THE WORLD OF PSYCHOLOGY, PORTABLE EDITION

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SAMPLE CHAPTER 6

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6 Memory

How accurate is your memory? Franco Magnani was born in 1934 in Pontito, an ancient village in the hills of Tuscany, Italy. His father died when Franco was eight. Soon after that, Nazi troops occupied the village. The Magnani family lived through many years of hardship, at times facing starvation. With the help of the village priest, Franco fulfilled a lifelong dream when he emigrated to the United States in 1958 and settled in San Francisco.

Several years after his arrival in America, Magnani developed a serious illness that required him to stop working for a prolonged period. Troubled and homesick, he decided to take up painting as a hobby. His first effort was a painting of the house in which he had grown up. He had no photograph of the house—only the pictures he carried in his mind. When he had completed the painting, he sent a photograph of it to his mother, who had also left Pontito. Her enthusiasm for the painting and the memories it brought back to her encouraged Magnani to paint more scenes of his hometown. Working entirely from his own memories, Magnani painted a series of pictures of Pontito and the surrounding countryside, scenes that he had not actually seen for decades. Many of Magnani's paintings are extraordinarily accurate when compared with photographs of the originals. For example, look at the photograph of the house in which the artist grew up and at his painting of the house. Here Magnani paints not only the house but also a view of his mother inside the house, laying the table for a meal, himself as a boy of about five looking in at her.

Photograph

Painting

As you can see, the painting is a very accurate rendering of the house, but it differs from the photograph in several striking ways. For one, Magnani probably had never actually seen his mother preparing a meal in the way he has shown it in the painting. Instead, the scene he paints represents an inference derived from the connections among the house, his experiences as a young boy, and his mother's cooking that exist in his memory. Likewise, the front steps are much steeper in the painting than in the photograph, suggesting that Magnani remembered the height of each step from the point of view of a small child. Again, the steps and his perspective on them as a boy are interconnected in his memory, perhaps inseparably so. Clearly, too, the painting is imbued with a warmth not evident in the photo. This warmth, no doubt, emanates from the artist's fondness for the

places he paints and for a time that is long gone. Thus, the scene Magnani has painted depicts elements that could never have been represented in a photograph. They are the unique product of his memory.

As Magnani's painting suggests, human memory does not function like a tape recorder or a camera in that objective bits of information constitute only one facet of any memory. To these, our memory system adds other pieces of information that are in some way associated with them, as well as emotions and perspectives that are entirely subjective. In this chapter, you will read what psychologists have learned about the fascinating processes that, together, make up human memory.

6.1 REMEMBERING

Psychologists think of remembering as involving three processes: encoding, storage, and retrieval (see Figure 6.1). The first process, **encoding, is the transformation of information into a form that can be stored.** For example, if you witness a car crash, you might try to form a mental picture of it to enable yourself to remember it. The second process, **storage, involves keeping or maintaining information. For encoded information to be stored, some physiological change must take place in the brain—a process called consolidation.** The final process, **retrieval, occurs when information is brought to mind.** To remember something, you must perform all three processes—encode the information, store it, and then retrieve it. Thus, **memory is a cognitive process that includes encoding, storage, and retrieval of information.**

The Atkinson-Shiffrin Model

What are the characteristics of each component of memory in the Atkinson-Shiffrin model?

How are memories stored? Most current efforts to understand human memory are conducted within a framework known as the *information-processing approach* (Klatzky, 1984). This approach makes use of modern computer science and related fields to provide models that help psychologists understand the processes involved in memory (Kon & Plaskota, 2000).

According to one widely accepted information-processing memory model, the *Atkinson-Shiffrin model*, there are three different, interacting memory systems: sensory memory, short-term memory, and long-term memory (Atkinson & Shiffrin, 1968; Broadbent, 1958). We will examine each of these three memory systems, which are shown in Figure 6.2.

FIGURE 6.1 The Processes Required for Remembering

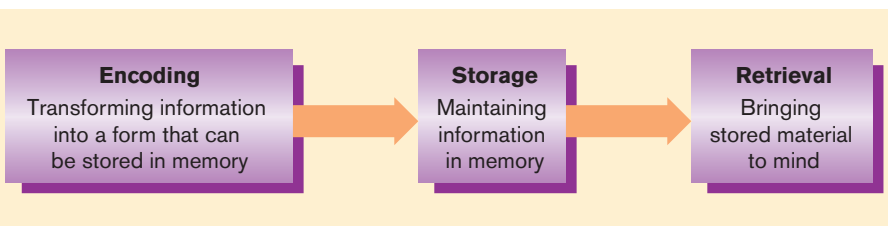
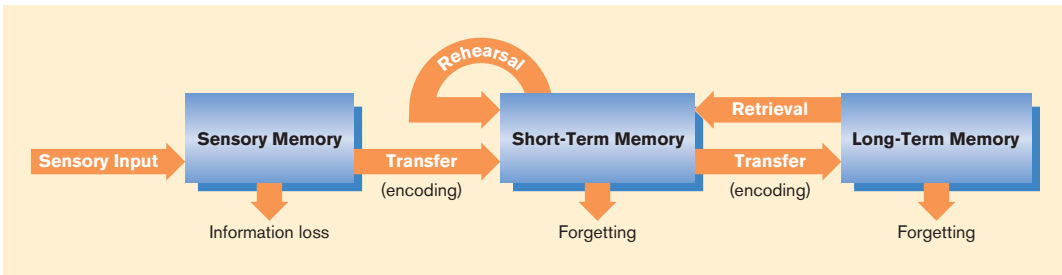


FIGURE 6.2 The Three Memory Systems

According to the Atkinson-Shiffrin model, there are three separate memory systems: sensory memory, short-term memory, and long-term memory.

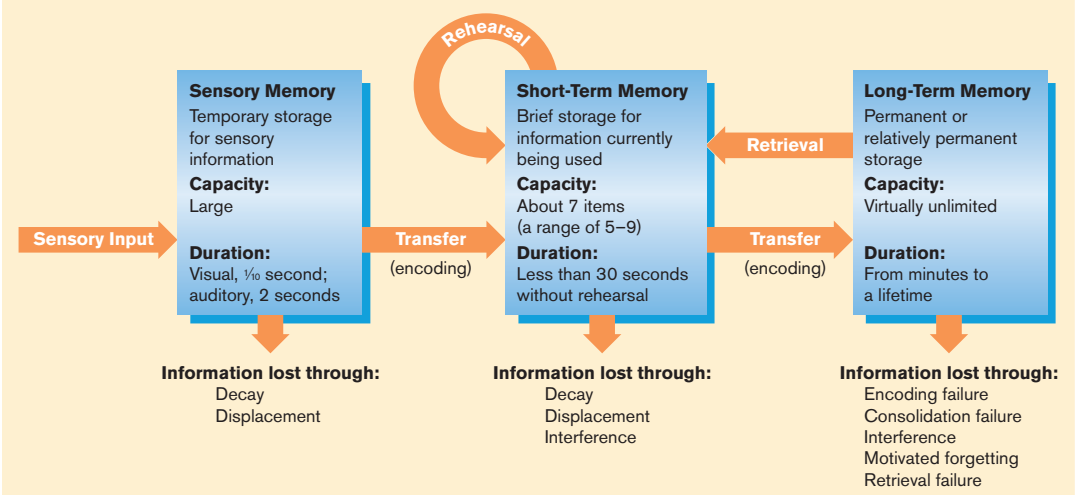


Sensory Memory Imagine yourself driving down a city street. How many separate pieces of information are you sensing? You are probably seeing, hearing, feeling, and smelling millions of tiny bits of information every minute. But how many of them do you remember? Very few, most likely. That's because, although virtually everything we see, hear, or otherwise sense is held in **sensory memory, the memory system that holds information from the senses for a period of time ranging from only a fraction of a second to about 2 seconds.** As shown in Figure 6.3, sensory memory normally holds visual images for a fraction of a second and sounds for about

FIGURE 6.3 Characteristics of and Processes Involved in the Three Memory Systems

The three memory systems differ in what and how much they hold and for how long they store it.

Source: Peterson & Peterson (1959).



2 seconds (Crowder, 1992; Klatzky, 1980). Visual sensory memory lasts just long enough to keep whatever you are viewing from disappearing when you blink your eyes. You experience auditory sensory memory when the last few words someone has spoken seem to echo briefly in your head. So, sensory memory functions a bit like a strainer; that is, most of what flows into it immediately flows out again.

Exactly how long does visual sensory memory last? Glance at the three rows of letters shown below for a fraction of a second, and then close your eyes. How many of the letters can you recall?

X B D F
M P Z G
L C N H

Most people can correctly recall only four or five of the letters when they are briefly presented. Does this indicate that visual sensory memory can hold only four or five letters at a time? To find out, researcher George Sperling (1960) briefly flashed 12 letters, as shown above, to participants. Immediately upon turning off the display, he sounded a high, medium, or low tone that signaled the participants to report only the top, middle, or bottom row of letters. Before they heard the tone, the participants had no way of knowing which row they would have to report. Yet Sperling found that, when the participants could view the rows of letters for $^{15}/_{1000}$ to $^{1}/_{2}$ second, they could report correctly all the items in any one row nearly 100% of the time. But the items faded from sensory memory so quickly that during the time it took to report three or four of them, the other eight or nine had already disappeared.

Sensory memory holds a visual image, such as a lightning bolt, for a fraction of a second—just long enough for you to perceive a flow of movement.

Short-Term Memory

So, you might be thinking, if almost everything flows out of sensory memory, how do we ever remember anything? Fortunately, our ability to attend allows us to grab onto some sensory information and send it to the next stage of processing, short-term memory (STM). Whatever you are thinking about right now is in your STM (see Figure 6.3). **Unlike sensory memory, which holds virtually the exact sensory stimulus, short-term memory usually codes information according to sound and holds about seven (plus or minus two) different items or bits of information at one time.** For example, the letter *T* is coded as the sound "tee," not as the shape T. This is just enough for phone numbers and ordinary zip codes. (Nine-digit zip codes strain the capacity of most people's STM.) When short-term memory is filled to capacity, displacement can occur. **In displacement, each new, incoming item pushes out an existing item, which is then forgotten.** Think of what happens when the top of your desk gets too crowded. Things start to "disappear" under other things; some items even fall off the desk. So, you can remember that short-term memory is the limited component of the memory system by associating it with the top of your desk: The desk is limited in size, causing you to lose things when it gets crowded, and the same is true of short-term memory.

One way to overcome the limitation of seven or so bits of information is to use a strategy that George A. Miller (1956), a pioneer in memory research, calls **chunking—organizing or grouping separate bits of information into larger units, or chunks.** A *chunk* is an easily identifiable unit such as a syllable, a word, an acronym, or a number (Cowan, 1988). For example, nine digits, such as 5 2 9 7 3 1 3 2 5, can be divided into three more easily memorized chunks, 529 73 1325. (Notice that this is the form of social security numbers in the United States.)

Anytime you chunk information on the basis of knowledge stored in long-term memory, that is, by associating it with some kind of meaning, you increase the effective capacity of short-term memory (Lustig & Hasher, 2002). And when you increase the effective capacity of short-term memory, you are more likely to transfer information to long-term memory. (*Hint:* The headings and subheadings, *Remember It* questions, and margin questions in this textbook help you sort information into manageable chunks. You will remember more of a chapter if you use them as organizers for your notes and as cues to recall information when you are reviewing for an exam.)

The duration of short-term memory **Items in short-term memory are lost in less than 30 seconds unless you repeat them over and over to yourself, a process known as rehearsal**. But rehearsal is easily disrupted. It is so fragile, in fact, that an interruption can cause information to be lost in just a few seconds. Distractions that are stressful are especially likely to disrupt short-term memory. And a threat to survival certainly does, as researchers showed when they pumped the odor of a feared predator, a fox, into a laboratory where rats were performing a task requiring short-term memory—the rats' performance plummeted (Morrison et al., 2002; Morrow et al., 2000).

How long does short-term memory last if rehearsal is prevented? In a series of early studies, participants were briefly shown three consonants (such as H, G, and L) and then asked to count backward by threes from a given number (738, 735, 732, and so on) (Peterson & Peterson, 1959). After intervals lasting from 3 to 18 seconds, participants were instructed to stop counting backward and recall the three letters. Following a delay of 9 seconds, the participants could recall an average of only one of the three letters. After 18 seconds, there was practically no recall whatsoever. An 18-second distraction had completely erased the three letters from short-term memory.

Short-term memory as working memory Allan Baddeley (1990, 1992, 1995) has suggested that "working memory" is a more fitting term than short-term memory. This memory system is where you work on information to understand it, remember it, or use it to solve a problem or to communicate with someone. Research shows that the prefrontal cortex is the brain area primarily responsible for working memory (Courtney et al., 1997; Rao et al., 1997).

So, just what kind of "work" goes on in working memory? One of the most important working memory processes is the application of *memory strategies*, such as chunking. Using a memory strategy involves manipulating information in ways that make it easier to remember. We use some memory strategies almost automatically, but others require more effort. For example, sometimes we repeat information over and over again until we can recall it easily. (Remember learning those multiplication tables in elementary school?) This strategy, sometimes called *rote rehearsal*, may work well

for remembering telephone numbers, license plate numbers, and even the multiplication tables, especially when combined with chunking. However, it isn't the best way to remember more complex information, such as the kind you find in a textbook. For this kind of information, the best memory is probably **elaborative rehearsal**, **which involves relating new information to something you already know.**

How does elaborative rehearsal work? Here is an example. Suppose you are taking a French class and have to learn the word *éscaliers*, which is equivalent to *stairs* in English. You might remember the meaning of *éscaliers* by associating it with the English word *escalator*.

Long-Term Memory

What happens next? If information is processed effectively in short-term memory, it makes its way to long-term memory. **Long-term memory (LTM) is a person's vast storehouse of permanent or relatively permanent memories** (refer to Figure 6.3). There are no known limits to the storage capacity of this memory system, and long-term memories can last for years, some of them for a lifetime. Information in long-term memory is usually stored in semantic form, although visual images, sounds, and odors can be stored there, as well.

Some experts believe that there are two main subsystems within long-term memory. The first, **declarative memory (also called *explicit memory*) stores facts, information, and personal life events that can be brought to mind verbally or in the form of images and then declared or stated.** It holds information that we intentionally and consciously recollect. There are two types of declarative memory: episodic memory and semantic memory.

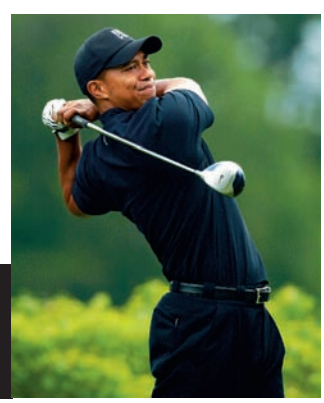
Episodic memory is the type of declarative memory that records events as they have been subjectively experienced (Wheeler et al., 1997). It is somewhat like a mental diary, a record of the episodes of your life—the people you have known, the places you have seen, and the personal experiences you have had. According to Canadian psychologist Endel Tulving (1989), "episodic memory enables people to travel back in time, as it were, into their personal past, and to become consciously aware of having witnessed or participated in events and happenings at earlier times" (p. 362). Using episodic memory, a person might make this statement: "I remember being in Florida on my vacation last spring, lying on the sand, soaking up some rays, and listening to the sound of the waves rushing to the shore."

