Key Questions/ Chapter Outline	Core Concepts	Psychology Matters
4.1 What Is Memory? Metaphors for Memory Memory's Three Basic Tasks	• Human memory is an information processing system that works constructively to encode, store, and retrieve information.	**Would You Want a "Photographic" Memory?** This ability is rare, and those who have it say that the images can sometimes interfere with their thinking.
4.2 How Do We Form Memories? The First Stage: Sensory Memory The Second Stage: Working Memory The Third Stage: Long-Term Memory	• Each of the three memory stages encodes and stores memories in a different way, but they work together to transform sensory experience into a lasting record that has a pattern or meaning.	**"Flashbulb" Memories: Where Were You When . . . ?** These especially vivid memories usually involve emotionally charged events. Surprisingly, they aren't always accurate.
4.3 How Do We Retrieve Memories? Implicit and Explicit Memory Retrieval Cues Other Factors Affecting Retrieval	• Whether memories are implicit or explicit, successful retrieval depends on how they were encoded and how they are cued.	**On the Tip of Your Tongue** It is maddening when you know the word, but you just can't quite say it. But you're not alone. Most people experience this about once a week.
4.4 Why Does Memory Sometimes Fail Us? Transience: Fading Memories Cause Forgetting Absent-Mindedness: Lapses of Attention Cause Forgetting Blocking: Access Problems Misattribution: Memories in the Wrong Context Suggestibility: External Cues Distort or Create Memories Bias: Beliefs, Attitudes, and Opinions Distort Memories Persistence: When We Can't Forget The Advantages of the "Seven Sins" of Memory Improving Your Memory with Mnemonics	• Most of our memory problems arise from memory's "seven sins"—which are really by-products of otherwise adaptive features of human memory.	**Using Psychology to Learn Psychology** In studying psychology there isn't much you will need to memorize. Instead, you will need mnemonic techniques that will help you learn and remember concepts.

Critical Thinking Applied: The Recovered Memory Controversy

chapter 4 memory

Can memory play tricks on us? Or does memory make an accurate and indelible record of our past? In fact, the truth about memory encompasses some of both of those extremes. Memory *does* sometimes play tricks on us. And many of our memories are quite accurate. The difficulty lies in knowing when to rely on memory, as the following cases will illustrate.

Case 1 Twelve-year-old Donna began to suffer from severe migraine headaches that left her sleepless and depressed. Concerned, her parents, Judee and Dan, agreed to find help for her. Over the next year, Donna was passed from one therapist to another, ending up with a psychiatric social worker who specialized in the treatment of child abuse. It was to that therapist that Donna disclosed—for the first time—having been sexually molested at the age of 3 by a neighbor. The therapist concluded that memories of the assault, buried in her mind for so long, were probably responsible for some of Donna's current problems, so she continued to probe for details and for other possible instances of sexual abuse.

Eventually, the therapist asked her to bring in a family photo album, which included a photo of Donna, taken at age 2 or 3, wearing underpants. The therapist suggested that this might be evidence that Donna's father had a sexual interest in her and, possibly, had molested her. Moreover, the therapist contacted the authorities, who began an investigation (ABC News, 1995).

For two years, Donna felt intense pressure to blame her father, but consistently denied that he had molested her. Finally, amid increasing confusion about her childhood memories, she began to believe that she suffered from "repressed memory syndrome" and that her father had abused her repeatedly during her childhood. Eventually, Donna was hospitalized. While in the hospital she was placed on medication, hypnotized repeatedly, and diagnosed with *multiple personality disorder* (now called *dissociative identity disorder*).

As for her father, Dan was arrested and tried on charges of abuse based solely on his daughter's recovered memory. When his two-week trial ended in a hung jury, Dan went free. Shortly after the trial, Donna moved to another state with a foster family. In new surroundings and far away from the system that had supported her story, she began to believe that her memories were false. Eventually, her doctor recommended she be sent back to her family, where they began the slow process of rebuilding lost relationships and trust.

Case 2 Ross is a college professor who entered therapy because he was unhappy with his life. Describing his condition, he said, "I felt somehow adrift, as if some anchor in my life had been raised. I had doubts about my marriage, my job, everything" (Schacter, 1996, p. 249). Then, some months after entering therapy, he had a dream that left him with a strong sense of unease about a certain camp counselor whom he had known as a youth. Over the next few hours, that sense of unease gradually became a vivid recollection of the counselor molesting him. From that point on, Ross became obsessed with this memory, finally hiring a private detective who helped him track down the counselor in a small Oregon town. After numerous attempts to talk with the counselor by telephone, Ross at last made contact and taped the phone conversation. The counselor admitted molesting Ross, as well as several other boys at the camp. Strangely, Ross claimed that he had simply not thought about the abuse for years—until he entered therapy.

PROBLEM: How can our knowledge about memory help us evaluate claims of recovered memories?

Keep in mind that there is no sure way to "prove a negative." That is, without some independent evidence, no one could ever prove conclusively that abuse or some other apparently long-forgotten event did *not* occur. Instead, we must weigh the claims against our understanding of memory. In particular, we will need to know the answers to the following questions:

- Does memory make an accurate record of everything we experience?
- Are traumatic experiences, such as those of sexual abuse, likely to be *repressed* (blocked from consciousness), as Sigmund Freud taught? Or, are we more likely to *remember* our most emotional experiences, both good and bad?

- How reliable are memories of experiences from early childhood?
- How easily can memories be changed by suggestion, as when a therapist or police officer might suggest that sexual abuse occurred?
- Are our most vivid memories more accurate than less vivid memories?

You will find the answers to these questions and many more in this chapter. Let's begin with the most fundamental question of all.

4.1 KEY QUESTION WHAT IS MEMORY?

Without doubt, memory does play tricks on us. Our best defense against those tricks comes from an understanding of how memory works. So, let's begin building that understanding with a definition: Cognitive psychologists view **memory** as a system that encodes, stores, and retrieves information—a definition, by the way, that applies equally to an organism or a computer. Unlike a computer's memory, however, we humans have a *cognitive* memory system that takes information from the senses and selectively converts it into meaningful patterns that can be stored and accessed later when needed. These memory patterns, then, form the raw material for thought and behavior. Such memory patterns allow you to recognize a friend's face, ride a bicycle, recollect a trip to Disneyland, and (if all goes well) recall the concepts you need during a test. More generally, our Core Concept characterizes memory this way:

CONNECTION • CHAPTER 1
Cognitive psychology is one of the six main perspectives in psychology.

Human memory is an information processing system that works constructively to encode, store, and retrieve information.

core concept

And how is memory related to *learning,* the topic of the last chapter? Learning and memory are different sides of the same coin. You might think of memory as the cognitive system that first processes, encodes, and stores the information we learn and, later, allows us to retrieve that information. So, this chapter is really an extension of our discussion of cognitive learning in Chapter 3. The focus here, however, will be on more complex *human* learning and memory, as contrasted with the simpler forms of animal learning and conditioning that we emphasized earlier.

Metaphors for Memory

We often use metaphors to help us understand complicated things. One such metaphor compares human memory to a library or a storehouse, emphasizing the ability of memory to hold large amounts of information (Haberlandt, 1999). Another, as we've just described, compares memory to a computer. Some metaphors for memory, however, can be misleading. That's certainly the case with the "video recorder" metaphor for memory, which leads people to believe that human memory makes a complete and accurate record of everything we experience.

Experiments have shown that this video-recorder metaphor is wrong. And especially in some cases of "recovered memories," believing in the unfailing accuracy of memory can be dangerously wrong. Instead, cognitive psychologists see human memory as an *interpretive* system that takes in information and, much

Memory Any system—human, animal, or machine—that encodes, stores, and retrieves information.

Memory encodes the best records for information on which we have focused attention.

like an artist, discards details and organizes the rest into meaningful patterns. As a result, our memories represent our *perceptions* of events, rather than being accurate representations of the events themselves.

When remembering, you retrieve fragments of memory—like pieces of a jigsaw puzzle. Then, from these fragments, you *reconstruct* the incident (or idea, emotion, or image) by filling in the blanks *as you think it was,* rather than the way it actually was. Most of the time this works well enough that you don't realize just how much of remembrance is reconstruction.

A look at Figure 4.1 should convince you of this reconstructive process. Which image in the figure is the most accurate portrayal of a penny? Although pennies are common in our everyday experience, you will probably find that identifying the real penny image is not easy. Unless you are a coin collector, you probably pay little attention to the details of these familiar objects. The result is a vague memory image that serves well enough in everyday life but is sparse on details. So, when retrieving the image of a penny, you automatically fill in the gaps and missing details—without realizing how much of the memory image you are actually creating. (The right answer, by the way, is A.)

Some memories are sketchier than others. In general, psychologists have found that we make the most complete and accurate memory records for:

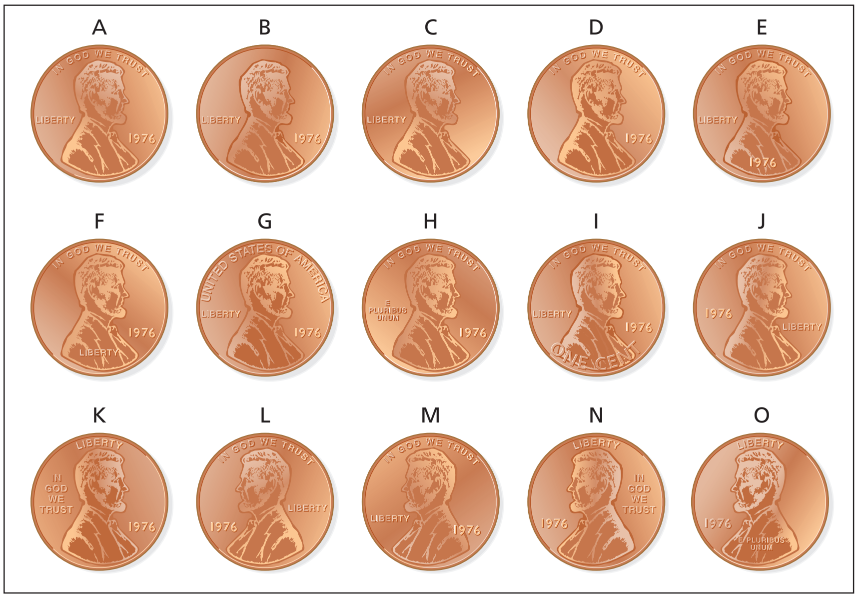
- Information on which we have *focused our attention,* such as a friend's words against a background of other conversations
- Information in which we are *interested,* such as the plot of a favorite movie
- Information that *arouses us emotionally,* such as an especially enjoyable or painful experience (unless the material also brings our biases into play, as when we listen to a highly partisan political presentation)
- Information that *connects with previous experience,* such as a news item about the musician whose concert you attended last week
- Information that we *rehearse,* such as material reviewed before an exam

Information-processing model A cognitive understanding of memory, emphasizing how information is changed when it is encoded, stored, and retrieved.

The rest of the chapter will unfold this cognitive approach to memory, known as the **information-processing model.** It emphasizes how information undergoes systematic changes on its way to becoming a permanent memory—quite differ-

FIGURE 4.1
The Penny Test

(*Source:* From "Long-Term Memory for a Common Object," by Nickerson and Adams in *Cognitive Psychology,* Vol. 11, Issue #1, 1979, pp. 287–307. Copyright © 1979. Reprinted by permission of Elsevier.)



ent from the naïve video recorder model. The information-processing model also emphasizes that memory is *functional*—that is, it performs some useful functions for us. The most basic of these, we will see below, are the *encoding, storage,* and *retrieval* of information.

Memory's Three Basic Tasks

In simplest terms, human memory takes essentially meaningless sensory information (such as the sounds of your professor's voice) and changes it into meaningful patterns (words, sentences, and concepts) that you can store and use later. To do so, memory must first *encode* the incoming sensory information in a useful format.

Encoding requires that you first *select* some stimulus event from among the vast array of inputs assaulting your senses and then make a preliminary classification of that stimulus. Is it a sound, a visual image, or an odor? Next you *identify* the distinctive features of that input. If it's a sound, is it loud, soft, or harsh? Does it fit some pattern, such as a car horn, a melody, a voice? Is it a sound you have heard before? Finally, you mentally tag, or *label,* an experience to make it meaningful. ("It's Dr. Johnson. He's my psychology professor!")

For many of our everyday experiences, encoding is so automatic and rapid that we have no awareness of the process. For example, you can probably recall what you had for breakfast this morning, even though you didn't deliberately try to make the experience "stick" in your mind. Emotionally charged experiences, such as an angry exchange with a colleague, are even more likely to lodge in memory without any effort on our part to encode it (Dolan, 2002).

On the other hand, memories for concepts, such the basic principles of psychology that you are learning about in this book, usually require a deliberate encoding effort, called *elaboration,* to establish a usable memory. During elaboration, you attempt to connect a new concept with existing information in memory. One way to do this is to link the new material with concrete examples, as when you associated the term *negative reinforcement* with the removal of pain when you take an aspirin. (As an aid to elaboration, this book deliberately provides many such examples that, we hope, will connect new concepts with your own experiences.)

Storage, the second essential memory task, involves the retention of encoded material over time. But it's not a simple process. As we get deeper into the workings of memory, you will learn that memory consists of three parts, or *stages,* each of which stores memories for different lengths of time and in different forms. The trick of getting difficult-to-remember material into long-term storage, then, is to recode the information in the way long-term memory "likes" it, before the time clock runs out. For example, while listening to a lecture, you may have just a few seconds to encode a pattern or meaning in the sound of your professor's voice before new information comes along and the old information is lost.

Retrieval, the third basic memory task, becomes the payoff for your earlier efforts in encoding and storage. When you have a properly encoded memory, it takes only a split second for a good cue to access the information, bring it to consciousness, or, in some cases, to influence your behavior at an unconscious level. (Let's test the ability of your conscious retrieval machinery to recover the material we just covered: Can you remember which of the three memory tasks occurs just before *storage?*)

Alas, retrieval doesn't always go well, because the human memory system—marvelous as it is—sometimes makes errors, distorts information, or even fails us completely. In the last section of the chapter, we will take a close look at these problems, which memory expert Daniel Schacter (1996) calls the "seven sins of memory." The good news is that you can combat memory's "sins" with a few simple techniques that you will also learn about in the following pages.

Encoding The first of the three basic tasks of memory, involving the modification of information to fit the preferred format for the memory system.

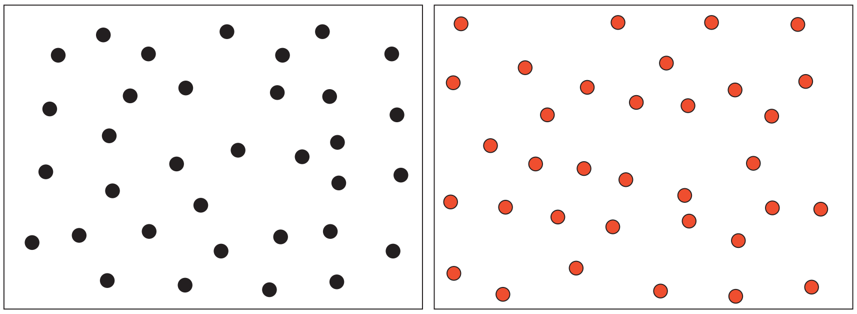
Storage The second of the three basic tasks of memory, involving the retention of encoded material over

Retrieval The third basic task of memory, involving the location and recovery of information from memory.

M04_ZIMB7883_06_SE_C04.QXD 10/17/08 1:40 PM Page 138

DO IT YOURSELF! A Test of Eidetic Imagery

Look at the dot pattern on the left in the figure for a few moments and try to fix it in your memory. With that image in mind, look at the dot pattern on the right. Try to put the two sets of dots together by recalling the first pattern while looking at the second one. If you are the rare individual who can mentally combine the two patterns, you will see something not apparent in either image alone. Difficult? No problem if you have eidetic imagery—but impossible for the rest of us. If you want to see the combined images, but can't combine them in your memory, look at Figure 4.2.



