cause to inadequate learning or to interference from competing information. Interference may come from two directions: In **retroactive interference**, new information interferes with old information already in LTM; **proactive interference** refers to the process by which old information already in LTM interferes with new information.

When environmental cues present during learning are absent during recall, context-dependent forgetting may occur. The ability to recall information is also affected by one's physiological state when the material was learned; this process is known *as state-dependent memory*.

Sometimes we "reconstruct" memories for social or personal self-defense. Research on long-term memory and on forgetting offers ideas for a number of steps that can be taken to improve recall.

SPECIAL TOPICS IN MEMORY

What factors can influence how well you remember a specific incident? Cultural values and customs profoundly affect what people remember and how easily they recall it. So do the emotions we attach to a memory, with some emotion-laden events being remembered for life. Also affecting how well we remember are the strategies we use to store and retrieve information.

Are the memory tasks in Western schools different from those in cultures that pass on traditions orally? Many Western schools stress being able to recall long lists of words, facts, and figures that are divorced from everyday life. In contrast, societies in which cultural information is passed on through a rich oral tradition may instead emphasize memory for events that directly affect people's lives.

What kinds of events are most likely to be remembered? *Autobiographical memory* refers to recollection of events from one's life. Not all of these events are recalled with equal clarity, of course, and some are not recalled at all. Autobiographical memories are typically strongest for events that had a major impact on our lives or that aroused strong emotion.

Why do we have so few memories from the first 2 years of life? People generally cannot remember events that occurred before age 2, a phenomenon called **childhood amnesia**. Childhood amnesia may result from the incomplete development of brain structures before age 2, from the infants' lack of a clear sense of self, or from the lack of language skills used to consolidate early experience. Research also suggests it may be related to an adult's inability to recall memories that were, in fact, stored during the first 2 years.

What is a photographic memory? People with exceptional memories have carefully developed memory techniques. **Mnemonists** are individuals who are highly skilled at using those techniques. A phenomenon called **eidetic imagery** enables some people to see features of an image in minute detail.

Are flashbulb memories always accurate? Years after a dramatic or significant event occurs, people often report having vivid memories of that event as well as the incidents surrounding it. These memories are known as **flashbulb memories**. Recent research has challenged the assumptions that flashbulb memories are accurate and stable.

How much can we trust eyewitness testimony? Jurors tend to put their faith in witnesses who saw an event with their own eyes. However, some evidence suggests that eyewitnesses sometimes are unable to tell the difference between what they witnessed and what they merely heard about or imagined.

Can people be persuaded to "create" new memories about events that never occurred? There are many cases of people who experience a traumatic event, lose all memory of it, but then later recall it. Such recovered memories are highly controversial, since research shows that people can be induced to "remember" events that never happened. So far there is no clear way to distinguish real recovered memories from false ones.

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