Semantic memory, **the other type of declarative memory, is memory for general knowledge, or objective facts and information.** In other words, semantic memory is a mental dictionary or encyclopedia of items like these:

Dictionary is spelled d-i-c-t-i-o-n-a-r-y.

10 times 10 equals 100.

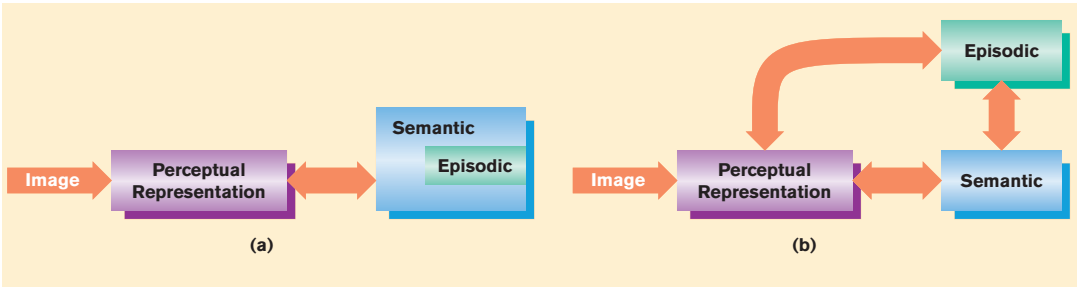
The three memory systems are sensory, short-term, and long-term.



Declarative memories involve facts, information, and personal life events, such as a trip to a foreign country. Nondeclarative memory encompasses motor skills, such as the expert swing of professional golfer Tiger Woods.

FIGURE 6.4 Two Models of the Relationship of Episodic and Semantic Memory

(a) Tulving's (1995) model shows the dependence of episodic memory on semantic memory. (b) The model of Graham and others (2000) shows the reliance of episodic memory on perceptual input and semantic memory.



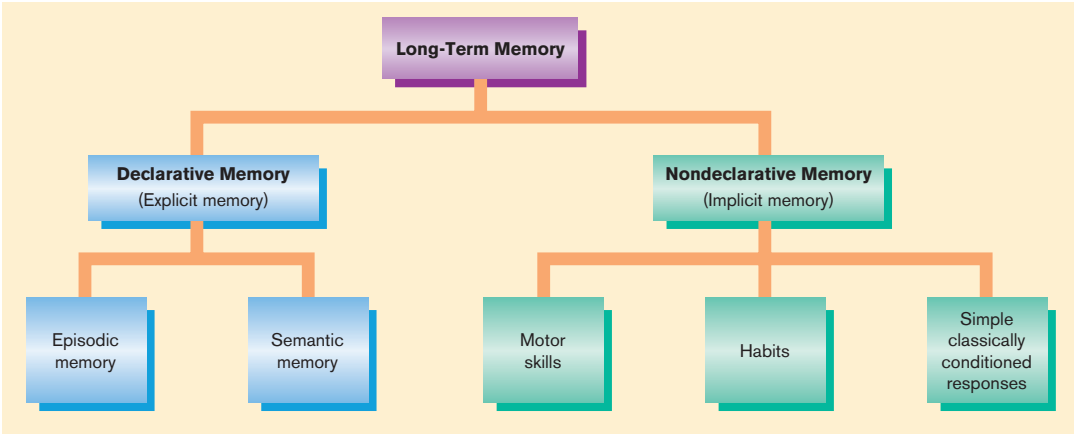
Brain-imaging studies show that the left hemisphere shows more activity than the right when a person is accessing semantic memory (Koivisto & Revensuo, 2000). Does this imply that the two types of declarative memory work independently? Could major damage be done to semantic memory without affecting episodic memory? Not according to Tulving (1995), who hypothesizes that episodic memory is dependent on the functioning of semantic memory; see Figure 6.4(a). However, researchers have recently demonstrated that some people who have suffered selective damage to their long-term semantic memory can still learn and remember using episodic memory (Graham et al., 2000). Patients with "semantic dementia" perform poorly on semantic tasks, such as picture naming, giving examples of general categories (e.g., household items), and sorting words or pictures into specified categories (e.g., living versus nonliving things). Yet their episodic memory is mainly unaffected (Hodges et al., 1995; Snowden et al., 1996). Figure 6.4(b) shows that although episodic and semantic memory are connected, episodic memory can store perceptual information without direct aid from or dependence on semantic memory (Graham et al., 2000).

Nondeclarative memory (also called *implicit memory*) is the subsystem within long-term memory that stores motor skills, habits, and simple classically conditioned responses (Squire et al., 1993). Motor skills are acquired through repetitive practice and include such things as eating with a fork, riding a bicycle, or driving a car. Although acquired slowly, once learned, these skills become habit, are quite reliable, and can be carried out with little or no conscious effort. For example, you probably use the keyboard on a computer without consciously being able to name the keys in each row from left to right. Figure 6.5 shows the two subsystems of long-term memory.

Associated with nondeclarative, or implicit, memory is a phenomenon known as priming, by which an earlier encounter with a stimulus (such as a word or a picture) increases the speed or accuracy of naming that stimulus or a related stimulus at a later time. Such improvement occurs without the person's conscious awareness of having previously seen or heard the stimulus. For example, a researcher might flash the word *elephant* on a computer screen so briefly that it is not

FIGURE 6.5 Subsystems of Long-Term Memory

Declarative memory can be divided into two subsystems: episodic memory, which stores memories of personally experienced events, and semantic memory, which stores facts and information. Nondeclarative memory consists of motor skills acquired through repetitive practice, habits, and simple classically conditioned responses.



consciously perceived by a viewer. But if asked later to name as many animals as come to mind, the viewer is quite likely to include "elephant" on the list (Challis, 1996).

Priming can influence not only performance, but preferences and behavior as well. Individuals exposed briefly (even subliminally) to pictures of abstract art showed greater preferences for that type of art than did others who did not see the pictures. And in one study, participants subliminally exposed to faces of real people later interacted with those people more than did individuals not exposed to the photos (Basic Behavioral Science Task Force, 1996).

The Levels-of-Processing Model

How does the levels-of-processing model differ from that proposed by Atkinson and Shiffrin?

Not all psychologists support the notion of three memory systems. **Craik and Lockhart** (1972) **proposed instead a levels-of-processing model which suggested that whether people remember something for a few seconds or a lifetime depends on how deeply they process the information.** With the shallowest levels of processing, a person is merely aware of incoming sensory information. Deeper processing takes place only when the person does more with the new information, such as forming relationships, making associations, attaching meaning to a sensory impression, or engaging in active elaboration on new material. However, the deeper levels of processing that establish a memory also require background knowledge, so that lasting connections can be formed between the person's existing store of knowledge and the new information (Willoughby et al., 2000).

Craik and Tulving (1975) tested the levels-of-processing model. They had participants answer "yes" or "no" to questions asked about words just before the words were flashed to them for 1/5 of a second. The participants had to process the words in three ways: (1) visually (is the word in capital letters?); (2) acoustically (does the word rhyme with another particular word?); and (3) semantically (does the word make sense when used in a particular sentence?). Thus, this test required shallow processing for the first question, deeper processing for the second question, and still deeper processing for the third question. Later retention tests showed that the deeper the level of processing, the higher the accuracy of memory. But this conclusion is equally valid for the three-system model. Some brain-imaging studies with *f*MRI revealed that semantic (deeper) encoding causes greater activity in the left prefrontal cortex (Gabrieli et al., 1996). Other studies of how brain activity is related to depth of (semantic) processing reveal two kinds of memory-related activity: information search and information retrieval (Rugg et al., 2000).

Three Kinds of Memory Tasks

What are the three methods used by psychologists to measure memory?

How many times have you recognized someone without being able to recall his or her name? This happens to everyone because recognition is an easier memory task than recall. A great deal of memory research has focused on understanding the differences between the two. Researchers have also studied another kind of memory task known as relearning.

Recall

Do you do well on essay tests? Most students prefer other kinds of exams, because essay tests usually require test takers to recall a lot of information. **In recall, a person must produce required information simply by searching memory.** Trying to remember someone's name, the items on a shopping list, or the words of a speech or a poem is a recall task. Which of the following test questions do you think is more difficult?

What are the three basic memory processes?

Which of the following is *not* one of the three basic memory processes?

a. encoding b. storage c. retrieval d. relearning

Most people think the second question is easier because it requires only recognition, whereas the first involves recall.

A recall task may be made a little easier if cues are provided to jog memory. **A retrieval cue is any stimulus or bit of information that aids in retrieving a particular memory.** Such a cue might consist of providing the first letters of the required words for fill-in-the-blank questions:

The three processes involved in memory are e_____, s_____, and r_____.

Sometimes *serial recall* is required; that is, information must be recalled in a specific order. This is the way you learned your ABCs, memorized poems, and learned

any sequences that had to be carried out in a certain order. Serial recall is often easier than *free recall*, or remembering items in any order. In serial recall, each letter, word, or task may serve as a cue for the one that follows. Indeed, research suggests that, in recall tasks, order associations are more resistant to distractions than meaningful associations are (Howard, 2002).

You may fail to recall information in a memory task even if you are given many retrieval cues, but this does not necessarily mean that the information is not in long-term memory. You might be able to remember it if a recognition task is used.

Recognition

Recognition is exactly what the name implies—a memory task in which a person must simply identify material as familiar (a face, a name, a task, a melody) or as having been encountered before. Multiple-choice, matching, and true/false questions are examples of test items based on recognition. The main difference between recall and recognition is that a recognition task does not require you to supply the information but only to recognize it when you see it. The correct answer is included along with other items in a recognition question.

Recent brain-imaging studies have discovered that the hippocampus plays an extensive role in memory tasks involving recognition and that the degree of hippocampal activity varies depending on the exact nature of the task. When the task is recognizing famous faces, widespread brain activity takes place in both hemispheres, involving the prefrontal and temporal lobes and including the hippocampus and the surrounding hippocampal region. Less widespread brain activity is observed during the recognition of recently encoded faces or the encoding of faces seen for the first time (Henson et al., 2002). Studies with monkeys whose brain damage is limited to the hippocampal region show conclusively that this region is absolutely essential for normal recognition tasks (Teng et al., 2000; Zola et al., 2000).

Relearning

There is another, more sensitive way to measure memory. **With the relearning method, retention is expressed as the percentage of time saved when material is relearned relative to the time required to learn the material originally.** Suppose it took you 40 minutes to memorize a list of words, and 1 month later you were tested on those words, using recall or recognition. If you could not recall or recognize a single word, would this mean that you had absolutely no memory of anything on the list? Or could it mean that the recall and recognition tasks were not sensitive enough to measure what little information you may have stored? How could a researcher measure such a remnant of former learning? Using the relearning method, a researcher could time how long it would take you to relearn the list of words. If it took 20 minutes to relearn the list, this would represent a 50% savings over the original learning time of 40 minutes. **The percentage of time saved—the savings score—reflects how much material remains in long-term memory.**

College students demonstrate the relearning method each semester when they study for comprehensive final exams. Relearning material for a final exam takes less time than it took to learn the material originally.

Remember It 6.1

1. Transforming information into a form that can be stored in memory is the process of _____; bringing to mind the material that has been stored is the process of _____.

2. Match each memory system with the best description of its capacity and the duration of time it holds information.

   ____ (1) sensory memory
   ____ (2) short-term memory
   ____ (3) long-term memory

   a. virtually unlimited capacity; long duration
   b. large capacity; short duration
   c. very limited capacity; short duration

3. _____ memory does not require consciousness.

4. Match each task with the corresponding method of measuring memory:

   ____ (1) identifying a suspect in a lineup
   ____ (2) answering a fill-in-the-blank question on a test
   ____ (3) having to study less for a comprehensive final exam than for all of the previous exams put together
   ____ (4) answering a matching or multiple-choice question on a test
   ____ (5) reciting one's lines in a play

   a. recognition
   b. relearning
   c. recall

ANSWERS: 1. encoding, retrieval; 2. (1) b, (2) c, (3) a; 3. Nondeclarative; 4. (1) a, (2) c, (3) b, (4) a, (5) c

6.2 THE NATURE OF REMEMBERING

Do you agree with Wilder Penfield (1969), a Canadian neurosurgeon, who claimed that experiences leave a "permanent imprint on the brain . . . as though a tape recorder had been receiving it all" (p. 165)? Penfield (1975) performed over 1,100 operations on patients with epilepsy. He found that when parts of the temporal lobes were stimulated with an electrical probe, 3.5% of patients reported flashback experiences, as though they were actually reliving parts of their past. After reviewing Penfield's findings, other researchers offered different explanations for his patients' responses. Neisser (1967) suggested that the experiences patients reported were "comparable to the content of dreams," rather than the recall of actual experiences (p. 169). Does human memory really function like a tape or video recorder? Probably not.

Memory as a Reconstruction

What is meant by the statement "Memory is reconstructive in nature"?

Other than Penfield's work, there is no research to suggest that memory works like a video recorder, capturing every part of an experience exactly as it happens. Normally, what a person recalls is not an exact replication of an event, according to Elizabeth Loftus, a leading memory researcher. Rather **a memory is a reconstruction—an account pieced together from a few highlights, using information that may or may not be accurate** (Loftus & Loftus, 1980). Put another way, "memory is not so much like reading a book as it is like writing one from fragmentary notes" (Kihlstrom, 1995, p. 341). Ample evidence indicates that memory is quite often inaccurate. "Critical details of an experience can be forgotten or become distorted, their source and order may be misremembered, and under certain circumstances completely new details may be incorporated into a memory" (Conway et al., 1996, p. 69). Recall is, even for people with the most accurate memories, partly truth and partly fiction. For example when people recall an event, such as a car accident, they are actually reconstructing it from memory by piecing together bits of information that may or may not be totally accurate. This was the finding of another pioneer in memory research, Englishman Sir Frederick Bartlett.

The Work of Frederick Bartlett

Sir Frederick Bartlett (1886–1969) studied memory by giving participants stories to read and drawings to study; then, after varying time intervals, he had them reproduce the original material. Accurate reports were rare. The participants seemed to reconstruct the material they had learned, rather than actually remember it. They recreated the stories, making them shorter and more consistent with their own individual viewpoints. They adapted puzzling features of the stories to fit their own expectations and often changed details, substituting more familiar objects or events. Errors in memory increased with time, and Bartlett's participants were not aware that they had partly remembered and partly invented. Ironically, the parts his participants had created were often the parts they most adamantly claimed to have remembered (Bartlett, 1932).