A Test of Eidetic Imagery

People with good eidetic imagery can mentally combine these two images to see something that appears in neither one alone.

PSYCHOLOGYMATTERS

Would You Want a "Photographic" Memory?

Suppose that your memory were so vivid and accurate that you could use it to "read" paragraphs of this book from memory during the next psychology exam. Such was the power of a 23-year-old woman tested by Charles Stromeyer and Joseph Psotka (1970). One of the amazing things she could do would be to look at the meaningless configuration of dots in the left-hand pattern in the "Do It Yourself!" box above and combine it mentally with the right-hand image. The result was the combined pattern shown in Figure 4.2. (Did you see the number "63" before you looked at the solution?) So, wouldn't it be great to have such a "photographic" memory? Not entirely, it turns out.

The technical term for "photographic memory" is **eidetic imagery.** Psychologists prefer this term because eidetic images differ in many important respects from images made by a camera (Haber, 1969, 1980). For example, a photographic image renders everything in minute detail, while an eidetic image portrays the most interesting and meaningful parts of the scene most accurately.

Eidetic memories also differ in several respects from the normal memory images that most of us experience. For one thing, *eidetikers* describe their memory images as having the vividness of the original experience (Neisser, 1967). For another, eidetic images are visualized as being "outside the head," rather than inside—in the "mind's eye." (Yet, unlike a person who is hallucinating, eidetikers recognize these images as *mental* images.) Further, an eidetic image can last for several minutes—even for days, in some cases. For example, the woman tested by Stromeyer and Psotka could pass the dot-combining test even when the two patterns were shown to her 24 hours apart. But, remarkable as this is, the persistence of eidetic images can be a curse. Eidetikers report that their vivid imagery sometimes clutters their minds and interferes with other things they want to think about (Hunter, 1964).

Eidetic imagery appears most commonly in children but only rarely in adults. One estimate says that up to 5% of children show some eidetic ability—although in most instances it's not good enough to pass the dot-combining test (Gray & Gummerman, 1975). While no one knows why eidetic imagery tends to disappear in adults, it may follow some sort of developmental sequence—like losing one's baby teeth. Possibly its disappearance is related to the child's development of abstract thought, which often begins to develop at about age 11 or 12.

Eidetic imagery An especially clear and persistent form of memory that is quite rare; sometimes known as "photographic memory."

CONNECTION • CHAPTER 6

In Piaget's theory, the formal operational stage, which often begins at about age 11 or 12, marks the appearance of abstract thought.

Case studies also suggest a connection between the decline of eidetic imagery and the development of language skills: Eidetikers report that describing an eidetic image in words makes the image fade from memory, and they learn to exploit this fact to control their intrusive imagery (Haber, 1969, 1970). Oddly enough, forensic psychologists have found that, for ordinary people (non-eidetikers), giving verbal descriptions of suspects' faces interferes with later memories for those faces. Likewise, trying to describe other hard-to-describe perceptions, such as a voice or the taste of a wine, impairs most people's abilities to recall those perceptions later (Bower, 2003; Dodson et al., 1997).

A study from Nigeria further supports the idea that the loss of eidetic ability may result from a conflict between language skills and visual imagery. This research found eidetic imagery to be common not only among children but also among illiterate adults of the Ibo tribe who were living in rural villages. Although many of the Ibo adults could correctly draw details of images seen sometime earlier, further testing found that members of the same tribe who had moved to the city and had learned to read showed little eidetic ability (Doob, 1964).

Whatever eidetic memory may be, it is clearly rare—so rare, in fact, that some psychologists have questioned its existence (Crowder, 1992). The few existing studies of "photographic memory" have portrayed it as different from everyday memory, as we have seen. But the fact is that we know relatively little about the phenomenon, and few psychologists are currently studying it.

Eidetic imagery presents not only a practical problem for those rare individuals who possess it but also a theoretical problem for cognitive psychologists. If eidetic imagery exists, is a known component of memory responsible? On the other hand, if it proves to be a unique form of memory, how does it fit with the widely accepted three-stage model of memory—which we will discuss next?

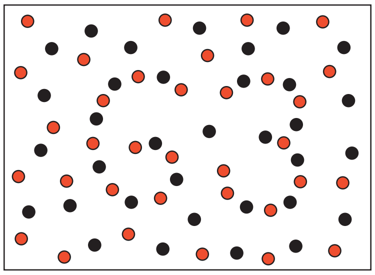


FIGURE 4.2
What an Eidetiker Sees

The combined images from the "Do It Yourself!" box form a number pattern.
(*Source:* From *Human Memory: Structures and Processes* by Roberta Klatzky. Copyright © 1975, 1980 by W. H. Freeman and Company. Used with permission.)

Check Your Understanding

1. **ANALYSIS:** What is a major objection to the "video recorder" model of human memory?
2. **RECALL:** What are the three essential tasks of memory?
3. **ANALYSIS:** Suppose that you have just gotten a new cat. You note her unique markings, so that you can remember what she looks like in comparison with other cats in the neighborhood. What would a cognitive psychologist call this process of identifying the distinctive features of your cat?
4. **UNDERSTANDING THE CORE CONCEPT:** Which one of the following memory systems reconstructs material during retrieval?
   a. computer memory
   b. human memory
   c. video recorder memory
   d. information recorded in a book

Answers **1.** Unlike a video recorder, which makes an accurate and detailed record, memory stores an interpretation of experience. **2.** Encoding, storage, and retrieval **3.** Encoding **4.** b

4.2 KEY QUESTION
HOW DO WE FORM MEMORIES?

If the information in a lecture is to become part of your permanent memory, it must be processed in three sequential stages: first in *sensory memory,* then in *working memory* (also called short-term memory), and finally in *long-term memory.* The three stages work like an assembly line to convert a flow of incoming stimuli into meaningful patterns that you can store and later recall. This three-stage model, originally developed by Richard Atkinson and Richard Shiffrin (1968), is now widely accepted—with some elaborations and modifications. Figure 4.3 shows how information flows through the three stages. (Caution: Don't get these three *stages* confused with the three basic *tasks* of memory that we covered earlier.)

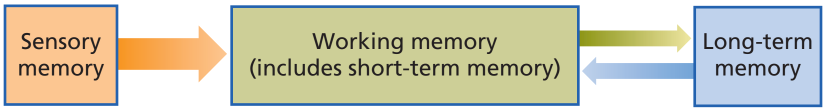


FIGURE 4.3
The Three Stages of Memory (Simplified)

The "standard model," developed by Atkinson and Shiffrin, says that memory is divided into three stages of processing. Everything that eventually goes into long-term storage must first be processed by sensory memory and working memory.

Sensory memory, the most fleeting of the three stages, typically holds sights, sounds, smells, textures, and other sensory impressions for only a fraction of a second. Although we are usually not aware of sensory memory, you can see its effects in the fading luminous trail made by a moving flashlight or a twirling Fourth-of-July sparkler. You can also hear the effects of fading sensory memories in the blending of one note into another as you listen to a melody. In general, these short-lived images allow us to maintain incoming sensory information just long enough for it to be screened for importance by working memory.

Working memory, the second stage of processing, takes information selectively from the sensory registers and makes connections with items already in long-term storage. (It is this connection we mean when we say, "That rings a bell!") Working memory holds information for only a few seconds, making it a useful buffer for temporarily holding a name you have just heard or a phone number you have just looked up. Originally, psychologists called this stage *short-term memory (STM),* a term still in use. The newer term *working memory* emphasizes some refinements of the original Atkinson and Shiffrin model that we will discuss in more detail shortly.

It is worth noting that everything entering consciousness passes into working memory. The opposite is also true: We are conscious of everything that enters working memory—although some information may not be the focus of our attention. Because of this intimate relationship, some psychologists have suggested that working memory is actually the long-sought seat of consciousness (Engle; 2002; LeDoux, 1996).

Long-term memory (LTM), the final stage of processing, receives information from working memory and can store it for much longer periods—sometimes for the rest of a person's life. Information in long-term memory constitutes our knowledge about the world. It includes material as varied as an image of your mother's face, the lyrics to your favorite song, and the year that Wilhelm Wundt established the first psychology laboratory. (You remember: That was in 18??.)

Our Core Concept captures the three stages in brief:

core concept

Each of the three memory stages encodes and stores memories in a different way, but they work together to transform sensory experience into a lasting record that has a pattern or meaning.

Our focus in this section will be on the unique contributions each stage makes to the final memory product. (See Table 4.1.) More specifically, we will look at each stage in terms of its storage *capacity,* its *duration* (how long it retains information), its *structure and function,* and its *biological basis.*

Sensory memory The first of three memory stages, preserving brief sensory impressions of stimuli.

Working memory The second of three memory stages, and the one most limited in capacity. It preserves recently perceived events or experiences for less than a minute without rehearsal.

Long-term memory (LTM) The third of three memory stages, with the largest capacity and longest duration; LTM stores material organized according to meaning.

The First Stage: Sensory Memory

Your senses take in far more information than you can possibly use. While reading this book, they serve up the words on the page, sounds in the room, the feel of your clothes on your skin, the temperature of the air, the slightly hungry feeling in your stomach. . . . And how does the brain deal with all of this sensory information?

It's the job of sensory memory to hold the barrage of incoming sensation just long enough (about 1/4 second) for your brain to scan it and decide which stream of information needs attention. But just how much information can sensory

TABLE 4.1 The Three Stages of Memory Compared

	Sensory Memory	Working Memory (STM)	Long-Term Memory (LTM)
Function	Briefly holds information awaiting entry into working memory	Involved in control of attention Attaches meaning to stimulation Makes associations among ideas and events	Long-term storage of information
Encoding	Sensory images: no meaningful encoding	Encodes information (especially by meaning) to make it acceptable for long-term storage	Stores information in meaningful mental categories
Storage capacity	12–16 items	"Magic number 7" ± 2 chunks	Unlimited
Duration	About 1/4; second	About 20–30 seconds	Unlimited
Structure	A separate sensory register for each sense	Central executive Phonological loop Sketchpad	Procedural memory and declarative memory (further subdivided into semantic and episodic memory)
Biological Basis	Sensory pathways	Involves the hippocampus and frontal lobes	Involves various parts of the cerebral cortex

memory hold? Cognitive psychologist George Sperling answered this question by devising one of psychology's simplest and most clever experiments.

The Capacity and Duration of Sensory Memory In brief, Sperling demonstrated that sensory memory can hold far more information than ever reaches consciousness. To do so, he first asked people to remember, as best they could, an array of letters flashed on a screen for a fraction of a second. (You might try glancing briefly at the array below and then trying to recall as many as you can.)

D	J	B	W
X	H	G	N
C	L	Y	K

There was no surprise here: Most people could remember only three or four items from a fraction-of-a-second exposure.

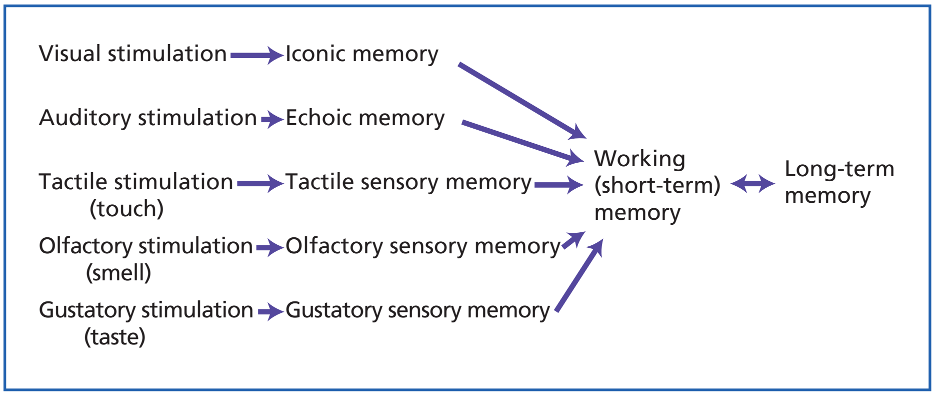
But, Sperling hypothesized, it might be possible that far more information than these three or four items might enter a temporary memory buffer but vanish before it can be reported. To test this conjecture, he modified the experimental task as follows. Immediately after the array of letters flashed on the screen, an auditory cue signaled which row of letters to report: A high-pitched tone indicated the top row, a medium tone the middle row, and a low tone meant the bottom row. Thus, immediately after seeing the brief image and hearing a beep, respondents were to report items *from only one row,* rather than items from the whole array.

Under this *partial report* condition, most people achieved almost perfect accuracy—no matter which row was signaled. That is, Sperling's volunteers could accurately report *any single row,* but *not all rows*. This result suggested that the actual storage capacity of sensory memory can be 12 or more items—even though all but three or four items usually disappear from sensory memory before they can enter consciousness (Sperling, 1960, 1963).

Would it be better if our sensory memories lasted longer, so we would have more time to scan them? Probably not. With new information constantly flowing in, old information needs to disappear quickly, lest the system become overloaded. We are built so that sensory memories last just long enough to dissolve into one another and give us a sense of flow and continuity in our experience. But they usually do not last long enough to interfere with new incoming sensory impressions.

FIGURE 4.4
Multiple Sensory Stores

We have a separate sensory memory for each of our sensory pathways. All feed into working (short-term) memory.



The Structure and Function of Sensory Memory You might think of sensory memory as a sort of mental "movie screen," where images are "projected" fleetingly and then disappear. In fact, this blending of images in sensory memory gives us the impression of motion in a "motion picture"—which is really just a rapid series of still images.

But, not all sensory memory consists of visual images. We have a separate *sensory register* for each sense, with each register holding a different kind of sensory information, as shown in Figure 4.4. The register for vision, called *iconic memory,* stores the encoded light patterns experienced as visual images. Similarly, the sensory memory for hearing, known as *echoic memory,* holds encoded auditory stimuli.

Please note that the images in sensory memory have no meaning attached to them—just as an image on photographic film has no meaning to a camera. It's the job of sensory memory simply to store the images briefly. Then, as we will see, it's in the next stage, working memory, where we add meaning to sensation.

The Biological Basis of Sensory Memory The biology of sensory memory appears to be relatively simple. Psychologists now believe that, in this initial stage, memory images take the form of neural activity in the sense organs and their pathways to the brain. In this view, sensory memory consists of the rapidly fading trace of stimulation in our sensory systems (Bower, 2000b; Glanz, 1998). Working memory then "reads" these fading sensory traces and decides which ones to admit into the spotlight of attention and which to ignore and allow to disappear.

The Second Stage: Working Memory

In the second stage of processing, working memory serves as the buffer in which you put the new name you have just heard. It also acts as the temporary storage site for the words in the first part of this sentence while you read toward the end. More broadly, working memory is the processor of conscious experience, including information coming from sensory memory, as well as information being retrieved from long-term memory (Jonides et al., 2005).

Additionally, working memory provides a mental "work space" where we sort and encode information before adding it to more permanent storage (Shiffrin, 1993). In doing so, it makes experiences meaningful by blending them with information from long-term memory. To give a concrete example: Working memory is the register into which you retrieve the information you learned in yesterday's class, as you review for tomorrow's test.

You might think of working memory, then, as the "central processing chip" for the entire memory system. In this role, it typically holds information for about 20 seconds—far longer than does sensory memory. If you make a special effort to rehearse the material, it can keep information active even longer, as when you repeat a phone number to yourself before dialing. It is also the men-

DO IT YOURSELF! Finding Your STM Capacity

Look at the following list of numbers and scan the four-digit number, the first number on the list. Don't try to memorize it. Just read it quickly; then look away from the page and try to recall the number. If you remember it correctly, go on to the next longer number, continuing down the list until you begin to make mistakes. How many digits are in the longest number that you can squeeze into your STM?