Bartlett concluded that people systematically distort the facts and the circumstances of experiences. Information already stored in long-term memory exerts a strong influence on how people remember new information and experiences. As Bartlett (1932) put it, "the past is being continually remade, reconstructed in the interest of the present" (p. 309).

Schemas and Memory

Bartlett suggested that his participants' inaccuracies in memory reflected their schemas—the integrated frameworks of knowledge and assumptions they had about people, objects, and events which affect how the person encodes and recalls information. Schemas aid in processing large amounts of material, because they provide frameworks into which people can incorporate new information and experience. Schemas also provide association cues that can help in retrieval.

Once formed, schemas influence what we notice and how we encode and recall information. When we encounter new information or have a new experience related to an

existing schema, we try to make it fit or be consistent with that schema. To accomplish this, we may have to distort some aspects of the information and ignore or forget other aspects. Some of the distorting and ignoring occurs as the material is being encoded; more can occur when we try to remember or reconstruct the original experience.

Distortion in Memory When people reconstruct memories, they do not purposely try to distort the actual experience—unless, of course, they are lying. But people tend to omit some details that actually occurred and to supply other details from their own imaginations. *Distortion* occurs when people alter the memory of an event or an experience in order to fit their beliefs, expectations, logic, or prejudices. The tendency toward systematic distortion of actual events has been proven many times. *Try It* demonstrates distortion in memory.

The *Try It* shows that we are very likely to alter or distort what we see or hear to make it fit with what we believe to be true. All the words on the list are related to sleep, so it seems logical that *sleep* should be one of the words. In experiments using word lists similar to the one in the *Try It*, between 40% and 55% of the participants "remembered" a key related word that was not on the list (Roediger & McDermott, 1995). If you added the word *sleep* when doing the *Try It*, you created a false memory, which probably seemed as real to you as a true memory (Dodson et al., 2000).

The tendency to distort makes the world more understandable and enables people to organize their experiences into their existing systems of beliefs and expectations. But this tendency often causes gross inaccuracies in what people remember. And they usually distort memories of their own lives in a positive direction. Bahrick and others (1996) found that 89% of college students accurately remembered the A's they earned in high school, but only 29% accurately recalled the D's. The most dramatic examples of systematic distortion often occur in eyewitness testimony.

Eyewitness Testimony

What conditions reduce the reliability of eyewitness testimony?

According to Elizabeth Loftus (1993a), a staggering number of wrongful convictions in the United States each year are based on eyewitness testimony. According to Huff (1995), the number is

Try It

Creating a False Memory

Read this list of words aloud at a rate of about one word per second. Then close your book, and write down all the words you can remember.

bed	awake	dream	snooze	nap	snore
rest	tired	wake	doze	yawn	slumber

Now check your list. Did you "remember" the word *sleep*? Many people do, even though it is not one of the words on the list (Deese, 1959).

probably at least 10,000. Yet it was not until October 1999 that the U.S. Department of Justice prepared the first national guidelines for the collection of eyewitness evidence (Wells et al., 2000).

Studies on the accuracy of human memory suggest that eyewitness testimony is highly subject to error, and that it should always be viewed with caution (Loftus, 1979). Nevertheless, it does play a vital role in the U.S. justice system. According to Loftus (1984), "We can't afford to exclude it legally or ignore it as jurors. Sometimes, as in cases of rape, it is the only evidence available, and it is often correct" (p. 24).

The composition of this police lineup is consistent with research findings that suggest that all individuals in a lineup should be similar to the suspect with respect to age, race, body build, and other physical characteristics.

Fortunately, eyewitness mistakes can be minimized. Eyewitnesses to crimes typically identify suspects from a lineup. If shown photographs of a suspect before viewing the lineup, eyewitnesses may mistakenly identify that suspect in the lineup because the person looks familiar. Research suggests that it is better to have an eyewitness first describe the perpetrator and then search for photos matching that description than to have the eyewitness start by looking through photos and making judgments as to their similarity to the perpetrator (Pryke et al., 2000).

The composition of the lineup is also important. Other subjects in a lineup must resemble the suspect in age, body build, and certainly race. Even then, if the lineup does not contain the guilty party, eyewitnesses may identify the person who most closely resembles the perpetrator (Gonzalez et al., 1993). Eyewitnesses are less likely to make errors if a sequential lineup is used—that is, if the members of the lineup are viewed one after the other, rather than simultaneously (Loftus, 1993a). Some police officers and researchers prefer a "showup," in which the witness sees only one suspect at a time and indicates whether or not that person is the perpetrator. There are fewer misidentifications with a showup, but also more failures to make a positive identification (Wells, 1993).

Eyewitnesses are more likely to identify the wrong person if the person's race is different from their own. According to Egeth (1993), misidentifications are approximately 15% higher in cross-race than in same-race identifications. Misidentification is also somewhat more likely to occur when a weapon is used in a crime. The witnesses may pay more attention to the weapon than to the physical characteristics of the criminal (Steblay, 1992).

Even the questioning of witnesses after a crime can influence what they later remember. Because leading questions can substantially change a witness's memory of an event, it is critical that the interviewers ask neutral questions (Leichtman & Ceci, 1995). Misleading information supplied after the event can result in erroneous recollections of the actual event, a phenomenon known as the *misinformation effect* (Kroll et al., 1988; Loftus & Hoffman, 1989). Loftus (1997) and her students have conducted "more than 20 experiments involving over 20,000 participants that document how exposure to misinformation induces memory distortion" (p. 71). Furthermore, after eyewitnesses have repeatedly recalled information, whether it is accurate or inaccurate, they become even more confident when they testify in court because the information is so easily retrieved (Shaw, 1996).

Witnessing a crime is highly stressful. How does stress affect eyewitness accuracy? Research suggests that eyewitnesses do tend to remember the central, critical details of the event, even though their arousal is high, but the memory of less important details suffers (Burke et al., 1992; Christianson, 1992).

Furthermore, as was demonstrated by Jennifer Thompson in this chapter's opening story, the confidence eyewitnesses have in their testimony is not necessarily an indication of its accuracy (Loftus, 1993a; Sporer et al., 1995). In fact, eyewitnesses who perceive themselves to be more objective have more confidence in their testimony, regardless of its accuracy, and are more likely to include incorrect information in their verbal descriptions (Geiselman et al., 2000). When witnesses make incorrect identifications with great certainty, they can be highly persuasive to judges and jurors alike. "A false eyewitness identification can create a real-life nightmare for the identified person, friends, and family members. . . . False identifications also mean that the actual culprit remains at large—a double injustice" (Wells, 1993, p. 568).

Recovering Repressed Memories

What is the controversy regarding the therapy used to recover repressed memories of childhood sexual abuse?

Do you believe that unconscious memories of childhood abuse can lead to serious psychological disorders? Perhaps because of the frequency of such cases in fictional literature, on television, and in movies, many people in the United States apparently do believe that so-called repressed memories can cause problems in adulthood (Stafford & Lynn, 2002). Such beliefs have also been fostered by self-help books such as *The Courage to Heal*, published in 1988, by Ellen Bass and Laura Davis. This best-selling book became the "bible" for sex abuse victims and the leading "textbook" for some therapists who specialized in treating them. Bass and Davis not only sought to help survivors who remember having suffered sexual abuse, but also reached out to other people who had no memory of any sexual abuse and tried to help them determine whether they might have been abused. They suggested that "if you are unable to remember any specific instances . . . but still have a feeling that something abusive happened to you, it probably did" (p. 21). They offered a definite conclusion: "If you think you were abused and your life shows the symptoms, then you were" (p. 22). And they freed potential victims of sexual abuse from the responsibility of establishing any proof: "You are not responsible for proving that you were abused" (p. 37).

However, many psychologists are skeptical about such "recovered" memories, claiming that they are actually false memories created by the suggestions of therapists. Critics "argue that repression of truly traumatic memories is rare" (Bowers & Farvolden, 1996, p. 355). Moreover, they maintain that "when it comes to a serious trauma, intrusive thoughts and memories of it are the most characteristic reaction" (p. 359). Repressed-memory therapists believe, however, that healing hinges on their patients' being able to recover their repressed memories.

Critics further charge that recovered memories of sexual abuse are suspect because of the techniques therapists usually use to uncover them—namely, hypnosis and guided imagery. As you have learned (in Chapter 4), hypnosis does not improve the accuracy of memory, only the confidence that what one remembers is accurate. And a therapist using guided imagery might tell a patient something similar to what Wendy Maltz (1991) advocates in her book:

> Spend time imagining that you were sexually abused, without worrying about accuracy, proving anything, or having your ideas make sense. . . . Ask yourself . . . these questions: What time of day is it? Where are you? Indoors or outdoors? What kind of things are happening? (p. 50)

Can merely imagining experiences in this way lead people to believe that those experiences had actually happened to them? Yes, according to some studies. Many research participants who are instructed to imagine that a fictitious event happened do, in fact, develop a false memory of that imagined event (Hyman et al., 1995; Hyman & Pentland, 1996; Loftus & Pickrell, 1995; Mazzoni & Memon, 2003; Worthen & Wood, 2001).

False childhood memories can also be experimentally induced. Garry and Loftus (1994) were able to implant a false memory of being lost in a shopping mall at 5 years of age in 25% of participants aged 18 to 53, after verification of the fictitious experience by a relative. Repeated exposure to suggestions of false memories can create those memories (Zaragoza & Mitchell, 1996). Further, researchers have found that adults who claim to have recovered memories of childhood abuse or of abduction by extraterrestrials are more vulnerable to experimentally induced false memories than are adults who do not report such recovered memories (McNally, 2003). So, individual differences in suggestibility may play a role in the recovery of memories.

Critics are especially skeptical of recovered memories of events that occurred in the first few years of life; in part because the hippocampus, vital in the formation of episodic memories, is not fully developed then. And neither are the areas of the cortex where memories are stored (Squire et al., 1993). Furthermore, young children, who are still limited in language ability, do not store semantic memories in categories that are accessible to them later in life. **The relative inability of older children and adults to recall events from the first few years of life is referred to as infantile amnesia**.

In light of these developmental limitations, is it possible that some individuals cannot recall incidents of childhood sexual abuse? Widom and Morris (1997) found that 64% of a group of women who had been sexually abused as children reported no memory of the abuse in a 2-hour interview 20 years later. Following up on women who had documented histories of sexual victimization, Williams (1994) found that 38% of them did not report remembering the sexual abuse some 17 years later. Memories of abuse were better when the victimization took place between the ages of 7 and 17 than when it occurred in the first 6 years of life. Keep in mind, however, that it is possible that some of these women may have remembered the abuse but, for whatever reason, chose not to admit it.

The American Psychological Association (1994), the American Psychiatric Association (1993), and the American Medical Association (1994) have issued status reports on memories of childhood abuse. The position of all three groups is that current evidence supports both the possibility that repressed memories exist and the likehood that false memories can be constructed in response to suggestions of abuse. This position suggests that recovered memories of abuse should be verified independently before they are accepted as facts. Taking such a position is critically important. As you saw in the *Try It* earlier, false memories are easily formed. And, once formed, they are often relied on with great confidence (Dodson et al., 2000; Henkel et al., 2000).

Unusual Memory Phenomena

What does research evidence say about flashbulb and photographic memories?

Flashbulb Memories: Extremely Vivid Memories

Do you remember where you were and what you were doing when you heard about the tragic events of September 11, 2001? Most people do. Likewise, most people over age 50 claim to have vivid memories of exactly when and where they received the news of the assassination of President John F. Kennedy. And many of their parents have very clear memories of learning about the attack on Pearl Harbor on December 7, 1941, which marked the entry of the United States into World War II. This type of extremely vivid memory is called a flashbulb memory (Bohannon, 1988). **Brown and Kulik (1977) suggest that an extremely vivid memory, or flashbulb memory, is formed when a person learns of an event that is very surprising, shocking, or highly emotional.** You might have a flashbulb memory of when you received the news of the death or the serious injury of a close family member or a friend.

Pillemer (1990) argues that flashbulb memories do not constitute a completely different type of memory. Rather, he suggests, all memories can vary on the dimensions of emotion, consequentiality (the importance of the consequences of the event), and rehearsal (how often people think or talk about the event afterwards). Flashbulb memories rank high in all three dimensions and thus are extremely memorable.

BIOGRAPHY

However, several studies suggest that flashbulb memories are not as accurate as people believe them to be. Neisser and Harsch (1992) questioned university freshmen about the televised explosion of the space shuttle *Challenger* the following morning. When the same students were questioned again 3 years later, one-third gave accounts that differed markedly from those given initially, but these individuals were extremely confident about their recollections. Further, flashbulb memories appear to be forgotten at about the same rate and in the same ways as other kinds of memories (Curci et al., 2001).

Eyewitnesses to the aftermath of the terrorist attacks on the World Trade Center almost certainly formed flashbulb memories of the horrific events they witnessed.

Eidetic Imagery

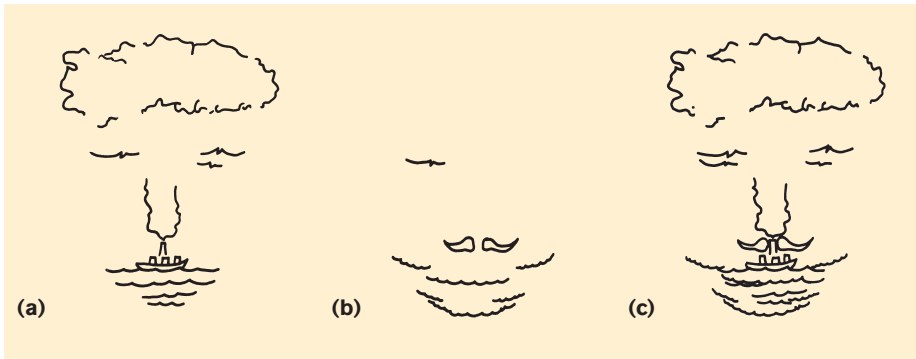
Have you ever wished you had a photographic memory? Psychologists doubt that there are more than a few rare cases of a truly photographic memory, one that captures all the details of an experience and retains them perfectly. But some studies do show that **about 5% of children have something like a photographic memory, an ability psychologists call eidetic imagery** (Haber, 1980). These children can retain the image of a visual stimulus, such as a picture, for several minutes after it has been removed from view and use this retained image to answer questions about the visual stimulus (see Figure 6.6).

Children with eidetic imagery generally have no better long-term memory than others their age. And virtually all children with eidetic imagery lose it before adulthood. One exceptional case, however, is Elizabeth, a teacher and a skilled artist. She can create on canvas an exact duplicate of a remembered scene in all its rich detail. Just as remarkable is her ability to retain visual images of words. "Years after having read a poem in a foreign language, she can fetch back an image of the printed page and copy the poem from the bottom line to the top line as fast as she can write" (Stromeyer, 1970, p. 77).

FIGURE 6.6 Test for Eidetic Imagery

Researchers test children for eidetic imagery by having them stare for 30 seconds at a picture like the one in (a). A few minutes later, the drawing in (b) is shown to the children, who are asked to report what they see. Those with eidetic imagery usually claim that they see a face and describe the composite sketch in (c). The face can be perceived only if the child retains the image of the first picture and fuses it with the middle drawing.

Source: Haber (1980).



Memory and Culture

How does culture influence memory?

Sir Frederick Bartlett (1932) believed that some impressive memory abilities operate within a social or cultural context and cannot be completely understood as a process. He stated that "both the manner and matter of recall are often predominantly determined by social influences" (p. 244). Studying memory in a cultural context, Bartlett (1932) described the amazing ability of the Swazi people of Africa to remember the slight differences in individual characteristics of their cows. One Swazi herdsman, Bartlett claimed, could remember details of every cow he had tended the year before. Such a feat is less surprising when you consider that the key component of traditional Swazi culture is the herds of cattle the people tend and depend on for their living. Do the Swazi people have super memory powers? Bartlett asked young Swazi men and young European men to recall a message consisting of 25 words. In this case, the Swazi had no better recall ability than the Europeans.

Among many tribal peoples in Africa, the history of the tribe is preserved orally by specialists, who must be able to encode, store, and retrieve huge volumes of historical data (D'Azevedo, 1982). Elders of the Iatmul people of New Guinea are also said to have committed to memory the lines of descent for the various clans of their people, stretching back for many generations (Bateson, 1982). The unerring memory of the elders for the kinship patterns of their people are used to resolve disputed property claims (Mistry & Rogoff, 1994).

Barbara Rogoff, an expert in cultural psychology, maintains that such phenomenal, prodigious memory feats are best explained and understood in their cultural context (Rogoff & Mistry, 1985). The tribal elders perform their impressive memory feats

In many traditional cultures, elders are oral historians, remembering and passing on the details of tribal traditions and myths as well as genealogical data.

because it is an integral and critically important part of the culture in which they live. Most likely, their ability to remember nonmeaningful information would be no better than your own.

A study examining memory for location among a tribal group in India, the Asur, who do not use artificial lighting of any kind, provides further information about the influence of culture on memory (Mishra & Singh, 1992). Researchers hypothesized that members of this group would perform better on tests of memory for locations than on memory tests involving word pairs, because, without artificial light, they have to remember where things are in order to be able to move around in the dark without bumping into things. When the tribe members were tested, the results supported this hypothesis: They remembered locations better than word pairs.

In classic research, cognitive psychologists have also found that people more easily remember stories set in their own cultures than those set in others. In one of the first of these studies, researchers told women in the United States and Aboriginal women in Australia a story about a sick child (Steffensen & Calker, 1982). Participants were randomly assigned to groups for whom story outcomes were varied. In one version, the girl got well after being treated by a physician. In the other, a traditional native healer was called in to help the girl. Aboriginal participants better recalled the story with the native healer, while the American women were more accurate in their recall of the story in which a physician treated the girl.

Remember It 6.2

1. _____ found that, rather than accurately recalling information detail by detail, people often reconstruct and systematically distort facts to make them more consistent with past experiences.
2. When a person uses _____ to process information, both encoding and retrieval can be affected.
3. _____ memories are vivid memories of where and when an individual learned of a particularly dramatic event.
4. _____ is the ability to retain the image of a visual stimulus for several minutes after it has been removed from view.

ANSWERS: 1. Bartlett; 2. schemas; 3. Flashbulb; 4. Eidetic imagery

6.3 FACTORS INFLUENCING RETRIEVAL

Why are some kinds of information easier to pull up out of memory than others? Researchers in psychology have identified several factors that influence memory. A person can control some of these factors, but not all of them.

The Serial Position Effect

What happens when information must be recalled in a particular order?

What would happen if you were introduced to a dozen people at a party? You would most likely recall the names of the first few people you met and the last one or two, but forget many of the names in the middle. **The reason is the serial position effect—the finding that, for information learned in a sequence, recall is better for items at the beginning and the end than for items in the middle of the sequence.**

Information at the beginning of a sequence is subject to the primacy effect—the tendency to recall the first items in a sequence more readily than the middle items. Such information is likely to be recalled because it already has been placed in long-term memory. **Information at the end of a sequence is subject to the recency effect—the tendency to recall the last items in a sequence more readily than those in the middle.** This information has an even higher probability of being recalled because it is still in short-term memory. The poorer recall of information in the middle of a sequence occurs because that information is no longer in short-term memory and has not yet been placed in long-term memory. The serial position effect lends strong support to the notion of separate systems for short-term and long-term memory (Postman & Phillips, 1965).

Environmental Context and Memory

How does environmental context affect memory?

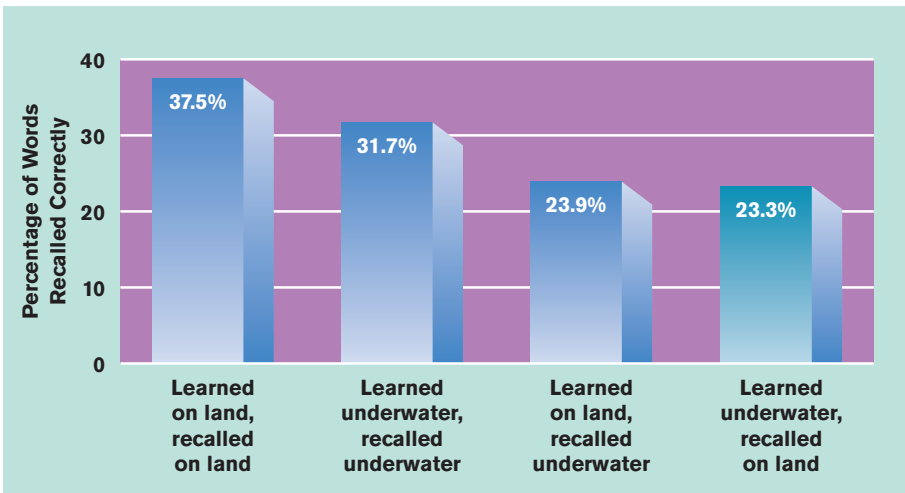
Have you ever stood in your living room and thought of something you needed from your bedroom, only to forget what it was when you got there? Did the item come to mind again when you returned to the living room? Tulving and Thompson (1973) suggest that many elements of the physical setting in which a person learns information are encoded along with the information and become part of the memory. If part or all of the original context is reinstated, it may serve as a retrieval cue. That is why returning to the living room elicits the memory of the object you intended to get from the bedroom. In fact, just visualizing yourself in the living room might do the trick (Smith et al., 1978). (*Hint:* Next time you're taking a test and having difficulty recalling something, try visualizing yourself in the room where you studied.)

Godden and Baddeley (1975) conducted one of the early studies of context and memory with members of a university diving club. Participants memorized a list of words when they were either 10 feet underwater or on land. They were later tested for recall of the words in the same environment or in a different environment. Words learned

FIGURE 6.7 Context-Dependent Memory

Godden and Baddeley showed the strong influence of environmental context on recall. Divers who memorized a list of words, either on land or underwater, had significantly better recall in the same physical context in which the learning had taken place.

Source: Data from Godden & Baddeley (1975).



underwater were best recalled underwater, and words learned on land were best recalled on land. In fact, when the divers learned and recalled the words in the same context, their scores were 47% higher than when the two contexts were different (see Figure 6.7).

In a more recent study of context-dependent memory, participants viewed videotapes and then were tested on their memory of the videos in two separate interviews conducted 2 days apart. The memory context was the same for all the participants, with one exception. Half the participants were questioned by different interviewers, whereas the other half were questioned by the same interviewer in both sessions. As you might expect, participants who were questioned twice by the same interviewer (same context) performed better than the other participants on the memory task (Bjorklund et al., 2000).

Odors can also supply powerful and enduring retrieval cues for memory. In a study by Morgan (1996), participants were placed in isolated cubicles and exposed to a list of 40 words. They were instructed to perform a cognitive task using the words but were not asked to remember them. Then, back in the cubicle 5 days later, participants were unexpectedly tested for recall of the 40 words. Experimental participants who experienced a pleasant odor during learning and again when tested 5 days later had significantly higher recall than did control participants who did not experience the odor during both learning and recall.

The State-Dependent Memory Effect

How do emotions and altered states of consciousness affect memory?

As we have seen, the external environment can influence performance on memory tasks, but might a person's internal state (happy or sad, intoxicated or sober) also do so? The answer is yes. **People tend to recall information better if they are in the same internal state (psychological or pharmacological) as when the information was encoded, psychologists call the state-dependent memory effect.**

Some studies have shown a state-dependent memory effect for alcohol and drugs such as marijuana, amphetamines, and barbiturates (Eich, 1980). Participants learned (encoded) material while sober or intoxicated and were later tested in either the sober or the intoxicated state. Recall was found to be best when the participants were in the same state for both learning and testing (Weingartner et al., 1976). As in other studies, the state-dependent memory effect was evident for recall but not for recognition.

Researchers have not been able to show conclusively that recall is best if participants are in the same happy or sad mood when they encode or learn material as when they try to recall it. However, evidence does suggest that anxiety and fear influence memory. For example, people going through significant life stress—death of a loved one, loss of a job, divorce—do more poorly on tests of recent memories. Further, when researchers exposed college students to spiders and/or snakes while they were learning lists of words, the students recalled more words when the creatures were also present during tests of recall (Lang et al., 2001).

Adults who are clinically depressed tend to recall more negative life experiences (Clark & Teasdale, 1982) and are likely to recall their parents as unloving and rejecting (Lewinsohn & Rosenbaum, 1987). Moreover, a meta-analysis of 48 studies revealed a significant relationship between depression and memory impairment. And recognition and recall were more impaired in younger depressed patients than in older ones (Burt et al., 1995). But, as depression lifts, the tendency toward negative recall and associated memory impairments reverses itself.

Remember It 6.3

1. When children learn the alphabet, they often can recite "A, B, C, D, …" and "…, W, X, Y, Z" before they can recite the letters in between. This is because of the _____.
2. Both _____ and _____ can provide retrieval cues for memories.
3. The _____ happens when individuals acquire information while in a pharmacologically altered state of consciousness or when experiencing a particular emotion.

ANSWERS: 1. serial position effect; 2. context, odors; 3. state-dependent memory effect

6.4 BIOLOGY AND MEMORY

Obviously, a person's vast store of memories must exist physically somewhere in the brain. But where?

The Hippocampus and Hippocampal Region

What rolees do the hippocampus and the hippocampal region play in memory?

Researchers continue to identify specific locations in the brain that house and mediate functions and processes in memory. One important source of information comes from people who have suffered memory loss resulting from damage to specific brain areas. One especially significant case is that of H.M., a man who suffered from such severe epilepsy that, out of desperation, he agreed to a radical surgical procedure. The surgeon removed the part of the brain believed to be causing H.M.'s seizures—the medial portions of both temporal lobes, containing the amygdala and **the hippocampal region, a part of the limbic system, which includes the hippocampus itself and the underlying cortical areas.** It was 1953, and H.M. was 27 years old.

After his surgery, H.M. remained intelligent and psychologically stable, and his seizures were drastically reduced. But unfortunately, the tissue cut from H.M.'s brain housed more than the site of his seizures. It also contained his ability to use working memory to store new information in long-term memory. The capacity of his short-term memory remains the same, and he remembers life events that were stored before the operation. H.M. suffers from **anterograde amnesia—the inability to form long-term memories of events occurring after a brain injury or brain surgery, although memories formed before the trauma are usually intact and short-term memory is unaffected.** He has not been able to remember a single event that has occurred since the surgery. And though H.M. is in his late 70s, as far as his conscious long-term memory is concerned, it is still 1953 and he is still 27 years old.

Surgery affected only H.M.'s declarative, long-term memory—his ability to store facts, personal experiences, names, faces, telephone numbers, and the like. But researchers were surprised to discover that he could still form nondeclarative memories; that is, he could still acquire skills through repetitive practice, although he could not remember having done so. For example, since the surgery, H.M. has learned to play tennis and improve his game, but he has no memory of ever having played (Milner, 1966, 1970; Milner et al., 1968).

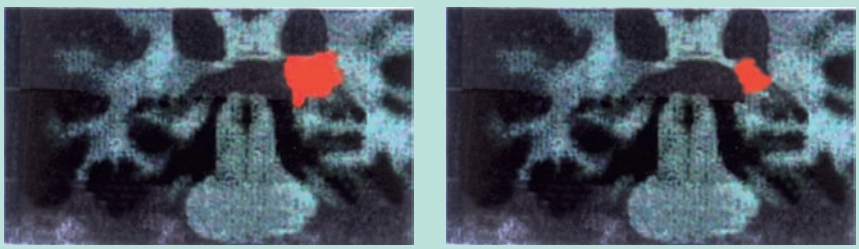
Animal studies support the conclusion that the parts of H.M.'s brain that were removed are critical to working memory function (Ragozzino et al., 2002). Moreover, other patients who have suffered similar brain damage show the same types of memory loss (Squire, 1992).

Most recent research supports the hypothesis that the hippocampus is especially important in forming episodic memories (Eichenbaum, 1997; Eichenbaum & Fortin, 2003; Gluck & Myers, 1997; Spiers et al., 2001). Semantic memory, however, depends not only on the hippocampus, but also on the other parts of the hippocampal region (Vargha-Khadem et al., 1997). Once stored, memories can be retrieved without the involvement of the hippocampus (Gluck & Myers, 1997; McClelland et al., 1995).

FIGURE 6.8 MRI Scans Showing the Larger Size of the Posterior Hippocampus in the Brain of an Experienced Taxi Driver

The posterior (rear) hippocampus of an experienced London taxi driver, shown in red in MRI scan (a), is significantly larger than the posterior hippocampus of a research participant who was not a taxi driver, shown in red in scan (b).

Source: Adapted from Maguire et al. (2000).



Consequently, many researchers argue that neurological underpinnings of episodic and semantic memories are entirely separate (e.g., Tulving, 2002). But the degree to which the brain processes associated with episodic and semantic memories can be clearly distinguished is being questioned by some neuroscientists. Research involving older adults who suffer from semantic dementia due to frontal lobe damage shows that many of them suffer from deficiencies in episodic memory (Nestor et al., 2002). Moreover, other studies show that damage to the temporal and occipital lobes can also affect episodic memory (Wheeler & McMillan, 2001).

An interesting recent study (Maguire et al., 2000), which was described briefly in Chapter 2, suggests that the hippocampus may serve special functions in addition to those already known. A part of the hippocampus evidently specializes in navigational skills by helping to create intricate neural spatial maps. Using magnetic resonance imaging (MRI) scans, researchers found that the rear (posterior) region of the hippocampus of London taxi drivers was significantly larger than that of participants in a matched control group whose living did not depend on navigational skills (see Figure 6.8). In addition, the more time spent as a taxi driver, the greater the size of this part of the hippocampus. Further, in many small mammals and birds, the size of the hippocampus increases seasonally, as navigational skills and spatial maps showing where food is hidden become critical for survival (Clayton, 1998; Colombo & Broadbent, 2000). Moreover, recent animal studies show that the hippocampus also plays an important role in the reorganization of previously learned spatial information (Lee & Kesner, 2002).