7485
36218
479103
2384971
36891756
747210324
8230138476

The result is your digit span, or your working (short-term) memory capacity for digits. Studies show that, under ideal testing conditions, most people can remember five to nine digits. If you remembered more, you may have been using special "chunking" techniques.

tal work space in which we consciously mull over ideas and images pulled from long-term storage, in the process that we call "thinking." In all of these roles, then, working memory acts much like the main processing chip in a computer—as not only the center of mental action but as a go-between for the other components of memory.

The Capacity and Duration of Working Memory Psychologist George Miller (1956) famously suggested that this second stage of memory is associated with the "magic number" seven. What he meant was that working memory holds about seven items—a fact that caused lots of distress when phone companies began requiring callers to add an area code to the old seven-digit phone number. Working memory's storage capacity does vary slightly from person to person, so you may want to assess how much yours can hold by trying the test in the "Do It Yourself!" box. In addition, STM has different capacities for different kinds of material, with some psychologists suggesting that it has a practical limit of only about three or four items (Cowan, 2001). The take-away message is that working memory has a limited capacity.

When we overload working memory, earlier items usually drop away to accommodate more recent ones. Yet, when working memory fills up with information demanding attention, we may not even notice new information streaming through our senses. That's why, in the opinion of some experts, this limited capacity of working memory makes it unsafe to talk on your cell phone while driving (Wickelgren, 2001).

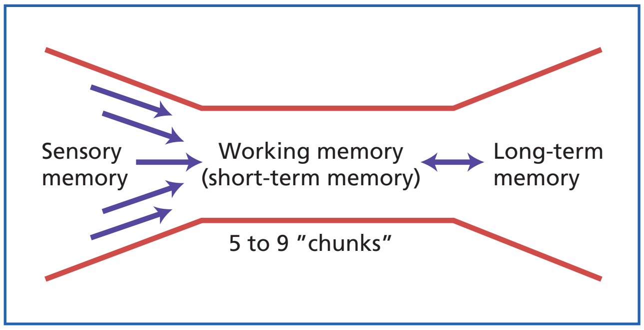
You will note that working memory's meager storage capacity is significantly smaller than that of sensory memory. In fact, working memory has the smallest capacity of the three memory stages. This limitation, combined with a tendency to discard information after about 20 seconds, makes working memory the information "bottleneck" of the memory system. (See Figure 4.5.) As you may have surmised, the twin problems of limited capacity and short duration present obstacles for students, who must process and remember large amounts of information when they hear a lecture or read a book. Fortunately, there are ways to work around these difficulties, as we will see.

Chunks and Chunking In memory, a *chunk* can be any pattern or meaningful unit of information. It might be a single letter or number, a name, or even a concept. For example, the letters P-H-I-L could constitute four chunks. However, you probably recognize this sequence as a name (in fact, the name of one of your authors), so you can combine the four letters into a single chunk in STM. Thus, by **chunking**, you can get more material into the seven slots of working memory.

Chunking Organizing pieces of information into a smaller number of meaningful units (or chunks)—a process that frees up space in working memory.

FIGURE 4.5
The STM Bottleneck

Caught in the middle, with a much smaller capacity than sensory and long-term memories, working memory (short-term memory) becomes an information bottleneck in the memory system. As a result, much incoming information from sensory memory is lost.



The phone company discovered chunking years ago—which is why they put hyphens in phone numbers. So, when they group the seven digits of a phone number (e.g., 6735201) into two shorter strings of numbers (673-5201), they have helped us arrange seven separate items into two chunks—which leaves room for the area code. The government uses the same chunking principle to help us remember our nine-digit Social Security numbers.

The Role of Rehearsal Speaking of phone numbers, suppose that you have just looked up the phone number mentioned in the preceding paragraph. To keep it alive in working memory, you can repeat the digits to yourself over and over. This technique is called **maintenance rehearsal,** and it serves us well for maintaining information temporarily in consciousness. Maintenance rehearsal keeps information fresh in working memory and prevents competing inputs from crowding it out. But repetition is not an efficient way to transfer information to long-term memory, even though people often attempt to do so. Sadly, the student who tries to learn the material for a test by using simple repetition (maintenance rehearsal) probably won't remember much.

A better strategy for transferring material into long-term memory involves **elaborative rehearsal.** With this method, information is not merely repeated but is actively connected to knowledge already stored. So, suppose that you are an ophthalmologist, and you want your patients to remember your phone number. Because numbers are notoriously difficult to remember, you can help your customers with their elaborative rehearsal by using a "number" that makes use of the letters on the phone buttons, such as 1-800-EYE-EXAM. The same principle can be used with more complex material, such as you are learning in psychology. For example, when you read about echoic memory, you may have elaborated it with a connection to "echo," which is also an auditory sensation.

The Structure and Function of Working Memory Figure 4.6 shows several components of working memory. Alan Baddeley and Graham Hitch (1974) originally proposed a *central executive* that directs your attention to important input from sensory memory, such as someone calling a name, or to material retrieved from long-term memory, as when you are taking a test. In addition, they proposed a *phonological loop* that temporarily stores sounds—helping you to remember the mental "echo" of a name or to follow a melody. A third part of working memory, that they dubbed the *sketchpad,* stores and manipulates visual images, as when you are imagining the route between your home and class.

Are there other components in the working memory system? Baddeley has, more recently, proposed an *episodic buffer* (Figure 4.6) that may help us remember events or "episodes" (Baddeley, 2000). Others have posited a *semantic buffer,* or language-processing module, that seems to help us attach meaning to words that we see or hear (Martin, 2005). Indeed, it would not be surprising if there were other components associated with other cognitive functions. Because the episodic and verbal buffers are not so well established, let's focus on the three components of working memory in the original Baddeley and Hitch model.

The Central Executive The information clearinghouse for working memory, the *central executive* is perhaps the most important and most poorly understood component of working memory. We do know that it serves as the interface between sensory memory, long-term memory, and the brain's voluntary (conscious) response system. In that role, the central executive is also part of the process that directs attention. Think of the central executive, then, as the heart and soul of the working memory system. Even now, as you sit reading this book, the central executive in your working memory is helping you decide whether to attend to these words, or to other stimuli flowing into working memory from your other senses, along with thoughts from long-term memory.

Maintenance rehearsal A working-memory process in which information is merely repeated or reviewed to keep it from fading while in working memory. Maintenance rehearsal involves no active elaboration.

Elaborative rehearsal A working-memory process in which information is actively reviewed and related to information already in LTM.

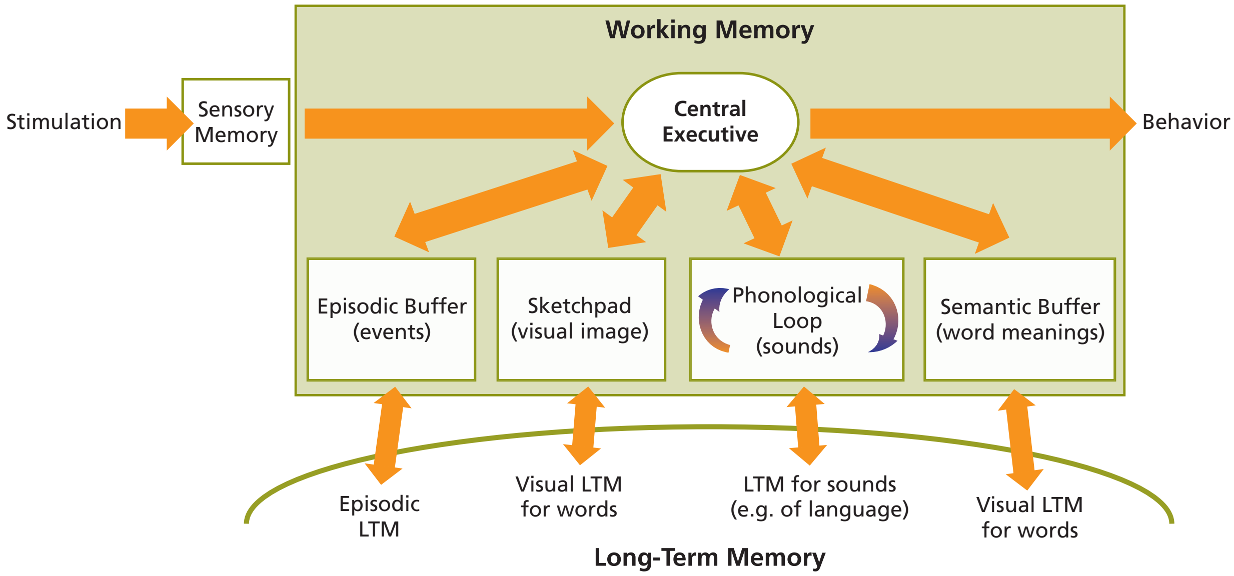


FIGURE 4.6
A Model of Working Memory

Atkinson and Shiffrin's original model divided memory into three stages. Events must first be processed by sensory memory and short-term memory (now called *working memory*) before they finally go into long-term memory storage—from which they can later be retrieved back into working memory. Baddeley's (2001) updated version of working memory includes a *central executive* that directs attention, a *sketchpad* for visual and spatial information, a *phonological loop* for sounds, and an *episodic buffer* that can combine many kinds of information into memories of events. More recently, neuroscience research has pointed to a *semantic buffer* that draws on the meaning of words in LTM (Martin, 2005). This drawing includes all of these refinements to the original model of working memory.

(*Source:* Adapted from "Episodic Buffer: A New Component of Working Memory?" by A. Baddeley, *Trends in Cognitive Sciences* [2000], 4, pp. 417–423, American Psychological Association.)

Acoustic Encoding: The Phonological Loop If you were reading poetry, containing words like "whirr," "pop," "cuckoo," and "splash," you could hear in your mind the sounds they describe. This **acoustic encoding** also happens with words that don't have imitative sounds. That is, working memory converts all the words we encounter into the sounds of spoken language and shuttles them into its phonological loop—whether the words come through our eyes, as in reading, or our ears, as in listening to speech (Baddeley, 2001). There, working memory maintains the verbal patterns in an acoustic (sound) form as they are processed.

Acoustic encoding in working memory can cause some interesting memory errors. When people recall lists of letters they have just seen, the mistakes they make often involve confusions of letters that have similar sounds—such as D and T—rather than letters that have a similar look—such as E and F (Conrad, 1964). Mistakes aside, however, acoustic encoding has its advantages, particularly in learning and using language (Baddeley et al., 1998; Schacter, 1999).

Visual and Spatial Encoding: The Sketchpad Serving much the same function for visual and spatial information, working memory's *sketchpad* encodes visual images and mental representations of objects in space. It holds the visual images you mentally rummage through when you're trying to imagine where you left your car keys. It also holds the mental map you follow from home to class. Neurological evidence suggests that the sketchpad requires coordination among several brain systems, including the frontal and occipital lobes.

Levels of Processing in Working Memory An important tip for students: The more connections you can make with new information in working memory, the more likely you are to remember it later. Obviously this requires an interaction between working memory and long-term memory. According to the **levels-of-processing theory** proposed by Fergus Craik and Robert Lockhart (1972), "deeper"

Acoustic encoding The conversion of information, especially semantic information, to sound patterns in working memory.

Levels-of-processing theory The explanation for the fact that information that is more thoroughly connected to meaningful items in long-term memory (more "deeply" processed) will be remembered better.

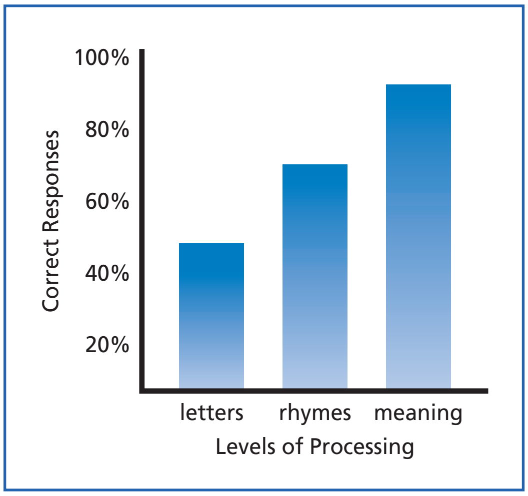


FIGURE 4.7
Results of Levels-of-Processing Experiment

In the Craik and Tulving (1975) experiment, words that were processed more deeply (for meaning) were remembered better than words examined for rhymes or for target letters.

processing—establishing more connections with long-term memories—makes new information more meaningful and more memorable. A famous experiment will illustrate this point.

Craik and Tulving (1975) had volunteer subjects examine a list of 60 common words presented on a screen one at a time. As each word appeared, the experimenters asked questions designed to influence how deeply each word was processed. For example, when BEAR appeared on the screen, the experimenters would ask one of three questions: "Is it in capital letters?" "Does it rhyme with *chair?*" "Is it an animal?" Craik and Tulving theorized that merely thinking about capital letters would not require processing the word as deeply as would comparing its sound with that of another word. But the deepest level of processing, they predicted, would occur when some aspect of the word's *meaning* was analyzed, as when they asked whether BEAR was an animal. Thus, they predicted that items processed more deeply would leave more robust traces in memory. And, sure enough, when the participants were later asked to pick the original 60 words out of a larger list of 180, they remembered the deeply processed words much better than words processed more superficially, as the graph in Figure 4.7 shows.

The Biological Basis of Working Memory Although the details remain unclear, working memory probably holds information in the form of messages flashed repeatedly in nerve circuits. Brain imaging implicates brain regions in the frontal cortex (Beardsley, 1997b; Smith, 2000). Moreover, these regions also project to all the sensory parts of the brain and to areas known to be involved in long-term storage—just as we might expect from our three-stage model of memory. Brain imaging also suggests that the frontal lobes house some anatomically distinct "executive processes" that focus attention on information in short-term storage (Smith & Jonides, 1999). Together, these brain modules direct attention, set priorities, make plans, update the contents of working memory, and monitor the time sequence of events.

The Third Stage: Long-Term Memory

Can you remember who discovered classical conditioning? What is the name of a play by Shakespeare? How many birthdays have you had? Such information, along with everything else you know, is stored in your long-term memory (LTM), the last of the three memory stages.

Given the vast amount of data stored in LTM, it is a marvel that we can so easily gain access to so much of it. Remarkably, if someone asks your name, you don't have to rummage through a lifetime of information to find the answer. The method behind the marvel involves a special feature of long-term memory: Words and concepts are encoded by their meanings. This connects them, in turn, with other items that have similar meanings. Accordingly, you might picture LTM as a huge web of interconnected associations. As a result, good retrieval cues (stimuli that prompt the activation of a long-term memory) can travel though the web and help you quickly locate the item you want amid all the data stored there. Information scientists would very much like to fully understand this feature of LTM and use it to increase the search and retrieval speed of computers.

The Capacity and Duration of Long-Term Memory How much information can long-term memory hold? As far as we know, it has unlimited storage capacity. (No one has yet maxed it out, so you don't have to conserve memory by cutting back on your studying.) LTM can store the information of a lifetime: all the experiences, events, information, emotions, skills, words, categories, rules, and judgments that have been transferred from working memory. Thus, your LTM contains your total knowledge of the world and of yourself. This makes long-term memory clearly the champion in both duration and storage capacity among the three stages of memory. But how does LTM manage to have unlimited capacity? That's another unsolved mystery of memory. Perhaps we might conceive of LTM as a sort of mental "scaffold," so the more associations you make, the more information it can hold.

Procedural memory allows experts like pitcher Josh Beckett to perform complex tasks automatically, without conscious recall of the details.

The Structure and Function of Long-Term Memory With a broad overview of LTM in mind, let's look at some of the details of its two main components. One, a register for the things we know how to *do,* is called *procedural memory.* The other, which acts as storage for the information that we can *describe*—the facts we know and the experiences we remember—is called *declarative memory.* We know that procedural and declarative memory are distinct because brain damaged patients may lose one but not the other (as we will see).