Thus, research has established that the hippocampus is critically important for storing and using mental maps to navigate in the environment. And the observed size increase in the hippocampus of the more experienced London taxi drivers confirms

that brain plasticity in response to environmental demands can continue into adulthood. These findings also raise the possibility of *neurogenesis* (the growth of new neurons) in the adult hippocampus.

We have considered how researchers have identified and located some of the brain structures that play a role in memory. But what happens within these brain structures as they change, reshape, and rearrange to make new memories?

Neuronal Changes and Memory

Why is long-term potentiation important?

Some researchers are exploring memory at deeper levels than the structures of the brain. Some look at the actions of single neurons; others study collections of neurons and their synapses and the neurotransmitters whose chemical action begins the process of recording and storing a memory. The first close look at how memory works in single neurons was provided by Eric Kandel and his colleagues, who traced the effects of learning and memory in the sea snail *Aplysia* (Dale & Kandel, 1990). Using tiny electrodes implanted in several single neurons in this snail, the researchers mapped the neural circuits that are formed and maintained as the animal learns and remembers. They also discovered the different types of protein synthesis that facilitate short-term and long-term memory (Sweatt & Kandel, 1989). Kandel won a Nobel Prize in 2000 for his work.

But the studies of learning and memory in *Aplysia* reflect only simple classical conditioning, which is a type of nondeclarative memory. Other researchers studying mammals report that physical changes occur in the neurons and synapses in brain regions involved in declarative memory (Lee & Kesner, 2002).

As far back as the 1940s, Canadian psychologist Donald O. Hebb (1949) argued that learning and memory must involve the enhancement of transmission at the synapses between neurons. The most widely studied model for learning and memory at the level of the neurons meets the requirements of the mechanism Hebb described (Fischbach, 1992). **Long-term potentiation (LTP) is an increase in the efficiency of neural transmission at the synapses that lasts for hours or longer** (Bliss & Lomo, 2000; Martinez & Derrick, 1996; Nguyen et al., 1994). (*To potentiate* means "to make potent, or to strengthen.") Long-term potentiation does not take place unless both the sending and the receiving neurons are activated at the same time by intense stimulation. Also, the receiving neuron must be depolarized (ready to fire) when the stimulation occurs, or LTP will not happen. LTP is common in the hippocampal region, which, as you have learned, is essential in the formation of declarative memories (Eichenbaum & Otto, 1993).

If the changes in synapses produced by LTP are the same changes that take place during learning, then blocking or preventing LTP should interfere with learning. And it does. When Davis and others (1992) gave rats a drug that blocks certain receptors in doses large enough to interfere with a maze-running task, they discovered that LTP in the rats' hippocampi was also disrupted. In contrast, Riedel (1996) found that LTP was enhanced and the rats' memory improved when a drug that excites those same receptors was administered shortly after maze training.

Researchers now believe that LTP has the required characteristics to be a process involved in consolidating new memories (Cotman & Lynch, 1989). However, contro-

versy continues as to whether the relatively long-lasting increase in synaptic efficiency that constitutes LTP is the result of an increase in the amount of neurotransmitter released, an increase in the number of receptors at the synapses, or both (Bennett, 2000).

Hormones and Memory

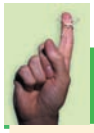
How do memories of threatening situations that elicit the "fight or flight response" compare with ordinary memories?

The strongest and most lasting memories are usually those fueled by emotion. Research by Cahill and McGaugh (1995) suggests that there may be two pathways for forming memories—one for ordinary information and another for memories that are fired by emotion. When a person is emotionally aroused, the adrenal glands release the hormones epinephrine (adrenalin) and norepinephrine (noradrenaline) into the bloodstream. Long known to be involved in the "fight or flight response," these hormones enable humans to survive, and they also imprint powerful and enduring memories of the circumstances surrounding threatening situations. Such emotionally laden memories activate the amygdala (known to play a central role in emotion) and other parts of the memory system. This widespread activation in the brain may be the most important factor in explaining the intensity and durability of flashbulb memories.

The strongest and most lasting memories are usually fueled by emotion. That's why most people have vivid memories of the events and circumstances that surround the experience of falling in love.

Other hormones may have important effects on memory. Excessive levels of the stress hormone *cortisol*, for example, have been shown to interfere with memory in patients who suffer from diseases of the adrenal glands, the site of cortisol production (Jelicic & Bonke, 2001). Furthermore, people whose bodies react to experimenter-induced stressors, such as forced public speaking, by releasing higher than average levels of cortisol perform less well on memory tests than those whose bodies release lower than average levels in the same situations (Al'absi et al., 2002).

Estrogen, the female sex hormone, appears to improve working memory efficiency (Dohanich, 2003). This hormone, along with others produced by the ovaries, also plays some role in the development and maintenance of synapses in areas of the brain known to be associated with memory (e.g, the hippocampus). This finding caused researchers to hypothesize that hormone replacement therapy might prevent or reverse the effects of Alzheimer's disease (Dohanich, 2003). However, recent research shows that postmenopausal women who take a combination of synthetic estrogen and progesterone, the two hormones that regulate the menstrual cycle, may actually increase their risk of developing dementia (Rapp et al., 2003; Shumaker et al., 2003).



Remember It 6.4

1. The hippocampus is involved primarily in the formation of _____ memories; the rest of the hippocampal region is involved primarily in the formation of _____ memories.
2. H.M. retained his ability to add to his _____ memory.
3. _____ is the long-lasting increase in the efficiency of neural transmission at the synapses; it may be the basis for learning and memory at the level of the neurons.
4. Memories of circumstances surrounding threatening situations that elicit the "fight or flight response" activate the _____.

ANSWERS: 1. episodic, semantic; 2. nondeclarative; 3. Long-term potentiation; 4. amygdala

6.5 FORGETTING

Wouldn't it be depressing if you remembered in exact detail every bad thing that ever happened to you? Most people think of forgetting as a problem to be overcome, but it's actually not always unwelcome. Still, when you need to remember particular information to answer an exam question, forgetting can be very frustrating.

Ebbinghaus and the First Experimental Studies on Forgetting

What did Ebbinghaus discover about forgetting?

Hermann Ebbinghaus (1850–1909) conducted the first experimental studies on learning and memory. Realizing that some materials are easier than others to understand and remember, Ebbinghaus faced the task of finding items that would all be equally difficult to memorize. So he invented **the nonsense syllable, a consonant-vowel-consonant combination that is not an actual word and is used in memory research.** Examples are LEJ, XIZ, LUK, and ZOH. Using nonsense syllables in his research largely accomplished Ebbinghaus's goal. But did you notice that some of the syllables sound more like actual words than others and would, therefore, be easier to remember?

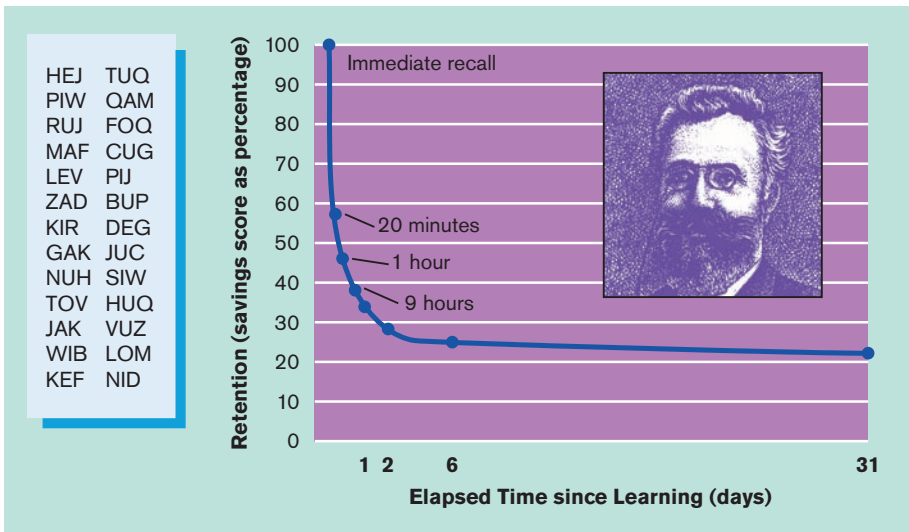
Ebbinghaus (1885/1964) conducted his studies on memory using 2,300 nonsense syllables as his material and himself as the only participant. He carried out all his experiments at about the same time of day in the same surroundings, eliminating all possible distractions. Ebbinghaus memorized lists of nonsense syllables by repeating them over and over at a constant rate of 2.5 syllables per second, marking time with a metronome or a ticking watch. He repeated a list until he could recall it twice without error, a measure he called *mastery*.

Ebbinghaus recorded the amount of time or the number of trials it took to memorize his lists to mastery. Then, after different periods of time had passed and forgetting had

FIGURE 6.9 Ebbinghaus's Curve of Forgetting

After memorizing lists of nonsense syllables similar to those at left, Ebbinghaus measured his retention after varying intervals of time using the relearning method. Forgetting was most rapid at first, as shown by his retention of only 58% after 20 minutes and 44% after 1 hour. Then, the rate of forgetting tapered off, with a retention of 34% after 1 day, 25% after 6 days, and 21% after 31 days.

Source: Data from Ebbinghaus (1885/1913).



occurred, he recorded the amount of time or number of trials needed to relearn the same list to mastery. Ebbinghaus compared the time or number of trials required for relearning with that for original learning and then computed the percentage of time saved. This savings score represented the percentage of the original learning that remained in memory.

Ebbinghaus learned and relearned more than 1,200 lists of nonsense syllables to discover how rapidly forgetting occurs. Figure 6.9 shows his famous curve of forgetting, which consists of savings scores at various time intervals after the original learning. The curve of forgetting shows that the largest amount of forgetting occurs very quickly, after which forgetting tapers off. Of the information Ebbinghaus retained after a day or two, very little more would be forgotten even a month later. But, remember, this curve of forgetting applies to nonsense syllables. Meaningful material is usually forgotten more slowly, as is material that has been carefully encoded, deeply processed, and frequently rehearsed.

What Ebbinghaus learned about the rate of forgetting is relevant for everyone. Do you, like most students, cram before a big exam? If so, don't assume that everything you memorize on Monday can be held intact until Tuesday. So much forgetting occurs within the first 24 hours that it is wise to spend at least some time reviewing the material on the day of the test. The less meaningful the material is to you, the more you will forget and the more necessary a review is. Recall from Chapter 4 that the quantity and quality of sleep you get between studying and taking the test also influences how much you will remember.

When researchers measured psychology students' retention of names and concepts, they found that the pattern of forgetting was similar to Ebbinghaus's curve. Forgetting of names and concepts was rapid over the first several months, leveled off in approximately 36 months, and remained about the same for the next 7 years (Conway et al., 1991).

The Causes of Forgetting

What causes forgetting?

Why do we fail to remember, even when we put forth a lot of effort aimed at remembering? There are many reasons.

Encoding Failure

When you can't remember something, could it be because the item was never stored in memory to begin with? Of course, there is a distinction between forgetting and not being able to remember. *Forgetting* is the inability to recall something that you could recall previously. But often when people say they cannot remember, they have not actually forgotten. **The inability to remember is sometimes a result of encoding failure—the information was never put into long-term memory in the first place.**

Of the many things we encounter every day, it is surprising how little we actually encode. Can you recall accurately, or even recognize, something you have seen thousands of times before? Read *Try It* to find out.

In your lifetime, you have seen thousands of pennies, but unless you are a coin collector, you probably have not encoded the details of a penny's appearance. If you did poorly on the *Try It*, you have plenty of company. After studying a large group of participants, Nickerson and Adams (1979) reported that few people could reproduce a penny from recall. In fact, only a handful of participants could even recognize an accurate drawing of a penny when it was presented along with incorrect drawings. (The correct penny is the one labeled A in the *Try It*.)

When preparing for tests, do you usually take on a passive role? Do you merely read and reread your textbook and your notes and assume that this process will even-

Try It

A Penny for Your Thoughts

On a sheet of paper, draw a sketch of a U.S. penny from memory using recall. In your drawing, show the direction in which President Lincoln's image is facing and the location of the date, and include all the words on the "heads" side of the penny. Or try the easier recognition task and see if you can recognize the real penny in the drawings below. (From Nickersen & Adams, 1979.)

A B C D E

tually result in learning? If you don't test yourself by reciting the material, you may find that you have been the unwilling victim of encoding failure. Textbook features such as margin questions and end-of-section reviews can help you by providing structure for rehearsing information to ensure that is encoded.

Decay

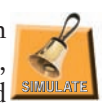
Decay theory, probably the oldest theory of forgetting, assumes that memories, if not used, fade with time and ultimately disappear entirely. The word *decay* implies a physiological change in the neurons that recorded the experience. According to this theory, the neuronal record may decay or fade within seconds, days, or even much longer periods of time.

Most psychologists now accept that decay, or the fading of memories, is a cause of forgetting in sensory and short-term memory but not in long-term memory. There does not appear to be a gradual, inevitable decay of long-term memories. In one study, Harry Bahrick and others (1975) found that after 35 years, participants could recognize 90% of their high school classmates' names and photographs, the same percentage as for recent graduates.

Interference

A major cause of forgetting that affects people every day is interference, where information or associations stored either *before* or *after* a given memory can interfere with the ability to remember it (see Figure 6.10). Whenever you try to recall any given memory, a second type of interference can hinder the effort. Interference can reach either forward or backward in time to affect memory—it gets us coming and going. Also, the more similar the interfering associations are to the information a person is trying to recall, the more difficult it is to recall the information (Underwood, 1964).

Proactive interference occurs when information or experiences already stored in long-term memory hinder the ability to remember newer information (Underwood, 1957). For example, Laura's romance with her new boyfriend, Todd, got off to a bad start when she accidentally called him "Dave," her former boyfriend's name. One explanation for proactive interference is the competition between old and new responses (Bower et al., 1994).



Retroactive interference happens when new learning interferes with the ability to remember previously learned information. The more similar the new material is to that learned earlier, the more interference there is. For example, when you take a psychology class, it may interfere with your ability to remember what you learned in your sociology class, especially with regard to theories (e.g., psychoanalysis) that are shared by the two disciplines but applied and interpreted differently.

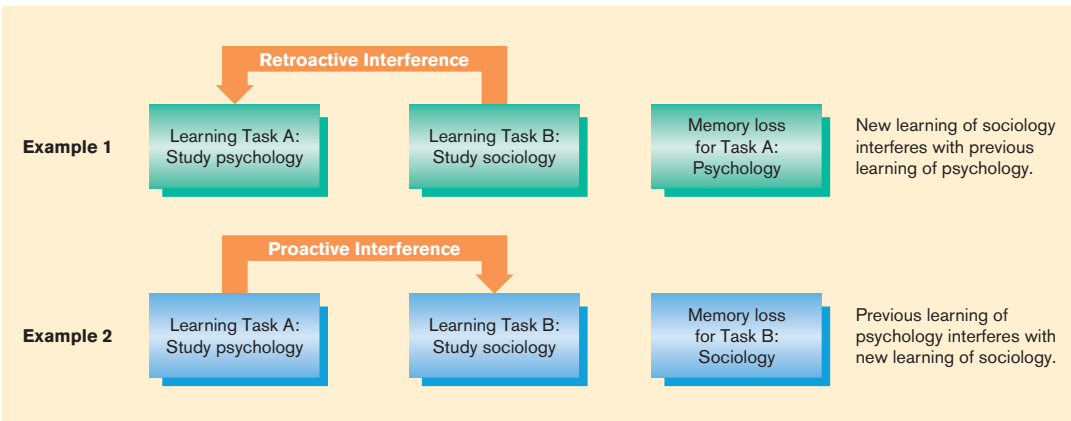
Consolidation Failure

Consolidation is the process by which encoded information is stored in memory. **Any disruption in consolidation that prevents a long-term memory from forming is called a consolidation failure.** Consolidation failure can result from anything that causes a person to lose consciousness—a car accident, a blow to the head, a grand mal epileptic seizure, or an electroconvulsive shock treatment given for severe depression. **Memory loss of the experiences that occurred shortly before the loss of consciousness is called retrograde amnesia.**

Researchers Nader and others (2000) demonstrated that conditioned fears in rats can be erased by infusing into the rats' brains a drug that prevents protein synthesis

FIGURE 6.10 Retroactive and Proactive Interference

As shown in Example 1, retroactive interference occurs when new learning hinders the ability to recall information learned previously. As shown in Example 2, proactive interference occurs when prior learning hinders new learning.



(such synthesis is necessary for memory consolidation). Rats experienced a single pairing of a tone (the conditioned stimulus, CS) and a foot shock (the unconditioned stimulus, US). Later, the rats were exposed to the sound of the tone alone (CS) and showed a fear response, "freezing" (becoming totally immobile as if frozen with fright). Clearly, the rats remembered the feared stimulus. Twenty-four hours later, the rats were again exposed to the tone alone, and it elicited fear, causing them to freeze. Immediately, the drug anisomycin, which prevents protein synthesis in the brain, was infused into the rats' amygdalae (the part of the brain that processes fear stimuli). After the drug was infused, the rats were shocked again, but they showed no fear response (freezing). The rats in the study had already consolidated the memory of the fear, but it was completely wiped out after the drug prevented protein synthesis from occurring. This means that fear memories, once activated, must be "reconsolidated," or they may disappear.

This finding has positive implications. If fear memories can be activated and then wiped out with drugs that prevent protein synthesis, a new therapy may be on the horizon for people who suffer from debilitating fears (Nader et al., 2000).

We have discussed ways to avoid forgetting, but there are occasions when people may want to avoid remembering—times when they want to forget.

Motivated Forgetting

Victims of rape or physical abuse, war veterans, and survivors of airplane crashes or earthquakes all have had terrifying experiences that may haunt them for years. These victims are certainly motivated to forget their traumatic experiences, but even people who have not suffered any trauma use **motivated forgetting (forgetting through suppression or repression)** to protect themselves from experiences that are painful, frightening, or otherwise unpleasant.

With one form of motivated forgetting, *suppression*, a person makes a conscious, active attempt to put a painful, disturbing, anxiety- or guilt-provoking memory out of

mind, but the person is still aware that the painful event occurred. **With another type of motivated forgetting, repression, unpleasant memories are literally removed from consciousness, and the person is no longer aware that the unpleasant event ever occurred** (Freud, 1922). People who have **amnesia (partial or complete memory loss)** that is not due to loss of consciousness or brain damage have repressed the events they no longer remember. Motivated forgetting is probably used by more people than any other method to deal with unpleasant memories. It seems to be a natural human tendency to forget the unpleasant circumstances of life and to remember the pleasant ones (Linton, 1979; Meltzer, 1930).

Prospective forgetting—not remembering to carry out some intended action (e.g., forgetting to go to your dentist appointment)—is another type of motivated forgetting. People are most likely to forget to do the things they view as unimportant, unpleasant, or burdensome. They are less likely to forget things that are pleasurable or important to them (Winograd, 1988).

However, as you probably know, prospective forgetting isn't always motivated by a desire to avoid something. Have you ever arrived home and suddenly remembered that you had intended to go to the bank to deposit your paycheck? Or you may have seen a review of a concert in the newspaper and suddenly remembered that you had intended to buy a ticket for it. In such cases, prospective forgetting is more likely to be the result of interference or consolidation failure.

Retrieval Failure How many times have these experiences happened to you? You are with a friend when you meet an acquaintance, but you can't introduce the two because you cannot recall the name of the acquaintance. Or, while taking a test, you can't remember the answer to a question that you are sure you know. Often, people are certain they know something, but are not able to retrieve the information when they need it. This type of forgetting is called *retrieval failure*.

Endel Tulving (1974) claims that much of what people call forgetting is really an inability to locate the needed information. The information is in long-term memory, but the person cannot retrieve it. In his experiments, Tulving found that participants could recall a large number of items they seemed to have forgotten if he provided retrieval cues to jog their memory. For example, odors often provide potent reminders of experiences from the past, and certain odors can serve as retrieval cues for information that was learned when those odors were present (Schab, 1990).

A common experience with retrieval failure is known as the *tip-of-the-tongue (TOT) phenomenon* (Brown & McNeil, 1966). You have surely experienced trying to recall a name, a word, or some other bit of information, knowing that you knew it but not able to come up with it. You were on the verge of recalling the word or name, perhaps aware of the number of syllables and the beginning or ending letter. It was on the tip of your tongue, but it just wouldn't quite come out.

Remember It 6.5

1. _____ invented the nonsense syllable, conceived the relearning method for retention, and plotted the curve of forgetting.
2. Match each cause of forgetting with the appropriate example.

   ____ (1) encoding failure
   ____ (2) consolidation failure
   ____ (3) retrieval failure
   ____ (4) repression
   ____ (5) interference

   a. failing to remember the answer on a test until after you turn the test in
   b. forgetting a humiliating childhood experience
   c. not being able to describe the back of a dollar bill
   d. calling a friend by someone else's name
   e. waking up in the hospital and not remembering you had an automobile accident
3. To minimize interference, it is best to follow learning with _____.
4. According to the text, the major cause of forgetting is _____.

ANSWERS: 1. Ebbinghaus; 2. (1) c, (2) e, (3) a, (4) b, (5) d; 3. sleep; 4. interference

6.6 IMPROVING MEMORY

How can organization, overlearning, spaced practice, and recitation improve memory?

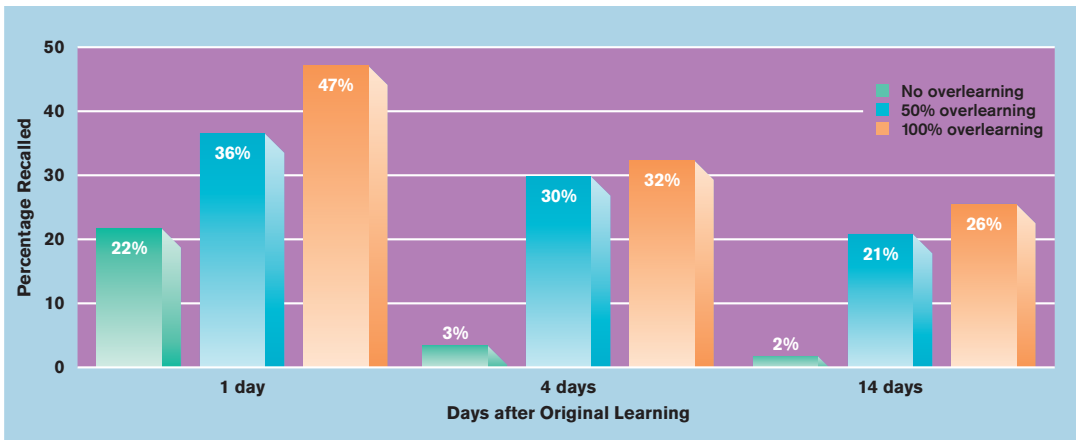
Have you ever wished there was a magic pill you could take before studying for an exam, one that would make you remember everything in your textbook and lecture notes? Sorry, but there are no magic formulas for improving your memory. Remembering is a skill that, like any other, requires knowledge and practice. In this section, we consider several study habits and techniques that can improve your memory.

Are you the kind of person who has a place for everything in your home or office, or do you simply toss things anywhere and everywhere? If you're the everything-in-its-place type, you probably have an easier time finding things than do people who are the "wherever" type. Memory works the same way. How information is organized strongly influences your ability to remember it. For example, almost anyone can name the months of the year in about 10 seconds, but how long would it take to recall them in alphabetical order? These 12 well-known items are much harder to retrieve in alphabetical order, because they are not organized that way in memory. Similarly, you are giving your memory an extremely difficult task if you try to remember large amounts of information in a haphazard fashion. Try to organize items you want to remember in alphabetical order, or according to categories, historical sequence, size, or shape, or in any other way that will make retrieval easier for you.

FIGURE 6.11 Overlearning

When a person learns material only to the point of one correct repetition, forgetting is very rapid. Just 22% is retained after 1 day, 3% after 4 days, and 2% after 14 days. When participants spend 50% more time going over the material, the retention increases to 36% after 1 day, 30% after 4 days, and 21% after 14 days.

Source: Data from Krueger (1929).



Do you still remember the words to songs that were popular when you were in high school? Can you recite many of the nursery rhymes you learned as a child even though you haven't heard them in years? You probably can because of **overlearning, practicing or studying material beyond the point where it can be repeated once without error.** Suppose you wanted to memorize a list of words, and you studied until you could recite them once without error. Would this amount of study or practice be sufficient? Research suggests that people remember material better and longer if they overlearn it (Ebbinghaus, 1885/1964). A pioneering study in overlearning by Krueger (1929) showed very substantial long-term gains for participants who engaged in 50% and 100% overlearning (see Figure 6.11). Furthermore, overlearning makes material more resistant to interference and is perhaps the best insurance against stress-related forgetting. So, the next time you study for a test, don't stop studying as soon as you think you know the material. Spend another hour or so going over it, using features of your textbook such as margin questions and end-of-section review questions; you will be surprised at how much more you will remember.

Most students have tried cramming for examinations, but spacing study over several sessions is generally more effective than **massed practice, learning in one long practice session without rest periods** (Glover & Corkill, 1987). You will remember more with less total study time if you space your study over a number of sessions. Long periods of memorizing make material particularly subject to interference and often result in fatigue and lowered concentration. Also, when you space your practice, you probably create new memories that may be stored in different places, thus increasing your chances for recall. The spacing effect applies to learning motor skills as well as to

REVIEW & REFLECT 6.A

EXAMPLES OF STRATEGIES FOR IMPROVING MEMORY

Strategy	Example
Organization	Write each heading and subheading of a textbook chapter on an index card; take notes on each section and subsection on the cards; keep them in order by chapter and use them to review for exams.
Overlearning	Memorize information that is easily organized into a list (e.g., the functions associated with the left and right cerebral hemispheres) until you can recall each item on the list automatically without error.
Spaced practice	When you have an hour to study, break it up into three 15-minute study periods with 5-minute breaks between them.
Recitation	After you finish studying this *Review and Reflect* table, close your eyes and see how much of the information you can repeat aloud.

learning facts and information. Music students can tell you that it is better to practice for half an hour each day, every day, than to practice many hours in a row once a week.

Furthermore, recent research suggests that significant improvement in learning results when spaced study sessions are accompanied by short, frequent tests of the material being studied (Cull, 2000). Thus, you should be doing well in this course if you are answering the questions in the *Remember It* boxes at the ends of sections in this textbook.

Do you ever reread a chapter just before a test? Research over many years shows that you will recall more if you increase the amount of recitation in your study. For example, it is better to read a page or a few paragraphs and then recite or practice recalling what you have just read. Then, continue reading, stop and practice reciting again, and so on. When you study for a psychology test and review the assigned chapter, try to answer each of the questions in the *Summary and Review* section at the end of the chapter. Then, read the material that follows each question and check to see if you answered the question correctly. This will be your safeguard against encoding failure. Don't simply read each section and assume that you can answer the question. Test yourself before your professor does.

A. I. Gates (1917) tested groups of students who spent the same amount of time in study, but who spent different percentages of that time in recitation and rereading. Participants recalled two to three times more if they increased their recitation time up to 80% and spent only 20% of their study time rereading.

Review and Reflect 6.A provides examples for each of the memory improvement techniques discussed in this section.

Remember It 6.6

1. When studying for an exam, it is best to spend:
   a. more time reciting than rereading.
   b. more time rereading than reciting.
   c. equal time rereading and reciting.
   d. all of the time reciting rather than rereading.

2. The ability to recite a number of nursery rhymes from childhood is probably due mainly to _____ .

ANSWERS: 1. a; 2. overlearning

Apply It

Improving Memory with Mnemonic Devices

Writing notes, making lists, writing on a calendar, or keeping an appointment book is often more reliable and accurate than trusting to memory (Intons-Peterson & Fournier, 1986). But what if you need information at some unpredictable time, when you do not have external aids handy? Several *mnemonics*, or memory devices, have been developed over the years to aid memory (Bower, 1973; Higbee, 1977; Roediger, 1980).

Rhyme

Rhymes are a common aid to remembering material that otherwise might be difficult to recall. Perhaps as a child you learned to recite "*i* before *e* except after *c*" when you were trying to spell a word containing that vowel combination.

The Method of Loci

The *method of loci* is a mnemonic device that can be used when you want to remember a list of items such as a grocery list, or when you give a speech or a class report and need to make your points in order without using notes. The word *loci* (pronounced "LOH-sye") is the plural form of *locus*, which means "location" or "place."