Procedural Memory We call on **procedural memory** when riding a bicycle, tying shoelaces, or playing a musical instrument. Indeed, we use procedural memory to store the mental directions, or "procedures," for all our well-practiced skills (Schacter, 1996). Much of procedural memory operates outside of awareness: Only during the early phases of training, when we must concentrate on every move we make, must we think consciously about the details of our performance. Later, after the skill is thoroughly learned, it operates largely beyond the fringes of awareness, as when a concert pianist performs a piece without consciously recalling the individual notes. (Figure 4.8 should help you clarify the relationship between the two major components of long-term memory.)

Declarative Memory We use **declarative memory** to store facts, impressions, and events. Recalling the directions for driving to a certain location, such as the grocery store, depends on declarative memory (although knowing *how* to drive a car requires procedural memory). In contrast with procedural memory, using declarative memory more often requires conscious mental effort, as you can tell when people roll their eyes or make facial gestures while trying to recall facts or experiences.

To complicate matters, declarative memory itself has two major subdivisions, *episodic memory* and *semantic memory.* One deals with the rich detail of personal experiences (your first kiss), while the other simply stores information, without an "I-remember-when" context—information like the multiplication tables or the capital of your state.

Episodic memory is the division of declarative memory that stores personal experiences: your memory for events, or "episodes," in your life. It also stores *temporal coding* (or time tags) to identify *when* the event occurred and *context coding* that indicates *where* it took place. For example, you store memories of your recent vacation or of an unhappy love affair in episodic memory, along with codes for where and when these episodes occurred. In this way, episodic memory acts as your internal diary or *autobiographical memory.* You consult it when someone says, "Where were you on New Year's Eve?" or "What did you do in class last Tuesday?"

Semantic memory is the other division of declarative memory. (Again, refer to Figure 4.8, if this is becoming confusing.) It stores the basic meanings of words and concepts. Usually, semantic memory retains no information about the time and place in which its contents were acquired. Thus, you keep the meaning of *cat* in semantic memory—but probably not a recollection of the occasion on which you first learned the meaning of *cat.* In this respect, semantic memory more closely resembles an encyclopedia or a database than an autobiography. It stores a vast quantity of facts about names, faces, grammar, history, music, manners, scientific principles, and religious beliefs. All the facts and concepts you know are stored there, and you consult its registry when someone asks you, "Who was the third president?" or "What are the two major divisions of declarative memory?"

Procedural memory A division of LTM that stores memories for how things are done.

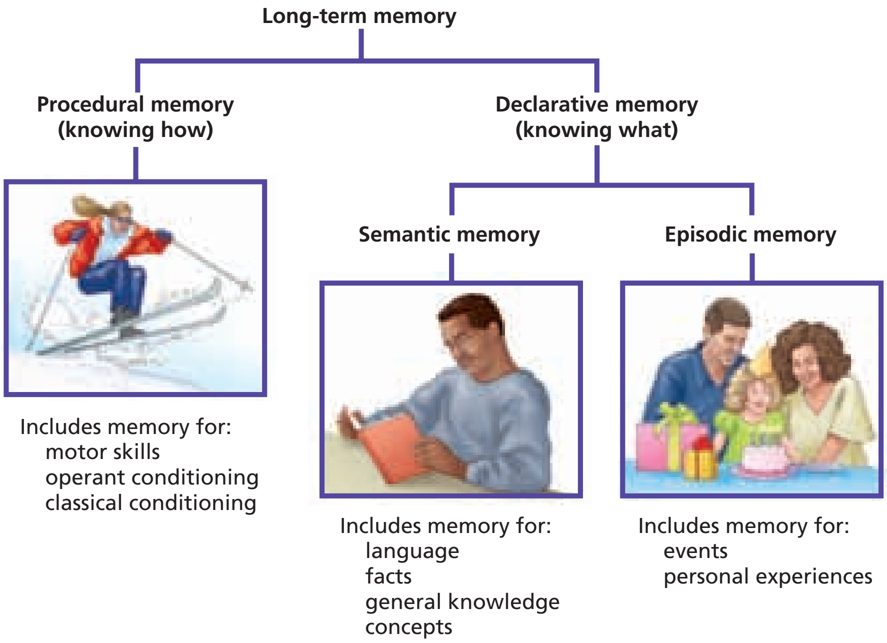
Declarative memory A division of LTM that stores explicit information; also known as *fact memory.* Declarative memory has two subdivisions, episodic memory and semantic memory.

Episodic memory A subdivision of declarative memory that stores memory for personal events, or "episodes."

Semantic memory A subdivision of declarative memory that stores general knowledge, including the meanings of words and concepts.

FIGURE 4.8
Components of Long-Term Memory

Declarative memory involves knowing specific information—knowing "what." It stores facts, personal experiences, language, concepts—things about which we might say, "I remember!" *Procedural memory* involves knowing "how"—particularly motor skills and behavioral learning.



Schemas When you attend a class, have dinner at a restaurant, make a phone call, or go to a birthday party, you know what to expect, because each of these events involve familiar scenarios. Cognitive psychologists call them **schemas**: clusters of knowledge in semantic memory that give us a context for understanding events (Squire, 2007). The exact contents of your schema depend, of course, on culture and personal experience, but the point is that we invoke our schemas to make new experiences meaningful.

Schemas allow us quick access to information. So, if someone says "birthday party," you can immediately draw on information that tells you what you might expect to be associated with a birthday party, such as eating cake and ice cream, singing "Happy Birthday," and opening presents. Just as important, when you invoke your "birthday party" schema, you don't have to sort through irrelevant knowledge in your memory—such as the information contained in your "attending class" schema or your "dinner at a restaurant" schema.

The details of how memory constructs its schemas are still murky—and, incidentally, of great interest to designers of computers and software—again, because human memory has such quick and efficient access to information. The main point, however, is that semantic long-term memory seems to be organized around schemas that make new experiences meaningful. We will have a closer look at schemas in the next chapter, when we discuss thinking.

Early Memories Most people have difficulty remembering events that happened before their third birthday, a phenomenon called **childhood amnesia.** This suggests to us that younger children have limited episodic memory ability. Learning clearly occurs, however, long before age 3, perhaps from the moment of birth. We see this in a baby that learns to recognize a parent's face or in a toddler learning language. Thus, we know that very young children have, at least, a semantic memory and a procedural memory.

Until recently, however, psychologists thought that childhood amnesia occurs because young children's brains have not yet made the neural connections required for episodic memory. New research, however, finds that the brain has created the necessary circuits by the end of the first year of life. Moreover, cognitive scientists have found that children as young as 9 months do show some signs of episodic memory—in the ability to imitate behaviors they have observed after a delay (Bauer et al., 2003). So why can't you remember your first birthday party? Part of the answer probably involves rudimentary language skills (for

Schema Cluster of related information that represents ideas or concepts in semantic memory. Schemas provide a context for understanding objects and events.

Childhood amnesia The inability to remember events during the first two or three years of life.

verbal encoding of memories) and the lack of the complex schemas older children and adults use to help them remember.

Other studies suggest that culture also influences people's early memories. For example, the earliest memories of Maori New Zealanders go back to 2.5 years, while Korean adults often do not remember anything before the age of 4. The difference seems to depend on how much the culture encourages children to tell detailed stories about their lives. "High elaborative" parents spend a lot of time encouraging children to talk about their daily experiences. This seems to strengthen early memories, which allows them to persist into adulthood (Leichtman, 2006; Winerman, 2005).

On the TV show, Are You Smarter Than a 5th Grader?, *host Jeff Foxworthy's questions call for facts stored in semantic memory.*

The Biological Basis of Long-Term Memory Scientists have searched for the **engram,** the biological basis of long-term memory, for more than a century. One of their tactics involves looking for the neural circuitry that the brain uses to forge memories. Another approach goes to the level of synapses, looking for biochemical changes that might represent the physical *memory trace* within nerve cells. A tragic figure, known as H. M., represents the first of these two approaches.

Clues from the Case of H. M. As a young man in 1953, H. M. lost most of his ability to form new memories—the result of an experimental brain operation performed as a last-ditch effort to treat his frequent epileptic seizures (Corkin, 2002; Hilts, 1995). Since that time, he has been almost completely unable to create new memories of the events in his life. At this writing, H. M. lives in a nursing home in Connecticut, where he has resided for decades. So profound is his memory impairment that he has never even learned to recognize the people who have taken care of him in the ensuing 55-plus years after his surgery.

New Zealand Maoris often remember events from when they were $2\frac{1}{2}$ years old—probably because their culture encourages children to tell stories about their lives.

Remarkably, H. M.'s memory for events prior to the operation remains normal, even as new experiences slip away before he can store them in long-term memory. He knows nothing of the 9/11 attacks, the moon landings, or the computer revolution. He cannot remember what he had for breakfast or the name of a visitor who left two minutes ago. Ironically, one of the very few things he has been able to retain is that he has a memory problem. Even so, he is mildly surprised to see an aging face in the mirror, expecting the younger man he was in 1953 (Milner et al., 1968; Rosenzweig, 1992). In brief, H. M. is a man caught in the present moment—which quickly fades away without being captured by memory. Yet, throughout this long ordeal, he has maintained generally good spirits and has worked willingly with psychologist Brenda Milner, whom he still cannot recognize.

H. M.'s medical record lists his condition as **anterograde amnesia**—which means a disability in forming new memories. To put the problem in cognitive terms, H. M. has a severe impairment in his ability to transfer new concepts and experiences from working memory to long-term memory (Scoville & Milner, 1957). From a biological perspective, the cause was removal of the hippocampus and amygdala on both sides of the brain. (See Figure 4.9.)

What have we learned from H. M.? Again speaking biologically, he has taught us that the hippocampus and amygdala are crucial to laying down *new* episodic memories, although they seem to have no role in retrieving *old* memories (Bechara et al., 1995; Wirth et al., 2003). Further, as we will see in a moment, H. M.'s case helps us understand the distinction between *procedural* memories and *declarative* memories. Surprisingly, H. M. is upbeat about his condition—even joking about his inability to remember—although, ironically, the removal of his amygdalas may have contributed to his positive disposition (Corkin, 2002).

Parts of the Brain Associated with Long-Term Memory In the last two decades, neuroscientists have added much detail to the picture that H. M. has given us of human memory. We now know that the hippocampus (Figure 4.9) is implicated in Alzheimer's disease—which also involves loss of ability to make new declarative memories. And we have learned about a process called **consolidation,** whereby new memories

Engram The physical changes in the brain associated with a memory. It is also known as the *memory trace.*

Anterograde amnesia The inability to form new memories (as opposed to retrograde amnesia, which involves the inability to remember information previously stored in memory).

Consolidation The process by which short-term memories are changed to long-term memories over a period of time.

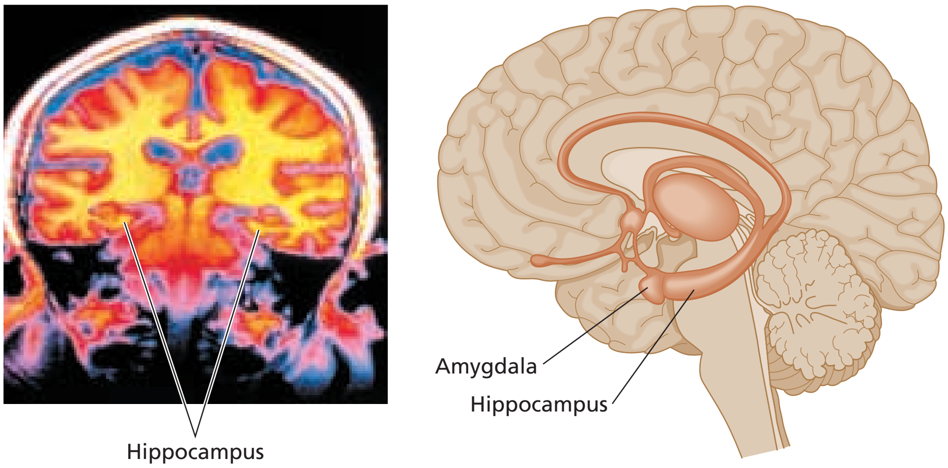


FIGURE 4.9
The Hippocampus and Amygdala

The hippocampus and amygdala were surgically removed from both sides of H. M.'s brain. To help yourself visualize where these structures lie, compare the drawing with the MRI image. The MRI shows the brain in cross section, with a slice through the hippocampus visible on each side.

processed in the hippocampus gradually form permanent memories in the cortex. But, in a discovery just out of the lab, researchers report that new experiences can consolidate much more rapidly if they are associated with existing memory schemas (Squire, 2007; Tse et al., 2007). For rats this might mean solving a familiar maze problem. For you it might mean connecting what you learned about the hippocampus in Chapter 2 with the new information about its role in consolidation that you are learning here.

Neuroscientists have also discovered that the hippocampus's neural neighbor, the amygdala, processes memories that have strong emotional associations (Bechara et al., 1995). These emotional associations, it seems, act as an aid for quick access and retrieval (Dolan, 2002). The amygdala, then, is probably the mechanism responsible for the persistent and troubling memories reported by soldiers and others who have experienced violent assaults. In some cases, these memories can be so disturbing that they constitute a condition known as *posttraumatic stress disorder.*

CONNECTION • CHAPTER 14
Lasting biological changes may occur in the brains of individuals having posttraumatic stress disorder.

But the amygdala and hippocampus aren't the whole memory show. When you bring to mind the colors of the flag, memory draws on the same visual circuits used when you see a real flag (Paller, 2004). Likewise, when you imagine riding a bicycle or hitting a ball, the image in your mind arises from the same motor pathways you would use if you were actually performing the action. That is, the brain uses some of the same circuits for memory that it uses for sensation, perception, and motor responses (Kandel & Squire, 2000; Packard & Knowlton, 2002). Under some conditions, neuroscientists have even learned to identify specific patterns of activity in the brain that correspond to certain memories (Polyn et al., 2005).

Memories, Neurons, and Synapses A standard plot in soap operas and movies depicts a person who develops *amnesia* (loss of memory) after a blow or injury to the head. But does research support this soap-opera neuroscience? In the modern picture of memory at the level of individual neurons, memories form initially as fragile chemical traces at the synapse and consolidate into more permanent synaptic changes over time. During this consolidation process, memories are especially vulnerable to interference by new experience, certain drugs, or a blow to the head (Doyère et al., 2007). The diagnosis, in the event of significant memory loss, would be **retrograde amnesia,** or loss of prior memory. (Note that retrograde amnesia is the opposite of H. M.'s problem, *anterograde* amnesia, which was the inability to form *new* memories.)

Retrograde amnesia The inability to remember information previously stored in memory. (Compare with anterograde amnesia.)

Memories can be strengthened, as well as weakened, during consolidation—especially by a person's emotional state. Research shows, however, that positive and negative emotions have vastly different effects on attention and therefore on memory. So, if you are happy, you tend to look at situations broadly and remember the "big picture." But if you are being robbed at gunpoint, you will most likely attend to the gun while giving less notice to details of the robber's appearance. In general, we can say that emotional arousal accounts for our most vivid memories, but the scope of happy memories tends to be larger, while negative emotions tend to restrict the focus of our memories (Dingfelder, 2005; Levine & Bluck, 2004).

From an evolutionary perspective, emotion plays a highly adaptive role in memory. If you survive a frightening encounter with a bear, for example, you are quite likely to remember to avoid bears in the future. The underlying biology involves emotion-related chemicals, such as epinephrine (adrenalin) and certain stress hormones, which act to enhance memory for emotion-laden experiences (McGaugh, 2000).

PSYCHOLOGYMATTERS

"Flashbulb" Memories: Where Were You When . . . ?

The closest most people will come to having a "photographic memory" is a **flashbulb memory,** an exceptionally clear recollection of an important and emotion-packed event (Brown & Kulik, 1977). You probably harbor a few such memories: a tragic accident, a death, a graduation, a big victory. It's as though you had made a flash picture in your mind of the striking scene. (The term was coined in the days when flash photography required a disposable "flashbulb" for each picture.)

Cognitive psychologists have taken advantage of the fact that large numbers of people form flashbulb memories of certain emotionally charged events in the news, such as the September 11 attacks, Princess Diana's death, the shootings at Columbine high school, or the O. J. Simpson murder trial verdict (Pillemer, 1984; Schmolck et al., 2000). These memories usually record precisely where the individuals were at the time they received the news, what they were doing, and the emotions they felt.

Remarkably, flashbulb memories can be quite accurate. Further, studies show that the more personally involved a person is at the time, the more accurate and durable these memories will be later (Berntsen & Rubin, 2007). Still, flashbulb memories can become distorted over time (Neisser, 1991). For example, on the morning after the Challenger space shuttle explosion, psychology professors asked their students to describe the circumstances under which they had heard the news. Three years later the same students were again asked to recall the event. Of the latter accounts, about one-third gave substantially different stories, mostly about details on which they had previously not focused their attention at the time. It is noteworthy that students whose recollections were seriously flawed reported a high level of confidence in their memories (Winograd & Neisser, 1992). The general pattern appears to be this: Up to a year later, most flashbulb memories are nearly identical to reports given immediately after the event, while recollections gathered after two or three years show substantial distortions (Schmolck et al., 2000). What doesn't change, oddly enough, is people's confidence in their recollections.

The attacks on the World Trade Center and the Pentagon were shocking events, and many Americans have "flashbulb" memories that include where they were and what they were doing when they learned of the attacks.

Flashbulb memory A clear and vivid long-term memory of an especially meaningful and emotional event.

CheckYourUnderstanding

1. **RECALL:** Which part of memory has the smallest capacity? (That is, which part of memory is considered the "bottleneck" in the memory system?)
2. **RECALL:** Which part of long-term memory stores autobiographical information?
3. **RECALL:** To get material into permanent storage, it must be made meaningful while it is in _____.
4. **APPLICATION:** As you study the vocabulary in this book, which of the following methods would result in the deepest level of processing?
   a. learning the definition given in the marginal glossary
   b. marking each term with a highlighter each time it occurs in a sentence in the text
   c. thinking of an example of each term
   d. having a friend read a definition, with you having to identify the term in question form, as on the TV show *Jeopardy*
5. **UNDERSTANDING THE CORE CONCEPT:** As the information in this book passes from one stage of your memory to the next, the information becomes more _____.

Answers **1.** Working memory or short-term memory **2.** Episodic memory **3.** Working memory or short-term memory **4.** c **5.** meaningful or associated with other information in LTM

4.3 KEY QUESTION HOW DO WE RETRIEVE MEMORIES?

Memory has several surprising tricks that it can play during retrieval. One involves the possibility of retrieving a memory that you didn't know you had—which tells us that some memories can be successfully encoded and stored without full awareness. Another quirk involves our being both quite confident of a memory and quite wrong—as we saw in flashbulb memories. Our Core Concept summarizes the retrieval process this way:

core concept

Whether memories are implicit or explicit, successful retrieval depends on how they were encoded and how they are cued.

Implicit and Explicit Memory

We will begin our exploration of retrieval with another lesson from H. M. Surprisingly, he has retained the ability to learn new motor skills, even though he has lost most of his ability to remember facts and events. For example, H. M. learned the difficult skill of mirror writing—writing while looking at his hands in a mirror (Milner et al., 1968; Raymond, 1989). In fact, his *procedural* memory for motor tasks is quite normal, even though he cannot remember learning these skills and doesn't even know that he knows how to perform them.

But you don't have to have brain damage like H. M. to have memories of which you are unaware. A normal memory has disconnected islands of information, too. For over a hundred years psychologists have realized that people with no memory defects can know something without knowing that they know it. Psychologist Daniel Schacter (1992, 1996) calls this **implicit memory**: memory that can affect your behavior without coming into full awareness. By contrast, **explicit memory** requires conscious awareness.

Procedural memories are often implicit, as when golfers remember how to swing a club without thinking about how to move their bodies. Likewise, H. M.'s mirror writing was an implicit memory. But implicit memories are not limited to procedural memory—nor is explicit memory the same as declarative memory. Information in your semantic store can be either *explicit* (such as in remembering the material you have studied for a test) or *implicit* (such as knowing the color of the building in which your psychology class is held). The general rule is this: A memory is implicit if it can affect behavior or mental processes without becoming conscious. Explicit memories, on the other hand, always involve consciousness during storage and retrieval.

In some striking new studies, Brian Skotko and his colleagues (2004) have shown that H. M. can learn some new semantic material through implicit channels—that is, even though he doesn't know he has learned it. To do this, Skotko's group exploited H. M.'s favorite pastime of doing crossword puzzles. They devised crosswords that linked knowledge H. M. had already acquired at the time of his operation with new information: For example, H. M. knew that polio was a dread disease, but the polio vaccine was not discovered until after his surgery, and so he had no knowledge of it. Yet by working on a specially designed crossword puzzle over a 5-day period, H. M. learned to respond correctly to the item, "childhood disease successfully treated by Salk vaccine." Similarly, he was able to learn that Jacqueline Kennedy, wife of assassinated President John Kennedy, subsequently became Jacqueline Onassis. This technique, then, shows that H. M.'s problem is primarily one of explicit memory.

Implicit memory A memory that has not deliberately learned or of which you have no conscious awareness.

Explicit memory Memory that has been processed with attention and can be consciously recalled.

Retrieval Cues

For accurate retrieval, both implicit and explicit memories require good cues. You have some feeling for such cues if you've ever used search terms in Google or another Internet search engine: Make a poor choice of terms, and you can come up either with nothing—or with Internet garbage. Things work in much the same way in long-term memory, where a successful search requires good mental **retrieval cues**, the "search terms" used to recover a memory. Sometimes the only retrieval cue required to bring back a long-dormant experience is a certain odor, such as the smell of fresh-baked cookies that you associated with visiting Grandma's house. At other times the retrieval cue might be an emotion, as when a person struggling with depression gets caught in a maelstrom of depressing memories.

On the other hand, some memories, especially semantic ones, are not so easily cued. During a test, for example, you can draw a blank if the wording of a question doesn't jibe with the way you framed the material in your mind as you were studying. In other words, your memory may fail if the question isn't a good retrieval cue. In general, whether a retrieval cue is effective depends on the type of memory being sought and the web of associations in which the memory is embedded.

In the following paragraphs, we will illustrate how retrieval cues can activate, or *prime*, implicit memories. Then we will return to the more familiar territory of explicit memory to show how recognition and recall are cued. Later in the chapter, we will discuss the failure of retrieval cues in the context of forgetting.

Retrieving Implicit Memories by Priming A quirk of implicit memory landed former Beatle George Harrison in court (Schacter, 1996). Lawyers for a singing group known as the Chiffons claimed that the melody in Harrison's song "My Sweet Lord" was nearly identical to that of the Chiffon classic "He's So Fine." Harrison denied that he deliberately borrowed the melody but conceded that he had heard the Chiffons's tune prior to writing his own. The court agreed, stating that Harrison's borrowing was a product of "subconscious memory." Everyday life abounds with similar experiences, says Daniel Schacter (1996). You may have proposed an idea to a friend and had it rejected, but weeks later your friend excitedly proposed the same idea to you, as if it were entirely new.

In such real-life situations it can be hard to say what prompts an implicit memory to surface. Psychologists have, however, developed ways to "prime" implicit memories in the lab (Schacter, 1996). To illustrate, imagine that you have volunteered for a memory experiment. First, you are shown a list of words for several seconds:

assassin, octopus, avocado, mystery, sheriff, climate

Then, an hour later, the experimenter asks you to examine another list and indicate which items you recognize from the earlier list: twilight, assassin, dinosaur, and mystery. That task is easy for you. But then the experimenter shows you some words with missing letters and asks you to fill in the blanks:

c h _ _ _ _ n k, o _ t _ _ _ u s, _ o g _ y _ _ _, _ l _ m _ t e

It is likely that answers for two of these pop readily into mind, *octopus* and *climate*. But chances are that you will be less successful with the other two words, *chipmunk* and *bogeyman*. The reason for this difference has to do with **priming**, the procedure of providing cues that stimulate memories without awareness of the connection between the cue and the retrieved memory. Because you had been primed with the words *octopus* and *climate*, they more easily "popped out" in your consciousness than did the words that had not been primed.

Retrieving Explicit Memories Anything stored in LTM must be "filed" according to its pattern or meaning. Consequently, the best way to add material to long-term memory is to associate it, while in working memory, with material already stored in LTM. We have called that process *elaborative rehearsal*. Encoding many

CONNECTION • CHAPTER 8
Priming is also a technique for studying nonconscious processes.

Retrieval cue Stimulus that is used to bring a memory to consciousness or to cue a behavior.

Priming A technique for cuing implicit memories by providing cues that stimulate a memory without awareness of the connection between the cue and the retrieved memory.

such connections by elaborative rehearsal gives you more ways of accessing the information, much as a town with many access roads can be approached from many directions.

Meaningful Organization One way of retrieving information from explicit memory involves getting just the general idea or *gist* of an event, rather than a memory of the event as it actually occurred. We saw this earlier in the penny demonstration, but let's look at another example of gist. Suppose you hear the sentence, "The book was returned to the library by Mary." Later, when asked if you heard the sentence, "Mary returned the book to the library," you may indeed mistakenly remember having heard the second sentence. This happens because we tend to remember the meaning or sense of the words—the **gist**— rather than the exact words themselves.

If you'll forgive us for repeating ourselves, your authors want to underscore the practical consequences of LTM being organized by meaning. *Storing new information in LTM usually requires that you make the information meaningful while it is in working memory.* This means that you must associate new information with things you already know. Sometimes it is important to remember all the details accurately (as in memorizing a mathematical formula), while at other times the important thing is to remember the gist (as when you read the case study of H. M.). In attempting to remember the gist, it is especially important to think of personal examples of the concepts and ideas you want to remember. (So, can you think of another example of *gist?*)

Recall and Recognition The cues we use to search for explicit memories come in two main forms. One involves the kinds of retrieval cues used on essay tests, the other involves the cues found on multiple choice tests. Essay tests require **recall,** a task in which you must retrieve a memory from minimal retrieval cues. That is, on an essay test, you must create an answer almost entirely from memory, with the help of only minimal cues from a question such as, "What are the two ways to cue explicit memories?"

Recognition, on another hand, is the method required by multiple-choice tests. In a recognition task, you merely identify whether a stimulus has been previously experienced. Normally, recognition is less demanding than recall because the cues available for a recognition task are much more complete. Incidentally, the reason people say, "I'm terrible with names, but I never forget a face," is because recall (names) is usually tougher than recognition (faces).

The police use recognition when they ask an eyewitness to identify a suspected robber in a lineup. The witness is required only to match an image from memory (the robber) against a present stimulus (a suspect in the lineup). And what would be a comparable recall task? A witness working with a police artist to make a drawing of a suspect must recall, entirely from memory, the suspect's facial characteristics.

Other Factors Affecting Retrieval

We have seen that the ability to retrieve information from explicit declarative memory depends on whether information was encoded and elaborated to make it meaningful. You won't be surprised to learn that alertness, stress level, drugs, and general knowledge also affect retrieval. Less well known, however, are the following influences related to the context in which you encoded a memory and also the context in which you are remembering.

Encoding Specificity The more closely the retrieval cues match the form in which the information was encoded, the better they will cue the appropriate memory. For example, you may have encountered your psychology professor at the grocery store, but you needed a moment to recognize who she or he was, because the context didn't cue you to think "psychology professor." On the other hand, you may have

Gist (pronounced *JIST*) The sense or meaning, as contrasted with the exact details.

Recall A retrieval method in which one must reproduce previously presented information.

Recognition A retrieval method in which one must identify present stimuli as having been previously presented.

been talking to a childhood friend, and your conversation cued a flood of memories that you hadn't thought about for years. These two experiences are examples of the **encoding specificity principle,** which says that successful recall depends on how well the retrieval cues match the cues present at the time a memory was encoded and stored.

As far as studying for your classes is concerned, one of the most important things you can do is to anticipate the retrieval cues you will get on the test and organize your learning around those probable cues. Students who merely read the material and hope for the best may have trouble. In fact, this is such a common problem for students that psychologist Robert Bjork (2000) has suggested that teachers introduce "desirable difficulties" into their courses to encourage students to encode the material in multiple ways. By desirable difficulties, Bjork means that students should be given assignments that make them come to grips with the material in many different ways—project, papers, problems, and presentations—rather than just memorizing the material and parroting it back. By doing so, the professor would help students build more connections into the web of associations into which a memory is embedded—and the more connections there are, the easier it becomes to cue a memory.

Because mood affects memory, depressed people may remember and report more negative symptoms to a physician. As a result, their treatment may differ from that given to patients with the same condition who are not depressed.

Mood and Memory Information processing isn't just about facts and events, it's also about emotions and moods. We use the expressions "feeling blue" and "looking at the world through rose-colored glasses" to suggest that moods can bias our perceptions. Likewise, our moods can also affect what we remember, a phenomenon called **mood-congruent memory.** If you have ever had an episode of uncontrollable giggling, you know how a euphoric mood can trigger one silly thought after another. And at the other end of the mood spectrum, people who are depressed often report that all their thoughts have a melancholy aspect. In this way, depression can perpetuate itself through retrieval of depressing memories (Sakaki, 2007).

Not just a laboratory curiosity, mood-congruent memory can also have important health implications. Says memory researcher Gordon Bower, "Doctors assess what to do with you based on your complaints and how much you complain" (McCarthy, 1991). Because depressed people are likely to emphasize their medical symptoms, they may receive treatment that is much different from that dispensed to more upbeat individuals with the same disease. This, says Bower, means that physicians must learn to take a person's psychological state into consideration when deciding on a diagnosis and a course of therapy.

Prospective Memory One of the most common memory tasks involves remembering to perform some action at a future time—such as keeping a doctor's appointment, going to lunch with a friend, or setting out the garbage cans on the appointed day. Psychologists call this **prospective memory.** Surprisingly, this important process of remembering-to-remember has received relatively little study. We do know that a failure in prospective memory can have consequences that range from merely inconvenient and embarrassing to horrific:

> After a change in his usual routine, an adoring father forgot to turn toward the day care center and instead drove his usual route to work at the university. Several hours later, his infant son, who had been quietly asleep in the back seat, was dead. (Einstein & McDaniel, 2005, p. 286)

How could such a terrible thing happen? The father probably became distracted from his intended task and fell into his customary routine. In situations like this, where people have to remember to deviate from their customary routine, they usually rely on *continuous monitoring,* which means trying to keep the intended action in mind. Continuous monitoring, however, can be easily

Encoding specificity principle The doctrine that memory is encoded and stored with specific cues related to the context in which it was formed. The more closely the retrieval cues match the form in which the information was encoded, the better it will be remembered.

Mood-congruent memory A memory process that selectively retrieves memories that match (are congruent with) one's mood.

Prospective memory The aspect of memory that enables one to remember to take some action in the future—as remembering a doctor's appointment.

derailed by distraction or by habit. So, if you find yourself faced with an important task requiring a change in a long-established routine, your best bet is to use a more reliable prompt, such as note on the dashboard. Another good technique involves thinking of a specific cue you expect to encounter just before you must perform the required task. In the case of the father who intended to take his son to the day care center, he might have imagined a prominent landmark that he would see just before the turn off his accustomed route and then imagined that landmark as a memory cue.

The Washington Monument is an example of a tapered stone object that is topped by a pyramid-shaped point. Can you recall the name for such objects? Or, is it "on the tip of your tongue"?