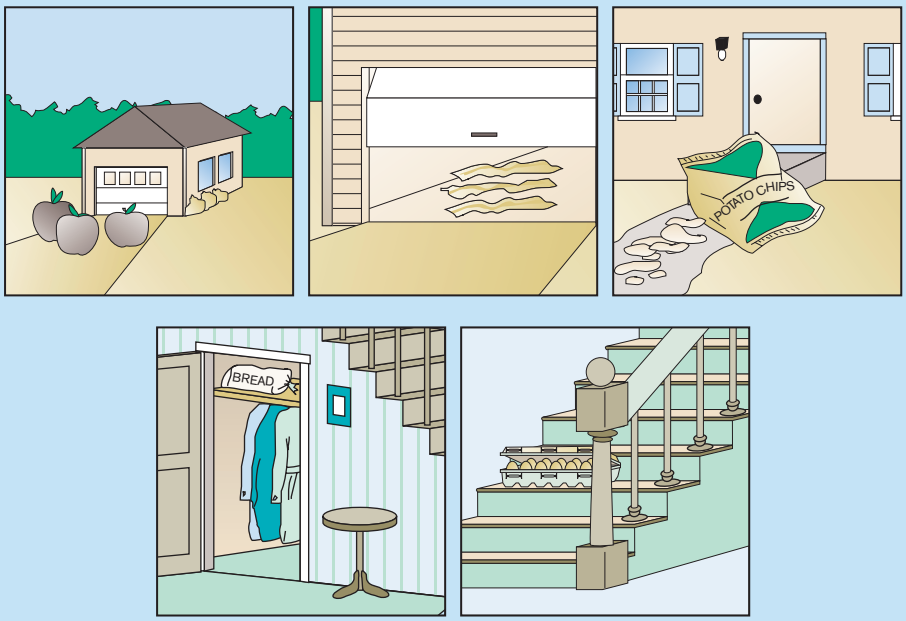
Figure 6.12 shows how to use the method of loci. Select any familiar place—your home, for example—and simply associate the items to be remembered with locations there. Progress in an orderly fashion: For example, visualize the first item or idea you want to remember in its place on the driveway, the second in the garage, the third at the front door, and so on, until you have associated each item you want to remember with a specific location. You may find it helpful to conjure up oversized images of the items that you place at each location. When you want to recall the items, take an imaginary walk starting at the first place—the first item will pop into your mind. When you think of the second place, the second item will come to mind, and so on.

The First-letter Technique

Another useful technique is to take the first letter of each item to be remembered and form a word, a phrase, or a sentence with those letters (Matlin, 1989). For example, suppose you had to memorize the seven colors of the visible spectrum in their proper order:

FIGURE 6.12 The Method of Loci

Begin by thinking of locations, perhaps in your home, that are in a sequence. Then, visualize one of the items to be remembered in each location.



Red
Orange
Yellow
Green
Blue
Indigo
Violet

You could make your task easier by using the first letter of each color to form the name Roy G. Biv. Three chunks are easier to remember than seven different items.

The Pegword System

Another mnemonic that has been proven effective is the *pegword system* (Harris & Blaiser, 1997). Developed in England around 1879, it uses rhyming words: *one* = *bun*; *two* = *shoe*; *three* = *tree*; *four* = *door*; *five* = *hive*; *six* = *sticks*; *seven* = *heaven*; *eight* = *gate*; *nine* = *wine*; *ten* = *hen*. The rhyming words are memorized in sequence and then linked through vivid associations with any items you wish to remember in order, as shown in Figure 6.13.

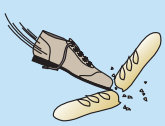
For example, suppose you want to remember to buy five items at the store: milk, bread, grapefruit, laundry detergent, and

eggs. Begin by associating the milk with a bun (your first pegword) by picturing milk being poured over a bun. Next, picture a shoe, the second pegword, kicking a loaf of bread. Then, continue by associating each item on your list with a pegword. To recall the items, simply go through your list of pegwords, and the associated word will immediately come to mind.

FIGURE 6.13 The Pegword System

Each item to be recalled is associated with a pegword using a mental image.

Source: Adapted from Bower (1973).

Item Number	Pegword	Peg Image	Item to Be Recalled	Connecting Image
1	bun		milk	 *Milk* pouring onto a soggy hamburger *bun*
2	shoe		bread	 A *shoe* kicking and breaking a brittle loaf of French *bread*

SUMMARY AND REVIEW

6.1 REMEMBERING p. 277

The Atkinson-Shiffrin Model

Sensory memory holds information coming in through the senses for up to 2 seconds. This is just long enough for the nervous system to begin to process the information and send some of it on to short-term memory. Short-term (working) memory holds about seven (plus or minus two) unrelated items of information for less than 30 seconds without rehearsal. Short-term memory also acts as a mental workspace for carrying out any mental activity. Long-term memory is the permanent or relatively permanent memory system with virtually unlimited capacity. Its subsystems are (1) declarative memory, which holds facts and information (semantic memory) along with personal life experiences (episodic memory); and (2) nondeclarative memory, which consists of motor skills acquired through repetitive practice, habits, and simple classically conditioned responses.

The Levels-of-Processing Model

The levels-of-processing model, proposed by Craik and Lockhart, is based on deep and shallow processing of information rather than separate memory stores. With deep processing, a person associates the incoming information with some form of meaning; with shallow processing, a person is merely aware of the incoming sensory information.

Three Kinds of Memory Tasks

Three methods of measuring retention of information in memory are (1) recall, where information must be supplied with few or no retrieval cues; (2) recognition, where information must simply be recognized as having been encountered before; and (3) the relearning method, which measures retention in terms of time saved when relearning material compared with the time required to learn it originally.

6.2 THE NATURE OF REMEMBERING p. 286

Memory as a Reconstruction

Memory does not work like a video recorder. People reconstruct memories, piecing them together from a few highlights and using information that may or may not be accurate. Sir Frederick Bartlett found that people systematically reconstruct and distort memories to fit information already stored in memory. Bartlett suggested that reconstructive memory involves the application of schemas, or integrated frameworks of prior knowledge and assumptions, during the encoding and retrieval phases of remembering.

Eyewitness Testimony

The reliability of eyewitness testimony is reduced when witnesses view a photograph of the suspect before viewing the lineup, when members of a lineup don't sufficiently resemble each other; when members of a lineup are viewed at the same time rather than one by one, when the perpetrator's race is different from that of the eyewitness, when a weapon has been used in the crime, and when leading questions are asked to elicit information from the witness.

Recovering Repressed Memories

Critics argue that therapists using hypnosis and guided imagery to help their patients recover repressed memories of childhood sexual abuse are actually implanting false memories in those patients. Therapists who use these techniques believe that a number of psychological problems can be treated successfully by helping patients recover repressed memories of sexual abuse.

Unusual Memory Phenomena

Flashbulb memories, which are formed when a person learns of events that are surprising, shocking, or highly emotional, may not be as accurate as people believe they are. Researchers have also found that some of the details in flashbulb memories change over time. Something similar to photographic memory, called eidetic imagery, appears to exist in about 5% of children.

Memory and Culture

The existence of oral historians in some cultures suggests that the ability to remember certain kinds of material may be influenced by culture. The status of the role and the importance of the particular information to members of the culture motivate individuals to store and retrieve large amounts of such

information. Their memory for other kinds of information, however, is no better than that of others. In addition, we more easily remember stories set in our own culture.

6.3 FACTORS INFLUENCING RETRIEVAL *p. 295*

The Serial Position Effect

The serial position effect is the tendency, when recalling a list of items, to remember the items at the beginning of the list (primacy effect) and the items at the end of the list (recency effect) better than items in the middle.

Environmental Context and Memory

People tend to recall material more easily if they are in the same physical location during recall as during the original learning.

The State-Dependent Memory Effect

The state-dependent memory effect is the tendency to recall information better if one is in the same pharmacological or psychological state as when the information was learned.

6.4 BIOLOGY AND MEMORY *p. 297*

The Hippocampus and Hippocampal Region

The hippocampus itself is involved primarily in the formation of episodic memories; the rest of the hippocampal region is involved in forming semantic memories.

Neuronal Changes and Memory

Long-term potentiation (LTP) is a long-lasting increase in the efficiency of neural transmission at the synapses. LTP is important because it may be the basis for learning and memory at the level of the neurons.

Hormones and Memory

Memories of threatening situations tend to be more powerful and enduring than ordinary memories, perhaps because of the strong emotions aroused in such situations.

6.5 FORGETTING *p. 302*

Ebbinghaus and the First Experimental Studies on Forgetting

In conducting the first experimental studies of learning and memory, Ebbinghaus invented the nonsense syllable, used the relearning method as a test of memory, and plotted the curve of forgetting. He discovered that the largest amount of forgetting occurs very quickly, then it tapers off.

The Causes of Forgetting

Encoding failure happens when an item is perceived as having been forgotten but, in fact, was never stored in memory. Information that has not been retrieved from memory for a long time may fade and ultimately disappear entirely (decay theory). Consolidation failure results from a loss of consciousness as new memories are being encoded. Interference occurs when information or associations stored either before or after a given memory hinder the ability to remember it. Sometimes, we forget because we don't want to remember something, a process called motivated forgetting. Other times, an item is stored in memory, but we are unable to retrieve it (retrieval failure).

6.6 IMPROVING MEMORY *p. 308*

Organization, as in using outlines based on chapter headings, provides retrieval cues for information. Overlearning means practicing or studying material beyond the point where it can be repeated once without error. You remember overlearned material better and longer, and it is more resistant to interference and stress-related forgetting. Short study sessions at different times (spaced practice) allow time for consolidation of new information. Recitation of newly learned material is more effective than simply rereading it.

KEY TERMS

amnesia, p. 307
anterograde amnesia, p. 298
chunking, p. 280
consolidation, p. 277
consolidation failure, p. 305
decay theory, p. 305
declarative memory, p. 281
displacement, p. 279
eidetic imagery, p. 292
elaborative rehearsal, p. 281
encoding, p. 277
encoding failure, 304
episodic memory, p. 281
flashbulb memory, p. 292
hippocampal region, p. 289
infantile amnesia, p. 291
interference, p. 305
levels-of-processing model, p. 283
long-term memory (LTM), p. 281
long-term potentiation (LTP), p. 300
massed practice, p. 309
memory, p. 277
motivated forgetting, p. 306
nondeclarative memory, p. 282
nonsense syllable, p. 302
overlearning, p. 309
primacy effect, p. 295
priming, p. 282
prospective forgetting, p. 307
recall, p. 284
recency effect, p. 295
recognition, p. 285
reconstruction, p. 287
rehearsal, p. 280
relearning method, p. 285
repression, p. 307
retrieval, p. 277
retrieval cue, p. 284
retrograde amnesia, p. 305
savings score, p. 285
schemas, p. 287
semantic memory, p. 281
sensory memory, p. 278
serial position effect, p. 295
short-term memory (STM), p. 279
state-dependent memory effect, p. 297
storage, p. 277

STUDY GUIDE

SECTION ONE: CHAPTER REVIEW
6.1 REMEMBERING (PP. 277–286)

1. The three processes of remembering are _____, _____, and _____.

2. Which model of memory divides memory into three types, sensory, short-term, and long-term?
a. Atkinson-Shiffrin model
b. mnemonics model
c. levels of processing model
d. working memory model

3. _____ memory holds virtually the exact sensory stimulus, while _____ memory usually codes information according to sound.

4. Match each example with the appropriate memory system:
____ (1) semantic memory
____ (2) episodic memory
____ (3) nondeclarative memory
a. movements involved in playing tennis
b. names of the presidents of the United States
c. what you did during spring break last year

5. In which subsystem of long-term memory are responses that make up motor skills stored?
a. episodic memory
b. semantic memory
c. nondeclarative memory
d. declarative memory

6. According to the _____ model, whether people remember something for a few seconds or a lifetime depends on how deeply they process something.

7. Which of the following methods can detect learning when other methods cannot?
a. recall
b. recognition
c. relearning
d. retrieval

8. An essay test requires the _____ method for retrieval of information, while a multiple choice test requires the _____ method.

6.2 THE NATURE OF REMEMBERING (PP. 286–294)

9. What early memory researcher proposed the concept of the schema?
   a. Freud
   b. Ebbinghaus
   c. Bartlett
   d. Skinner

10. Which of the following is *not* true of schemas?
   a. Schemas are the integrated frameworks of knowledge and assumptions a person has about people, objects, and events.
   b. Schemas affect the way a person encodes information.
   c. Schemas affect the way a person retrieves information.
   d. When a person uses schemas, memories are always accurate.

11. There are fewer errors in eyewitness testimony if
   a. eyewitnesses are identifying a person of their own race.
   b. eyewitnesses view suspects' photos prior to a lineup.
   c. a weapon has been used in the crime.
   d. questions are phrased to provide retrieval cues for the eyewitness.

12. As a rule, people's memories are more accurate under hypnosis. (true/false)

13. When you remember where you were and what you were doing when you received a shocking piece of news, you are experiencing
   a. flashbulb memory.
   b. sensory memory.
   c. semantic imagery.
   d. interference.

14. The psychological term for photographic memory is _____.
   a. mental imagery.
   b. photo remembrance.
   c. exact image processing.
   d. eidetic imagery.

6.3 FACTORS INFLUENCING RETRIEVAL (PP. 295–297)

15. The tendency to recall the first items in a sequence more readily than the middle items is referred to as the _____, while the tendency to recall the last items in a sequence more readily than those in the middle is referred to as the _____.

16. Recall is best when it takes place in the same context in which information was learned. (true/false)

17. Scores on recognition tests (either multiple-choice or true/false) will be higher if testing and learning take place in the same physical environment. (true/false)

18. Which best explains why information learned when one is feeling anxious is best recalled when experiencing feelings of anxiety?
   a. consistency effect
   b. state-dependent memory effect
   c. context-dependent effect
   d. consolidation failure

19. Compared to nondepressed people, depressed people tend to have more sad memories. (true/false)

6.4 BIOLOGY AND MEMORY (PP. 298–302)

20. H.M. retained his ability to add to his nondeclarative memory. (true/false)

21. Which of the following is true regarding the hippocampus and memory?
   a. The hippocampus is critically important for storing and using mental maps to navigate in the environment
   b. The hippocampus is unrelated to recognizing previously learned spatial information
   c. The hippocampus is critical to developing implicit memories
   d. all of the above

22. Long-Term Potentiation is known to _____.
   a. take place in situations involving low levels of neural stimulation
   b. be involved in consolidating new memories
   c. decrease the efficiency of neural transmission for up to four hours
   d. none of the above

23. Memories of circumstances surrounding threatening situations that elicit the "fight-or-flight response" tend to be more powerful and enduring than ordinary memories. (true/false)

6.5 FORGETTING (PP. 302–308)

24. Who plotted the curve of forgetting?
   a. George Sperling
   b. H. E. Burtt
   c. Frederick Bartlett
   d. Hermann Ebbinghaus

25. The curve of forgetting shows that memory loss
   a. occurs most rapidly at first and then levels off to a slow decline.
   b. begins to occur about 3 to 4 hours after learning.
   c. occurs at a fairly steady rate over a month's time.
   d. occurs slowly at first and increases steadily over a month's time.