PSYCHOLOGYMATTERS

On the Tip of Your Tongue

Try to answer as many of the following questions as you can:

- What is the North American equivalent of the reindeer?
- What do artists call the board on which they mix paints?
- What is the name for a tall, four-sided stone monument with a point at the top of its shaft?
- What instrument do navigators use to determine latitude by sighting on the stars?
- What is the name of a sheath used to contain a sword or dagger?
- What is the name of a small Chinese boat usually propelled with a single oar or pole?

If this demonstration works as expected, you couldn't remember the answer, but you had a strong sense that you had it somewhere in memory. We might say that the answer was "on the tip of your tongue." Appropriately enough, psychologists refer to this sort of a near-miss memory as the **TOT phenomenon** (Brown, 1991). Surveys show that most people have a TOT experience about once a week. Among those who watch *Jeopardy* or play the board game Trivial Pursuit, it may occur even more frequently. And, according to a recent study, deaf persons who use sign language sometimes have a "tip of the fingers" (TOF) experience, in which they are sure they know a word, but cannot quite retrieve the sign (Thompson et al., 2005). Obviously, then, some fundamental memory process underlies both the TOT and the TOF phenomena.

The most common TOT experiences center on names of personal acquaintances, names of famous persons, and familiar objects (Brown, 1991). About half the time, the target words finally do pop into mind, usually within about one agonizing minute. Most reports suggest that the experience is uncomfortable (Brown & McNeill, 1966).

What accounts for the TOT phenomenon? One possibility—often exploited in laboratory studies—involves inadequate context cues. This was probably what made you stumble on some of the items above: We did not give you enough context to activate the schema associated with the correct answer.

Another possibility involves *interference:* when another memory blocks access or retrieval, as when you were thinking of Jan when you unexpectedly meet Jill (Schacter, 1999). And, even though you were unable to recall some of the correct words in our demonstration of TOT (caribou, palette, obelisk, sextant, scabbard, sampan), you would probably have spotted the right answer in a recognition format. It's also likely that some features of the sought-for words abruptly popped to mind ("I know it begins with an *s!*"), even though the words themselves eluded you. So, the TOT phenomenon occurs during a recall attempt, when there is a weak match between retrieval cues and the encoding of the word in long-term memory.

And we'll bet you can't name all seven dwarfs.

TOT phenomenon The inability to recall a word, while knowing that it is in memory. People often describe this frustrating experience as having the word "on the tip of the tongue."

Check Your Understanding

1. **APPLICATION:** Remembering names is usually harder than remembering faces because names require _____, while faces merely require _____.
2. **APPLICATION:** At a high school class reunion you are likely to experience a flood of memories that would be unlikely to come to mind under other circumstances. What memory process explains this?
3. **APPLICATION:** Give an example of mood-congruent memory.
4. **APPLICATION:** Give an example of a situation that would require prospective memory.
5. **RECALL:** A person experiencing the TOT phenomenon is unable to _____ a specific word.
6. **UNDERSTANDING THE CORE CONCEPT:** An implicit memory may be activated by priming, and an explicit memory may be activated by a recognizable stimulus. In either case, a psychologist would say that these memories are being
   a. cued.
   b. recognized.
   c. encoded.
   d. chunked.

Answers **1.** recall / recognition **2.** encoding specificity **3.** Good examples would involve situations in which people who are feeling a strong emotion or mood will selectively remember experiences associated with that mood. Thus, during a physical exam, a depressed person might report more unpleasant physical symptoms than would a happy person. **4.** Prospective memory involves having to remember to perform some action at some time in the future, such as taking medicine tonight, stopping at the grocery store on the way home, or calling one's parents next Friday evening. **5.** recall **6.** a

4.4 KEY QUESTION
WHY DOES MEMORY SOMETIMES FAIL US?

We forget appointments and anniversaries. During today's test you can't remember the terms you studied the night before. Or a familiar name seems just out of your mental reach. Yet, ironically, we sometimes cannot rid memory of an unhappy event. So, why does memory play these tricks on us—making us remember what we would rather forget and forget what we want to remember?

According to memory expert Daniel Schacter, the blame falls on what he terms the "seven sins" of memory: *transience, absent-mindedness, blocking, misattribution, suggestibility, bias,* and *unwanted persistence* (Schacter, 1999, 2001). Further, he claims that these seven problems are really the consequences of some very useful features of human memory. From an evolutionary perspective, they are features that stood our ancestors in good stead and so are preserved in our own memory systems. Our Core Concept puts this notion more succinctly:

Most of our memory problems arise from memory's "seven sins"—which are really by-products of otherwise adaptive features of human memory.

core concept

While looking into the "seven sins," we will have the opportunity to consider such everyday memory problems as forgetting where you left your car keys or the inability to forget an unpleasant experience. Finally, we will look at some strategies for improving memory by overcoming some of Schacter's "seven sins"—with special emphasis on how certain memory techniques can improve your studying. We begin with the frustration of fading memories.

Transience: Fading Memories Cause Forgetting

How would you do on a rigorous test of the course work you took a year ago? We thought so—because memories seem to weaken with time. Although no one has directly observed a human memory trace fade and disappear, much circumstantial evidence points to this **transience,** or impermanence, of long-term memory—the first of Schacter's "sins."

Transience The impermanence of a long-term memory. Transience is based on the idea that long-term memories gradually fade in strength over time.

Ebbinghaus and the Forgetting Curve In a classic study of transience, pioneering psychologist Hermann Ebbinghaus (1908/1973) first learned lists of

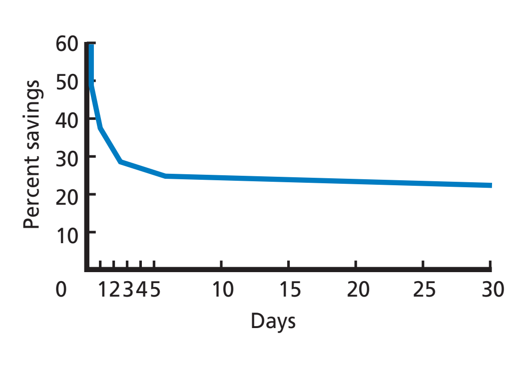


FIGURE 4.10
Ebbinghaus's Forgetting Curve

Ebbinghaus's forgetting curve shows that the savings demonstrated by relearning drops rapidly and reaches a plateau, below which little more is forgotten.

(*Source:* P. G. Zimbardo and R. J. Gerrig, *Psychology and Life*, 15th ed. Published by Allyn and Bacon, Boston, MA. Copyright © 1999 by Pearson Education. Reprinted by permission of the publisher.)

CONNECTION • CHAPTER 2
PET and fMRI are brain scanning techniques that form images of especially active regions in the brain.

nonsense syllables (such as POV, KEB, FIC, and RUZ) and tried to recall them over varying time intervals. This worked well over short periods, up to a few days. But to measure memory after long delays of weeks or months, when recall had failed completely, Ebbinghaus had to invent another method: He measured the number of trials required to *relearn* the original list. Because it generally took fewer trials to relearn a list than to learn it originally, the difference indicated a "savings" that could serve as a measure of memory. (If the original learning required 10 trials and relearning required 7 trials, the savings was 30%.) By using the *savings method,* Ebbinghaus could trace what happened to memory over long periods of time. The curve obtained from combining data from many experiments appears in Figure 4.10. There you can see how the graph initially plunges steeply and then flattens out over longer intervals. This, curve, then, represents one of Ebbinghaus's most important discoveries: *For relatively meaningless material, we have a rapid initial loss of memory, followed by a declining rate of loss.* Subsequent research shows that this **forgetting curve** captures the pattern of transience by which we forget much of the verbal material we learn.

Modern psychologists have built on Ebbinghaus's work, but they now have more interest in how we remember *meaningful* material, such as information you read in this book. Meaningful memories seem to fade, too—just not as rapidly as did Ebbinghaus's nonsense syllables. Modern work sometimes uses brain scanning techniques, such as fMRI and PET, to visualize the diminishing brain activity that characterizes forgetting (Schacter, 1996, 1999).

Not all memories, however, follow the classic forgetting curve. We often retain motor skills, for example, substantially intact in procedural memory for many years, even without practice—"just like riding a bicycle." The same goes for especially memorable emotional experiences, such as "flashbulb" incidents.

Interference Schacter tells us that one of the most common causes of transience comes from *interference*—when one item prevents us from forming a robust memory for another item. This often occurs when you attempt to learn two conflicting things in succession, such as if you had a French class followed by a Spanish class.

What is likely to cause interference? Three main factors top the list:

1. *The greater the similarity between two sets of material to be learned, the greater the interference between them is likely to be.* So, French and Spanish classes are more likely to interfere with each other than are, say, psychology and accounting.
2. *Meaningless material is more vulnerable to interference than meaningful material.* Because LTM is organized by meaning, you will have more trouble remembering two locker combinations than you will two news bulletins. (The exception occurs when you experience a direct conflict in meaning, as when two of your professors seem to be telling you conflicting things.)
3. *Emotional material can be an especially powerful cause of interference.* So, if you broke up with your true love last night, you will probably forget what your literature professor says in class today.

Interference commonly arises when an old habit gets in the way of learning a new response, as we saw in the case of the father who forgot to stop at the day care center. Interference can also happen when people switch from one word-processing program to another. And, of course, interference accounts for the legendary problem old dogs have in learning new tricks. Everyday life offers many more examples, but interference theory groups them in two main categories, *proactive interference* and *retroactive interference.*

Forgetting curve A graph plotting the amount of retention and forgetting over time for a certain batch of material, such as a list of nonsense syllables. The typical forgetting curve is steep at first, becoming flatter as time goes on.

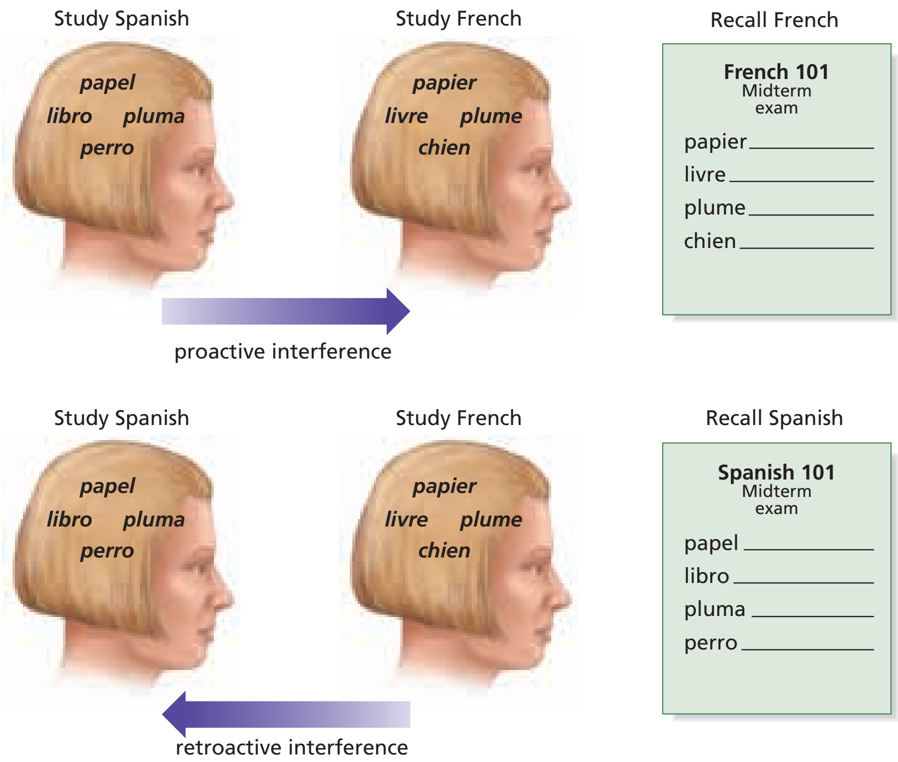


FIGURE 4.11
Two Types of Interference

In proactive interference, earlier learning (Spanish) interferes with memory for later information (French). In retroactive interference, new information (French) interferes with memory for information learned earlier (Spanish).

Proactive Interference When an old memory disrupts the learning and remembering of new information, **proactive interference** is the culprit. An example of proactive interference occurs every January, when we all have trouble remembering to write the correct date on our checks. *Pro-* means "forward," so in proactive interference, old memories act forward in time to block your attempts at new learning.

Retroactive Interference When the opposite happens—when new information prevents your remembering older information—we can blame forgetting on **retroactive interference.** *Retro-* means "backward"; the newer material reaches back into your memory to push old material out of memory. (See Figure 4.11.) In a computer, retroactive interference occurs when you save a new document in place of an old one. Much the same thing happens in your own memory when you meet two new people in succession, and the second name causes retroactive interference that makes you forget the first one.

The Serial Position Effect You may have noticed that the first and last parts of a poem or a vocabulary list are usually easier to learn and remember than the middle portion. In general, the *primacy effect* refers to the relative ease of remembering the first items in a series, while the *recency effect* refers to the robustness of memory for the most recent items. Together, with diminished memory for the middle portion, we term this the **serial position effect.** To illustrate, when you are introduced to several people in succession, you are more likely to remember the names of those you met first and last than you are those you met in between. (That's assuming other factors are equal, such as the commonness of their names, distinctiveness of their appearance, and their personalities.)

How does interference theory explain the serial position effect? Unlike the material at the ends of the poem or list, the part in the middle is exposed to a double dose of interference—both retroactively and proactively. That is, the middle part receives interference from both directions, while material at either end gets interference from only one side. So, in view of the serial position effect, perhaps it would be helpful to pay special attention to the material in the middle of this chapter.

Proactive interference A cause of forgetting by which previously stored information prevents learning and remembering new information.

Retroactive interference A cause of forgetting by which newly learned information prevents retrieval of previously stored material.

Serial position effect A form of interference related to the sequence in which information is presented. Generally, items in the middle of the sequence are less well remembered than items presented first or last.

Misplacing your car keys results from a shift in attention. Which of the seven "sins" does this represent?

Absent-Mindedness: Lapses of Attention Cause Forgetting

When you misplace your car keys or forget an anniversary, you have had an episode of **absent-mindedness,** the second "sin" of memory. It's not that the memory has disappeared from your brain circuits. Rather, you have suffered a retrieval failure caused by shifting your attention elsewhere. In the case of a forgotten anniversary, the attention problem occurred on the retrieval end—when you were concentrating on something that took your attention away from the upcoming anniversary. And as for the car keys, your attentive shift probably occurred during the original encoding—when you should have been paying attention to where you laid the keys. In college students, this form of absent-mindedness commonly comes from listening to music or watching TV while studying.

This kind of encoding error was also at work in the "depth of processing" experiments we discussed earlier: People who encoded information shallowly ("Does the word contain an *e?*") were less able to recall the target word than those who encoded it deeply ("Is it an animal?"). Yet another example can be found in demonstrations of *change blindness:* In one study, participants viewed a movie clip in which one actor who was asking directions was replaced by another actor while they were briefly hidden by two men carrying a door in front of them. Amazingly, fewer than half of the viewers noticed the change (Simons & Levin, 1998). Much the same thing may happen to you in the magic trick demonstration in Figure 4.12.

Blocking: Access Problems

Blocking, the third of Schacter's seven "sins" of memory, occurs when we lose access to the information we have in memory. You may have experienced blocking when you see familiar people in new surroundings and can't remember their names. The most thoroughly studied form of blocking, however, involves the maddening "tip-of-the-tongue" (TOT) experience: when you *know you know* the name for something but can't retrieve it. As we saw earlier, the TOT phenomenon often results from poor context cues that fail to activate the necessary memory schema.

Stress, too, can produce blocking, perhaps through failure to sustain one's focus of attention. Similarly, distraction has been shown to cause blocking on prospective memory tasks, such as remembering to perform a certain action at a certain time. Age plays a role, too, with blocking becoming a greater problem as one grows older.

Studies of brain-injury patients who exhibit blocking point to specific regions of the brain that, when damaged, seem especially likely to interfere with memory. These include the frontal lobes, hippocampus, and temporal lobe. These studies suggest that blocking involves many different brain circuits, because damage in different regions produces different kinds of blocks, such as loss of proper names, but not the names of objects.

Misattribution: Memories in the Wrong Context

All three "sins" discussed so far make memories unavailable in one way or another. But these are not the only kinds of memory problems we experience. For example, we can retrieve memories, but associate them with the wrong time, place, or person. Schacter (1999) calls this **misattribution.** It stems from the reconstructive nature of long-term memory. In the penny demonstration at the beginning of the chapter, you learned that we commonly retrieve incomplete memories and fill in the blanks so as to make them meaningful to us. This paves the way to mistakes that arise from connecting information with the wrong, but oh-so-sensible, context.

Absent-mindedness Forgetting caused by lapses in attention.

Blocking Forgetting that occurs when an item in memory cannot be accessed or retrieved. Blocking is caused by interference.

Misattribution A memory fault that occurs when memories are retrieved but are associated with the wrong time, place, or person.

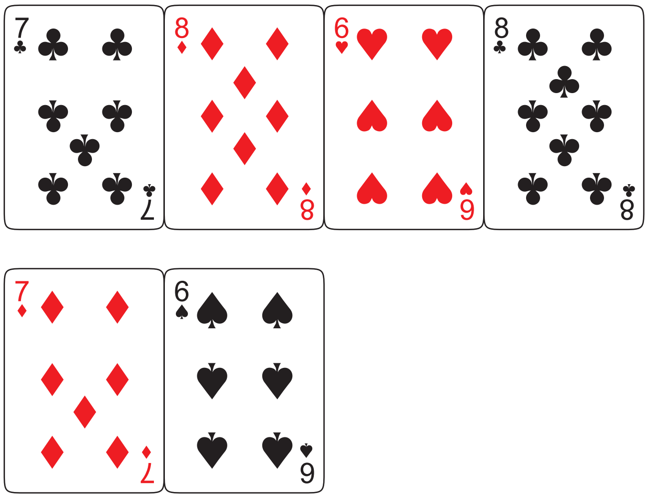


FIGURE 4.12A
The "Magic of Memory"

Pick one of the cards. Stare at it intently for at least 15 seconds, being careful not to shift your gaze to the other cards. Then turn the page.

Here's an example of misattribution: Psychologist Donald Thompson was accused of rape, based on a victim's detailed, but mistaken, description of her assailant (Thompson, 1988). Fortunately for Thompson, his alibi was indisputable. At the time of the crime he was being interviewed live on television—about memory distortions. The victim, it turned out, had been watching the interview just before she was raped and had misattributed the assault to Thompson.

Misattribution also can cause people to believe mistakenly that other people's ideas are their own. This sort of misattribution occurs when a person hears an idea and keeps it in memory, while forgetting its source. Unintentional plagiarism comes from this form of misattribution, as we saw earlier in the case of Beatle George Harrison.

Yet another type of misattribution can cause people to remember something they did not experience at all. Such was the case with volunteers who were asked to remember a set of words associated with a particular theme: *door, glass, pane, shade, ledge, sill, house, open, curtain, frame, view, breeze, sash, screen,* and *shutter.* Under these conditions, many participants later remembered *window,* even though that word was not on the list (Roediger & McDermott, 1995, 2000). This result again shows the power of context cues in determining the content of memory. And it demonstrates yet again how people tend to create and retrieve memories based on meaning.

Suggestibility: External Cues Distort or Create Memories

Suggestion can also distort or even create memories, a possibility of particular concern to the courts. Witnesses may be interviewed by attorneys or by the police, who may make suggestions about the facts of a case—either deliberately or unintentionally—that might alter a witness's memory. Such concerns about **suggestibility** prompted Elizabeth Loftus and John Palmer to find out just how easily eyewitness memories could be distorted.

Memory Distortion Participants in the Loftus and Palmer study first watched a film of two cars colliding. Then, the experimenters asked them to estimate how fast the cars had been moving (Loftus, 1979, 1984; Loftus & Palmer, 1973). Half of the witnesses were asked, "How fast were the cars going when they *smashed* into each other?" Their estimates, it turned out, were about 25% higher than those given by respondents who were asked, "How fast were the cars going when they *hit* each other?" This distortion of memory caused by misinformation has been dubbed, appropriately, as the **misinformation effect.**

Clearly, the Loftus and Palmer study showed that memories can be distorted and embellished by cues and suggestions given at the time of recall. But memories

Suggestibility The process of memory distortion as the result of deliberate or inadvertent suggestion.

Misinformation effect The distortion of memory by suggestion or misinformation.

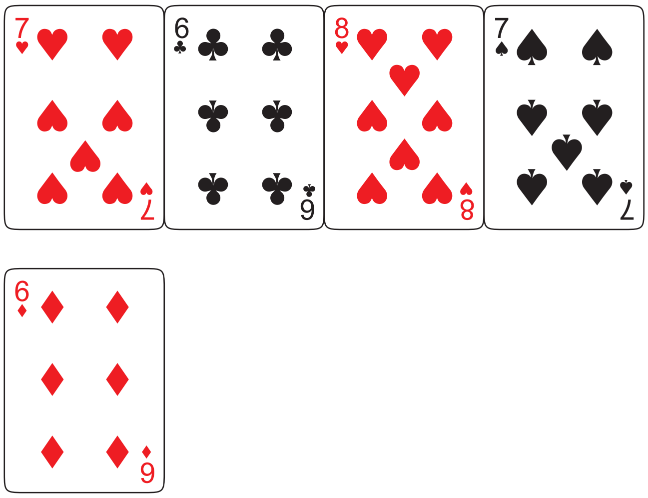


FIGURE 4.12B
The "Magic of Memory" (continued)

Your card is gone! How did we do it? We didn't read your mind; it was your own *reconstructive memory* and the "sin" of *absent-mindedness* playing card tricks on you. If you don't immediately see how the trick works, try it again with a different card.

can also be *created* by similar methods. And it can be done without the individual's awareness that memory has been altered.

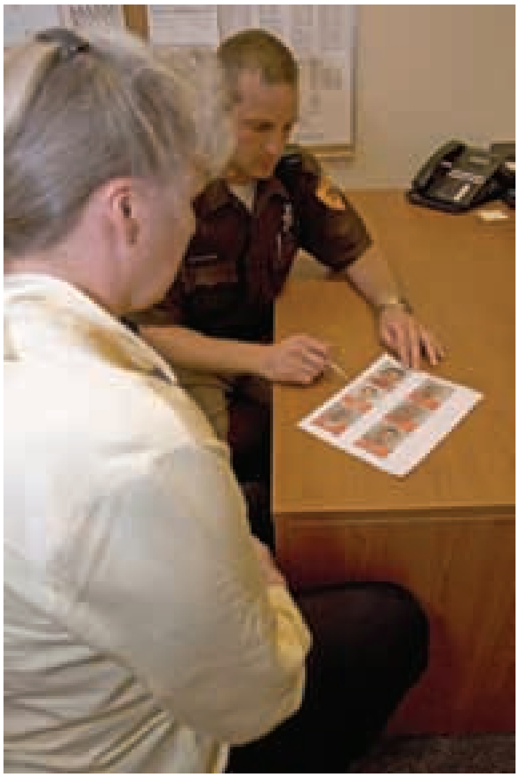
Fabricated Memories The famed developmental psychologist, Jean Piaget, described a vivid memory of a traumatic event from his own early childhood:

> One of my first memories would date, if it were true, from my second year. I can still see, most clearly, the following scene in which I believed until I was about fifteen. I was sitting in my pram, which my nurse was pushing in the Champs Elysées [in Paris], when a man tried to kidnap me. I was held in by the strap fastened round me while my nurse bravely tried to stand between me and the thief. She received various scratches, and I can still see vaguely those on her face. . . .

Piaget's nurse described the alleged attack in vivid detail and was given an expensive watch from his parents as a token of their thanks for her bravery. However, years later, the former nurse sent a letter to Piaget's family confessing that the story had been fabricated and returning the watch she had received as a reward. From this, Piaget concluded:

> I, therefore, must have heard, as a child, the account of this story, which my parents believed, and projected into the past in the form of a visual memory. (Piaget, 1951)

Are we all susceptible to laying down fabricated memories such as the one Piaget described? To find out, Elizabeth Loftus and her colleagues decided to do an experiment. They first contacted the parents of a group of college students, obtaining lists of childhood events, which the students were then asked to recall. But, embedded in those lists were plausible events that never happened, such as being lost in a shopping mall, spilling the punch bowl at a wedding, meeting Bugs Bunny at Disneyland (impossible because Bugs is not a Disney character), or experiencing a visit by a clown at a birthday party (Loftus, 2003a). After repeated recall attempts over a period of several days, about one-fourth of the students claimed to remember the bogus events. All that was required were some credible suggestions. (This experiment may remind you of Donna's case, with which we began our chapter: Repeated suggestions by the therapist led to Donna's fabricated memory.) New research also suggests that doctored photographs can also create false memories, perhaps even more powerfully than the stories used by Loftus and her colleagues. For example, in a variation of the lost-in-the-mall technique, adults viewed altered photographs purporting to show them riding in a hot air balloon. After seeing the photos several times over a period of two weeks, half of the participants "remembered" details about the fictitious balloon ride (Wade et al, 2002). Even in this age of digital cameras and image-altering software, people don't always stop to question whether a photograph may have been modified (Garry & Gerrie, 2005).



The way mug shots are presented can bias the recollections of witnesses. Realizing this, the U.S. Department of Justice has published guidelines for interrogating eyewitnesses.

Factors Affecting the Accuracy of Eyewitnesses So, to what extent can we rely on eyewitness testimony? Obviously, it is possible in laboratory experiments to distinguish false memories from true ones. But what about in real-life situations in which people claim to have recovered long-forgotten memories?

As we saw in our second case at the beginning of the chapter, Ross's recollection was independently verified by the confession of a camp counselor, but such objective evidence doesn't always materialize. In such cases, the best we can do is look for evidence of suggestion that may have produced the memory—as we see in false-memory experiments. If suggestion has occurred, a healthy dose of skepticism is warranted, unless objective evidence appears. Specifically, we should beware of eyewitness reports tainted by the following factors (Kassin et al., 2001):

- *Leading questions* ("How fast were the cars going when they *smashed* into each other?") can influence witnesses' recollections. But such questions have less effect if witnesses are forewarned that interrogations can create memory bias.
- *The passage of substantial amounts of time,* which allows the original memory to fade, makes people more likely to misremember information.
- *Repeated retrieval:* Each time a memory is retrieved, it is reconstructed and then restored (much like a computer document that is retrieved, modified, and saved), increasing the chances of error.
- *The age of the witness:* Younger children and older adults may be especially susceptible to influence by misinformation in their efforts to recall.
- *Unwarranted confidence:* Confidence in a memory is not a sign of an accurate memory. In fact, misinformed individuals can actually come to believe the misinformation in which they feel confidence.

Based such concerns, the U.S. Department of Justice (1999) has published national guidelines for gathering eyewitness testimony, available on its website.

Bias: Beliefs, Attitudes, and Opinions Distort Memories

The sixth memory "sin," which Schacter calls *bias,* refers to the influence of personal beliefs, attitudes, and experiences on memory. Lots of domestic arguments of the "Did not! Did too!" variety owe their spirited exchanges to bias. While it's easier to see another person's biases than our own, here are two common forms that you should especially guard against.

Expectancy Bias An unconscious tendency to remember events as being congruent with our expectations produces *expectancy bias.* To illustrate, suppose that you are among a group of volunteers for an experiment in which you read a story giving details about the relationship between Bob and Margie, a couple who plan to get married. Part of the story reveals that Bob doesn't want to have children, and he is worried about how Margie is going to take this disclosure. When he does tell her, Margie is shocked, because she desperately wants children. Then, suppose that, after reading the story you are informed, contrary to your expectations, that Bob and Margie did get married. Meanwhile, another group of volunteers read the same story, but they are told that the couple ended their relationship. Other than the ending, will people in those two groups remember the Bob and Margie story differently?

In a laboratory experiment using this same story, those who heard the unexpected ending (the condition in which Bob and Margie decided to get married) gave the most erroneous reports. Why? Because of their expectancy biases, they recalled distorted information that made the outcome fit their initial expectations (Schacter, 1999; Spiro, 1980). One person, for example, "remembered" that Bob and Margie had separated but decided their love could overcome their differences.Another related that the couple had decided on adoption, as a compromise.

Self-Consistency Bias People abhor the thought of being inconsistent, even though research suggests that they are kidding themselves. This Schacter calls the **self-consistency bias.** For example, studies have found people to be far less consistent than they realized in their support for political candidates, as well as on political issues such as the equality of women, aid to minority groups, and the legalization of marijuana (Levine, 1997; Marcus, 1986).

Of particular interest for the study of memory, the self-consistency bias can affect what we remember (Levine & Safer, 2002). So, in a study of dating couples who were interviewed twice, two months apart, memories about the course of the relationship would change, depending on how well the relationship had progressed over the two-month interval, although the participants generally did not recognize their inconsistencies. Those who had grown to like each other more remembered their initial evaluations of their partners as more positive than they had before, while those whose relationships had become more negative had the opposite response (Scharfe & Bartholomew, 1998). In all of these studies, whether they involve attitudes, beliefs, opinions, or emotions, we see that our biases act as a sort of distorted mirror in which our memories are reflected, but without our awareness that our memories had been altered.

Persistence: When We Can't Forget

The seventh "sin" of memory, **persistence,** reminds us that memory sometimes works all too well. We all experience this occasionally, when a persistent thought, image, or even a melody cycles over and over in our minds. Such intrusive memories are usually short lived. Yet they can become a problem when we have persistent thoughts colored by intense negative emotions. At the extreme, the persistence of memories for unpleasant events creates a downward emotional spiral whereby people suffering from *depression* or *posttraumatic stress disorder* can't stop ruminating about unhappy events or traumas in their lives. Similarly, patients with *phobias* may become obsessed by fearful memories about snakes, dogs, crowds, spiders, or lightning. All of this again points to the powerful role that emotion plays in memory.

CONNECTION • CHAPTER 12
People with *phobias* have extreme and unreasonable fears of specific objects or situations.

The Advantages of the "Seven Sins" of Memory

Despite the grief they cause us, the "seven sins" arise from adaptive features of memory, argues Daniel Schacter (1999). Thus, transience—maddening as it can be to the student taking a test—is actually a way the memory system prevents itself from being overwhelmed by information that it no longer needs. Similarly, blocking is helpful when it allows only the most relevant information—the information most strongly associated with the present cues—to come to mind. Again, this is a process that prevents us from a flood of unwanted and distracting memories.

Absent-mindedness, too, is the by-product of the useful ability to shift our attention. Similarly, misattributions, biases, and suggestibility result from a mem-

Self-consistency bias The commonly held idea that we are more consistent in our attitudes, opinions, and beliefs than we actually are.

Persistence A memory problem in which unwanted memories cannot be put out of mind.

ory system built to deal with *meaning* and discard details: The alternative would be a computer-like memory filled with information at the expense of understanding. And, finally, we can see that the "sin" of persistence is really a feature of a memory system responsive to emotional experiences, particularly those involving dangerous situations. In general, then, the picture that emerges of memory's "failures" is also a picture of a system well adapted to the conditions people have faced for thousands of years.

Improving Your Memory with Mnemonics

To improve your memory, your authors recommend a tool kit of mental strategies known as *mnemonics* (pronounced *ni-MON-ix,* from the Greek word meaning "remember"). **Mnemonic strategies** work by helping you encode new information to be remembered by associating it with information already in long-term memory. To illustrate, we will take a detailed look at two mnemonic strategies, the *method of loci* and *natural language mediators,* both of which are especially useful for remembering lists. Then, we will offer some tips that can help with the common problem of remembering names.