26. The fact that few students would accurately be able to describe what is on the cover of their introductory psychology textbook without looking at it, even though they have handled it many times over the course of a semester is an example of _____.
   a. retrieval failure
   b. encoding failure
   c. consolidation failure
   d. motivated forgetting

27. To minimize _____, it is best to follow learning with sleep.

28. Most psychologists accept decay theory as a good explanation for the loss of information from long-term memory. (true/false)

29. If you accidentally call your new cat by the name of a cat you previously owned, which of the following might explain this mistake?
   a. amnesia
   b. encoding failure
   c. decay theory
   d. proactive interference

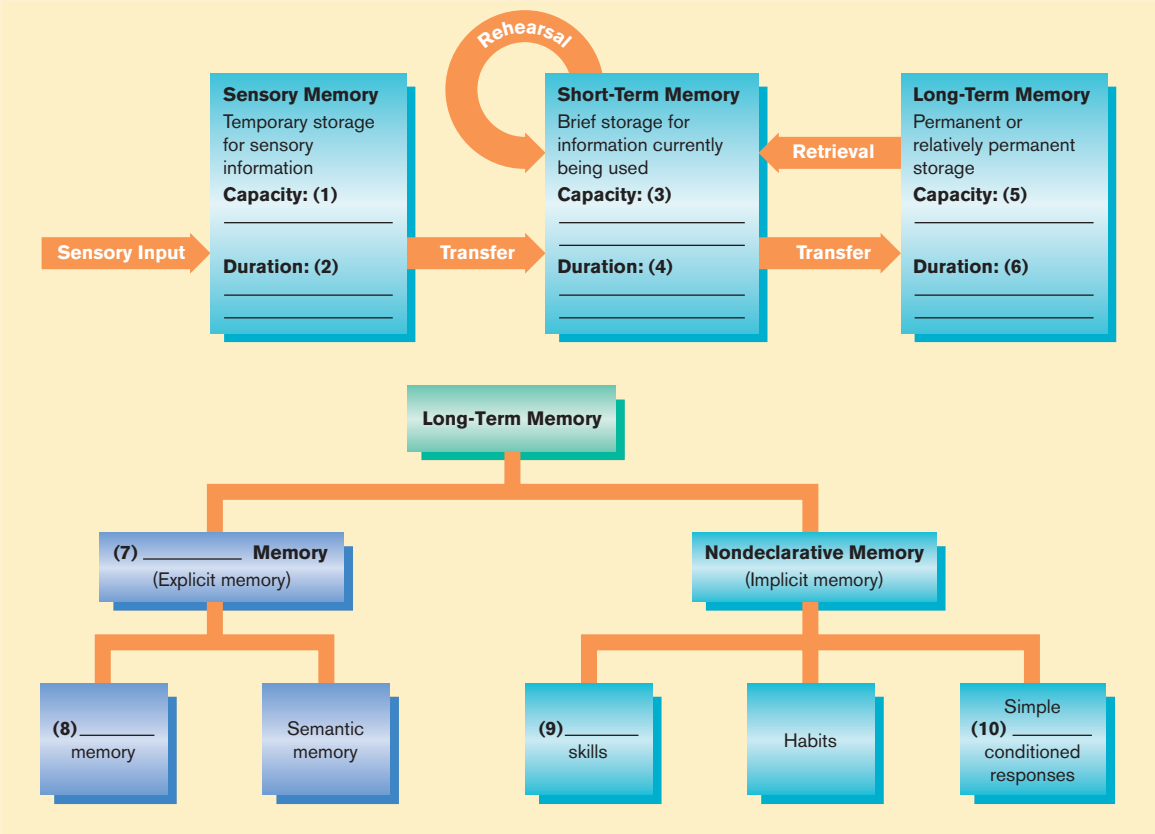
6.6 IMPROVING MEMORY (PP. 308–311)

30. Learning material in one long practice session without rest periods is referred to as _____.

31. Research suggests that _____, studying material beyond the point where it can be repeated once without error, is more resistant to interference than any other type of learning.

SECTION TWO: COMPLETE THE DIAGRAMS

Fill in the blanks in each diagram with the missing words.



SECTION THREE: FILL IN THE BLANK

1. The first step in the memory process is _____.
2. Short-term memory seems to have a limited life span—less than 30 seconds. If you want to keep a phone number in short-term memory, you will need to use some form of _____, such as repeating the number several times.
3. Another name for short-term memory is _____ memory.
4. When people talk about memory, they are usually talking about _____-term memory.
5. When you take a test in your psychology class, you may be asked to list the names of famous psychologists and their major contributions to psychology. For this task you would use _____ memory.
6. A fill-in-the-blank question requires you to _____ the correct answers.
7. In a list of items, those in the _____ position are the items least easily remembered.
8. The _____ _____ memory effect is the tendency to remember best when in the same physical or psychological state as when the information was encoded.

9. The _____ _____ of the brain appears to be very important in the formation of long-term memory.
10. One theory of memory suggests that neural transmission becomes more efficient at certain synapses along neural paths. This increase in transmission efficiency is known as long-term _____.
11. The capacity of short-term memory can be expanded through the use of _____.
12. A patient survived delicate brain surgery and displayed no signs of personality change or loss of intelligence. Days after the surgery, the doctor realized that the patient was unable to form long-term memories. He was, however, able to remember everything from before the surgery. The patient was diagnosed as having _____ _____.
13. When Raquel moved to a new town, she had trouble remembering her new ZIP code. Every time she tried to think of her new ZIP code, her old ZIP code seemed to interfere with her recall. This is probably an example of _____ interference.
14. A patient cannot remember the period of his life ranging from age 5 through 7. A doctor can find no physical cause for this amnesia. The patient also has no history of injury or other trauma at any age. This is very likely a case of _____.
15. Serge found himself in trouble during his physics test—he could not remember the formulas from class. He realized that he should have been paying more attention during the lectures. His current memory problem is probably due to _____ failure.
16. Pete started studying for his psychology test six nights ago, spending about 45 minutes per night. Fiona studied for her test all in one night, in a nonstop, 6-hour study session. Pete got a better grade on the test than Fiona. Fiona used a study technique called _____ practice, a strategy that is usually not as effective as spacing sessions.
17. When you study for your next psychology test, you may want to study beyond the point where you think you know the material. If you repeat or rehearse the material over and over, you will probably remember it better. This study technique is known as _____.
18. Excessive levels of the stress hormone _____ are known to interfere with memory in patients who suffer from diseases of the adrenal glands.

SECTION FOUR: COMPREHENSIVE PRACTICE TEST

1. The first step in the memory process is known as _____, when information is transformed into a form that can be stored in short-term memory.
   a. retrieval c. encoding
   b. storage d. rehearsal
2. The process in which information is stored in permanent memory involves a change in the brain's physiology. This change is known as
   a. consolidation.
   b. transformation.
   c. hippocampal transformation.
   d. recalcitration.
3. You are at a party and meet someone you are really interested in. You get that person's phone number but have no way to write it down, so you use the process of _____ to get it into memory.
   a. encoding c. rehearsal
   b. latent retrieval d. recalcitration
4. The kind of memory that has a large capacity but a very short duration is _____ memory.
   a. short-term c. long-term
   b. sensory d. temporary
5. Alice's ability to remember all the actions required to ride her motorcycle is due to her repetitive practice, to the point where riding it is almost reflexive. Any set of skills acquired this way is part of _____ memory.

6. Implicit memory is to explicit memory as _____ are to _____.
   a. motor skills; facts and information
   b. episodic memories; semantic memories
   c. semantic memories; episodic memories
   d. facts and information; motor skills

7. Cristina and her friends were talking about some great times they had in high school. Recounting those stories as if they had happened yesterday, the friends were relying on _____ memory.
   a. semantic
   b. implicit
   c. personal
   d. episodic

8. You use _____ memory when you answer questions such as "What is the capital of California?"
   a. episodic
   b. semantic
   c. geographic
   d. flashbulb

9. An example of good recall is doing well on an essay test. (true/false)

10. An example of good recognition ability is doing well on a fill-in-the-blank test. (true/false)

11. Freud did extensive research on memory. He used nonsense syllables to determine forgetting curves. (true/false)

12. When she was 16 years old, Sarah was severely injured in a car accident and was unconscious for 14 days. She can remember nothing immediately preceding the accident. This is known as _____ amnesia.
   a. trauma
   b. retroactive
   c. proactive
   d. retrograde

13. With retroactive interference, _____ information interferes with _____ information.
   a. new; old
   b. old; new
   c. unpleasant; pleasant
   d. factual; emotional

14. Using _____, a person removes an unpleasant memory from consciousness.
   a. regression
   b. traumatic amnesia
   c. repression
   d. degeneration

15. Penfield's hypothesis that memory functions like a tape recorder has been supported by research. (true/false)

16. Psychologists doubt the validity of people's recovered memories of having been abused in infancy because the hippocampal region of the infant brain is not sufficiently developed to form such memories. (true/false)

17. Experts say that overlearning is basically a waste of time—that is, after you have gone over material once, you will not benefit from further study. (true/false)

18. It appears that the _____ is important in the formation of episodic memory.
   a. hippocampus
   b. cerebellum
   c. amygdala
   d. temporal lobe

19. Pablo's vivid memory of the day Princess Diana was killed is known as a _____ memory.
   a. histrionic
   b. flashbulb
   c. semantic
   d. retroactive

20. Eyewitnesses are more likely to identify the wrong person if the person is of a different race. (true/false)

21. Which of the following is true regarding culture and memory?
   a. Non-literate cultures that rely on oral histories have better memory for orally presented information than literate cultures.
   b. Stories set in cultures different from one's own are more readily remembered due to novelty of information.
   c. Memory for locations is not influenced by culture.
   d. Context and culture have little influence on memory ability.

SECTION FIVE: CRITICAL THINKING

1. Some studies cited in this chapter involved only one or a few participants.
   a. Select two of these studies and discuss the possible problems in drawing conclusions based on results from so few participants.
   b. Suggest several possible explanations for the findings other than those proposed by the researchers.

2. Drawing on your knowledge, formulate a plan that you can put into operation to help improve your memory and avoid the pitfalls that cause forgetting.

PRACTICE TEST

6.1 REMEMBERING

1. The processing of information for storage in memory is
   a. attention.
   b. encoding.
   c. elaboration.
   d. imagery.
2. The process of keeping or maintaining information in memory is
   a. attention.
   b. encoding.
   c. storage.
   d. retrieval.
3. The process of bringing information in memory to mind is
   a. attention.
   b. encoding.
   c. storage.
   d. retrieval.
4. As students walk across campus, they see and then almost immediately forget the faces of many people. This brief visual memory is called
   a. echoic.
   b. episodic.
   c. short-term.
   d. sensory.
5. When people repeat information they want to remember, such as unfamiliar telephone numbers, until they can write the number, they are practicing
   a. rehearsal.
   b. chunking.
   c. intermediate processing.
   d. episodic memory.
6. The fact that most people will remember where they were and how they learned about the terrorist actions of 9/11 is explained by
   a. sensory memory.
   b. implicit memory.
   c. procedural memory.
   d. episodic memory.
7. College students taking a test are using
   a. semantic memory.
   b. procedural memory.
   c. episodic memory
   d. implicit memory.
8. The ability of adults to ride a bicycle after many years can be explained by
   a. retrospective memory.
   b. nondeclarative memory.
   c. state-dependent memory.
   d. eidetic memory.
9. Essay tests are primarily memory tasks that require
   a. eidetic memory.
   b. nondeclarative memory.
   c. recall.
   d. recognition.
10. Multiple choice tests are primarily memory tasks that require
    a. eidetic memory.
    b. nondeclarative memory.
    c. recall.
    d. recognition.
11. The percentage of time saved when relearning material compared with the amount of time required to learn the material initially is called the
    a. levels-of-processing theory.
    b. the savings score.
    c. the primacy effect.
    d. reconstruction

6.2 THE NATURE OF REMEMBERING

12. The integrated frameworks of knowledge and assumptions that a person has about the world that affects how the person encodes and recalls information are
a. reconstructions.
b. schemas.
c. flashbulb memories.
d. mnemonics.

13. The relative inability of people to recall events from the first few years of life is
a. reconstruction failure.
b. encoding failure.
c. decay.
d. infantile amnesia.

14. When people recall their vivid memories of conditions in the environment when they receive surprising or shocking information, they are experiencing
a. semantic memories.
b. flashbulb memories.
c. eidetic imagery.
d. emotional recall.

15. The ability to retain the image of a visual stimulus for several minutes after the stimulus has been removed from view and to use the retained image to answer questions about the stimulus is
a. eidetic imagery.
b. semantic memory.
c. flashbulb memory.
d. total recall.

6.3 FACTORS INFLUENCING RETRIEVAL

16. Students have a one-hour break just before a test during which they can study a list of vocabulary words that they had studied the night before. According to the serial position effect, the students should spend the hour reviewing
a. all the words on the list.
b. the words at the beginning of the list.
c. the words in the middle of the list.
d. the words at the end of the list.

17. The tendency to be able to recall the last items in a sequence more readily than the items in the middle of the sequence is the
a. serial position effect.
b. primacy effect.
c. recency effect.
d. state-dependent memory effect.

18. The fact that if students are anxious when they prepare for a test, they will perform better if they are anxious when they take the test is explained by the
a. serial position effect.
b. primacy effect.
c. recency effect.
d. state-dependent memory effect.

6.4 BIOLOGY AND MEMORY

19. Inability to form semantic memories might follow removal of which brain area?
a. The reticular activation system.
b. The corpus callosum.
c. The hippocampal region.
d. The hypothalamus.

20. The inability of people who suffer serious head injuries to remember the names of people they meet after the injury is an example of
a. anterograde amnesia.
b. transience.
c. retroactive interference.
d. episodic memory.

21. An increase in the efficiency of neural transmission at the synapses is
a. consolidation.
b. priming.
c. long-term memory.
d. long-term potentiation.

6.5 FORGETTING

22. The fact that few students would be able to describe the clothes worn by the people sitting next to them in class is attributable to
a. retrieval failure.
b. encoding failure.
c. consolidation failure.
d. motivated forgetting.

23. The theory of forgetting that holds that unused memories fade with time is
a. encoding failure theory.
b. decay theory.
c. interference theory.
d. consolidation failure theory.

24. Loss of memory of events that occurred shortly before loss of consciousness is
a. motivated forgetting.
b. encoding failure.
c. anterograde amnesia.
d. retrograde amnesia.

25. People who survived automobile crashes in which other people died, and who remove memories of the event so that they are unaware that the event occurred, have used
a. repression.
b. consolidation failure.
c. prospective forgetting.
d. interference theory.

26. Students who have trouble completing assignments on time or who forget test dates have difficulty with
a. prospective interference.
b. retroactive interference.
c. prospective forgetting.
d. retrograde amnesia.

6.6 IMPROVING MEMORY

27. If students who must recite a poem in class practice the poem several times beyond the point at which they can repeat it once without error, the students are
a. using the recency effect.
b. consolidating.
c. depending on eidetic imagery.
d. overlearning.

28. Learning that takes place in long sessions without rest periods is said to be
a. massed.
b. distributed.
c. consolidating.
d. spaced.

29. The memory technique based on rhyming words such as "one is a bun," "two is a shoe," is called the
a. first-letter technique.
b. pegword method.
c. method of loci.
d. recitation method.

30. Repeating information aloud after it has been read is
a. overlearning.
b. spaced ppppppractice.
c. a mnemonic device.
d. recitation.