The Method of Loci Dating back to the ancient Greeks, the **method of loci** (pronounced *LOW-sye,* from *locus,* or "place"), is literally one of the oldest tricks in this book. Greek orators originally devised the method of loci to help them remember the major points of their speeches.

To illustrate, imagine a familiar sequence of places, such as the bed, desk, and chairs in your room. Then, using the method of loci, mentally move from place to place in the room, and as you go imagine putting one item from a list in each place. To retrieve the series, you merely take another mental tour, examining the places you used earlier. There you will "see" the item you have put in each locus. To remember a grocery list, for example, you might mentally picture a can of *tuna* on your bed, *shampoo* spilled on your desktop, and a box of *eggs* open on a chair. Bizarre or unconventional image combinations are usually easier to remember—so a can of tuna in your bedroom will make a more memorable image than tuna in your kitchen (Bower, 1972).

The mental images used in the method of loci work especially well because they employ both verbal and visual memories (Paivio, 1986). It's worth noting, by the way, that visual imagery is one of the most effective forms of encoding: You can easily remember things by associating them with vivid, distinctive mental pictures. In fact, you could remember your grocery list by using visual imagery alone. Simply combine the mental images of tuna, shampoo, and eggs in a bizarre but memorable way. So, you might picture a tuna floating on an enormous fried egg in a sea of foamy shampoo. Or you might imagine a politician you dislike eating tuna from the can, hair covered with shampoo suds, while you throw eggs at her.

Natural Language Mediators Memory aids called **natural language mediators** associate meaningful word patterns with new information to be remembered. Using this method to remember a grocery list, you would make up a story. Using the same list as before (tuna, shampoo, and eggs), the story might link the items this way: "The cat discovers I'm out of *tuna* so she interrupts me while I'm using the *shampoo* and meows to *egg* me on." (OK, we know it's hokey—but it works!) Similarly, advertisers know that rhyming slogans and rhythmic musical jingles can make it easier for customers to remember their products and brand names ("Oscar Mayer has a way with . . ."). The chances are that a teacher in your past used a simple rhyme to help you remember a spelling rule ("*I* before *E* except after *C*") or the number of days in each month ("Thirty days has September . . ."). In a physics class you may have used a natural language mediator in the form of an *acronym*—a word made up of initials—to learn the colors of the visible spectrum in their correct

Mnemonic strategy Technique for improving memory, especially by making connections between new material and information already in long-term memory.

Method of loci A mnemonic technique that involves associating items on a list with a sequence of familiar physical locations.

Natural language mediator Word associated with new information to be remembered.

Mnemonic strategies help us remember things by making them meaningful. Here, Wangari Maathai, the Nobel Peace Prize laureate from Kenya, tries her hand at learning the chinese character for "tree"—which bears a resemblance to a stylized tree. Many chinese and Japanese characters originally were drawings of the objects they represented.

order: "Roy G. Biv" stands for red, orange, yellow, green, blue, indigo, violet.[1]

Remembering Names The inability to remember people's names is one of the most common complaints about memory. So, how could you use the power of association to remember names? In the first place, you must realize that remembering names doesn't happen automatically. People who do this well must work at it by making deliberate associations between a name and some characteristic of the person—the more unusual the association, the better.

Suppose, for example, you have just met the authors of this book at a psychological convention. You might visualize Bob's face framed in a big *O,* taken from the middle of his name. To remember Vivian, think of her as "Vivacious Vivian," the liveliest person at the convention. And, as for Phil, you might visualize putting a hose in Phil's mouth and "fill"-ing him with water. (While unusual associations may be easier to remember than mundane ones, it is best not to tell people about the mnemonic you have devised to remember their names.)

In general, the use of mnemonics teaches us that memory is flexible, personal, and creative. It also teaches us that *memory ultimately works by meaningful associations.* With this knowledge and a little experimentation, you can devise techniques for encoding and retrieval that work well for you, based on your own personal associations and, perhaps, on your own sense of humor.

PSYCHOLOGYMATTERS

Using Psychology to Learn Psychology

Mnemonic strategies designed for learning names or memorizing lists of unrelated items won't help much with the material you need to learn in your psychology class. There the important material consists of concepts—often abstract concepts, such as "operant conditioning" or "retroactive interference"—ideas for which you need to learn the *gist,* rather than merely memorize. Such material calls for different mnemonic strategies geared both to concept learning and to avoiding the two memory "sins" feared most by college students, *transience* and *blocking.* So, let's see what advice cognitive psychologists would give to students for avoiding these two quirks of memory.

Studying to Avoid Transience

- *Make the material personally meaningful.* Many studies have shown that memories will remain stronger if the information is approached in a way that makes it meaningful, rather than just a collection of facts and definitions (Baddeley, 1998; Haberlandt, 1999). One good strategy for doing this is the **whole method,** a technique often used by actors who must learn a script in a short time. With this approach, the learner begins by getting an overview of all the material to be learned—the "big picture" into which the details can be assimilated. Suppose, for example, that you have a test on this chapter coming up next week. Using the whole method, you would look over the chapter outline and summary, along with all the Key Questions and Core Concepts on the chapter opening page, before beginning to read the details of the chapter.

Whole method The mnemonic strategy of first approaching the material to be learned "as a whole," forming an impression of the overall meaning of the material. The details are later associated with this overall impression.

[1]Schacter's "seven sins" of memory are a pun on the famous seven sins of medieval times. You can remember them by the acronym WASPLEG, which refers to *W*rath, *A*varice, *S*loth, *P*ride, *L*ust, *E*nvy, and *G*luttony.

This approach erects a mental framework on which you can hang the details of encoding, interference, retrieval, and other memory topics.

- *Spread your learning out over time.* A second way to build strong memories that resist transience involves **distributed learning.** In less technical terms, you would study your psychology repeatedly and at frequent intervals, rather than trying to learn it all at once in a single "cram" session (called *massed learning*). Distributed learning not only avoids the lowered efficiency of massed learning, which causes fatigue, but it also strengthens memories that are in the process of consolidation. One study found that students could double the amount of information they learned in a given amount of time and also increase their understanding of the material by studying in two separate sessions, rather than in one session (Bahrick et al., 1993). Studies have also shown that distributed learning results in the material being retained longer (Schmidt & Bjork, 1992).
- *Take active steps to minimize interference.* You can't avoid interference altogether, but you can avoid studying for another class after your review session for tomorrow's psychology test. And you can make sure that you understand all the material and that you have cleared up any potentially conflicting points well before you go to the test. If, for example, you are not sure of the difference between *declarative memory* and *semantic memory,* you should discuss this with your instructor.

Studying to Avoid Blocking on the Test The strategies mentioned above will help you get to the test with a strong memory for the material you need to know. But you also will want to avoid blocking, the inability to find and retrieve what you have in memory. To help you achieve this, we suggest some techniques that apply two ideas you have learned in this chapter, *elaborative rehearsal* and *encoding specificity:*

- *Review and elaborate on the material.* Students often think that, just because they have read the material once and understood it, they will remember it. With complex concepts and ideas, you probably need to review what you have learned, perhaps several times. But your review should not be mindless and passive—merely looking at the words in the book. Rather, you should employ the technique of *elaborative rehearsal.* One of the best ways of doing this when studying for a test is to create your own examples of the concepts. So, as you study about proactive interference, think of an example from your own experience. And don't forget to think of examples involving the Core Concepts, too. This approach will help to prevent blocking because adding associations to the material you are learning adds more ways that the material can be accessed when you need it.
- *Test yourself with retrieval cues you expect to see on the examination.* By using the principle of *encoding specificity,* you can learn the material in a form that is most likely to be cued by the questions your psychology professor puts on the test. To do this it is helpful to work with a friend who is also studying for the same test. We recommend that you get together for this purpose a day or two before the exam, after both of you have studied the material thoroughly enough to feel you understand it. Your purpose, at this point, will not be to learn new material but to anticipate the most likely test items. Does your professor prefer essay questions? Short-answer questions? Multiple choice? Try to think of and answer questions of the type most likely to appear on the test. Don't overlook the Key Questions throughout the chapter.

And please don't overlook the other mnemonic features we have included throughout this book to guide you in your study. These include the "Check Your Understanding" quizzes and the "Do It Yourself!" demonstrations. All these mnemonic devices are based on well-established principles of learning and memory. Studying this way may sound like a lot of work—and it is. But the results will be worth the mental effort.

Distributed learning A technique whereby the learner spaces learning sessions over time, rather than trying to learn the material all in one study period.

Check Your Understanding

1. **ANALYSIS:** What happens to memory over time, as described by Ebbinghaus's forgetting curve?
2. **APPLICATION:** Which kind of forgetting is involved when the sociology I studied yesterday makes it more difficult to learn and remember the psychology I am studying today?
3. **RECALL:** What is the term for the controversial notion that memories can be blocked off in the unconscious, where they may cause physical and mental problems?
4. **RECALL:** Which one of the seven "sins" of memory was responsible for Piaget's fabricated memory of an attempted kidnapping?
5. **UNDERSTANDING THE CORE CONCEPT:** Which one of the "sins" of memory probably helps us avoid dangerous situations we have encountered before?

Answers **1.** We forget rapidly at first and then more slowly as time goes on. **2.** proactive interference **3.** repression **4.** suggestibility **5.** persistence

Critical Thinking Applied: The Recovered Memory Controversy

Let's return now to the case studies with which we began the chapter. All involved claims of recovered memories: Ross's memory of molestation by a camp counselor was clearly accurate, and Donna's memory of abuse by her father was eventually repudiated. So where does that leave us when we hear about other such claims?

We should also say that most claims of sexual abuse do *not* involve "recovered" memories. In general, we have no reason to doubt people who say they have been molested and have always remembered. The controversy centers on memories said to have been "recovered" after having been forgotten for long periods of months or even years.

What Is the Issue?

The controversy centers on the accuracy of claims of recovered memories—*not* on the reality of sexual abuse. Is it possible that recovered memories could be false? If so, we must decide how to judge the accuracy of recovered memories, especially memories of traumatic events.

What Critical Thinking Questions Should We Ask?

Let's begin by asking: Is the notion of recovered memories of sexual abuse reasonable or outrageous? That is, does it fit with what we know, both about memory and about sexual abuse? Let's see what the evidence can tell us.

Sexual Abuse Does Occur We need to emphasize that sexual abuse of children *does* occur and poses a serious problem. How widespread is it? While estimates vary considerably, it appears that from 4% to 20% of children in the United States have experienced at least one incident of sexual abuse (McAnulty & Burnette, 2004; Terry & Tallon, 2004). Accurate figures are difficult to obtain, of course, because people can be reluctant to discuss these experiences. And *if* it is true that sexual abuse can be blocked out of consciousness for long periods, the actual numbers could be much higher.

Do People Forget Traumatic Events? The general public harbors a strong, but unfounded, belief that the most common response to trauma is *repression,* the blocking of memories in the unconscious, as first described by Sigmund Freud. But, in fact, most people who have traumatic experiences remember them vividly, rather than forgetting them (McNally, 2003). Unwelcome remembering of disturbing experiences is precisely the problem in posttraumatic stress disorder (PTSD). Nevertheless, such cases don't eliminate the possibility that some people may react differently by repressing a memory of a particularly unpleasant experience—although it is difficult to get credible data on how often this might occur.

Only a few studies have addressed the question of how common repression may be, and the resulting data do not give us a very precise picture: Anywhere from 20 to 60% of people who remember being abused also report a period of time during which they did not remember (Schacter, 1996). None of these studies cited corroborating evidence for the memories, so a critical look at these data raises the question as to how many of those forgotten-then-recovered recollections might be false memories. Again, we are left without definitive evidence.

The Role of Suggestion We have seen that memory does not make a complete record of our experiences. Nor is it always accurate. On the other hand, we do sometimes recover memories—accurate memories—of long-forgotten events. A chance remark, a peculiar odor, or an old tune can cue vivid recollections that haven't surfaced in years. These more common "recovered" memories, however, are not typically the sort of threatening memories that might have been blocked from consciousness. Rather, they are likely to be memories that we have not had occasion to think about for years—such as the name of a pal in the fourth grade.

Of special relevance to the recovered memory controversy is the research we discussed earlier in the chapter, showing that memories can rather easily be modified, or even created, by suggestion. As a result, participants not only reported false memories but came to believe them (Bruck & Ceci, 2004). Such experiments should make us skeptical of memories recovered during therapy or interrogation involving suggestive techniques. Memory expert Elizabeth Loftus argues that therapists who assume that most mental problems stem from childhood sexual abuse commonly use suggestive practices, although she does not say how widespread the problem might be (Loftus, 2003a, b). And in the book *Making Monsters,* social psychologist Richard Ofshe and his coauthor describe how clients can unknowingly tailor their recollections to fit their therapists' expectations. He adds that "therapists often encourage patients to redefine their life histories based on the new pseudomemories and, by doing so, redefine their most basic understanding of their families and themselves" (Ofshe & Watters, 1994, p. 6). As you can imagine, the issue has provoked deep divisions within psychology.

We are *not* saying that all, or even most, therapists use suggestive techniques to probe for memories of sexual abuse, although some certainly do (Poole et al., 1995). Nevertheless, patients should be wary of therapists who go "fishing" for repressed memories of early sexual experiences, using such techniques as hypnosis, dream analysis, and suggestive questioning. No evidence exists in support of these methods for the recovery of accurate memories.

Another source of suggestion that pops up in a surprisingly large proportion of recovered memory cases is a book: *The Courage to Heal.* This book argues that forgotten memories of incest and abuse may lie behind people's feelings of powerlessness, inadequacy, vulnerability, and a long list of other unpleasant thoughts and emotions (Bass & Davis, 1988). The authors state, "If you . . . have a feeling that something abusive happened to you, it probably did" (pp. 21–22). None of these assertions, however, rests on anything more solid than speculation. Thus, say memory experts Elizabeth Loftus and Katherine Ketcham (1994), it seems likely that *The Courage to Heal* has contributed to many false memories of sexual abuse.

A Logical Error: The Post Hoc Fallacy? When we observe that things are associated, we have a natural tendency to suspect that one might cause the other—as we associate overeating with gaining weight or spending time in the sun with a sunburn. Most of the time this logic serves us well, but occasionally it leads us to the wrong conclusions—as when we conclude that a chill causes a cold or that eating sweets causes a "sugar high." Experts call this the post hoc fallacy: *Post hoc* literally means "after the fact," and the idea is that looking back at events occurring in succession (e.g., sugar followed by excitement) we may erroneously conclude that the first event is the cause of the second.

How could the post hoc fallacy contribute to the "recovered memory" controversy? When people "look back" in their memories and find a memory (accurate or not) of abuse that seems to be associated with their current unhappiness, they assume that the abusive event (again, whether real or erroneously remembered) is the cause of their current mental state. But, as we have seen, this conclusion may be faulty. Ironically, this can reinforce one's belief in the memory—through confirmation bias.

Emotional Biases We should also note that the issue of recovered memories is both complex and charged with emotion—always a worrisome influence on critical thinking. Not only does the issue of sexual abuse strike many people close to home, but none of us wants to turn our back on those who believe they have been victims of sexual abuse. Yet what we know about memory tells us that we should not accept long-forgotten traumatic memories without corroborating evidence.

What Conclusions Can We Draw?

So, where does this leave us? You should weigh the evidence yourself on a case-by-case basis, mindful of the possibility that emotional biases can affect your thinking. Keep in mind the following points, as well:

- Sexual abuse of children *does* occur, and it is more prevalent than most professionals had suspected just a generation ago (McAnulty & Burnette, 2004).
- On the other hand, memories cued by suggestion, as from therapists or police officers, are particularly vulnerable to distortion and fabrication (Loftus, 2003a). So, without independent evidence, there is no way to tell whether a recovered memory is true or false.
- Remember that people can feel just as certain about false memories as accurate ones.
- Although traumatic events can be forgotten and later recalled, they are much more likely to form persistent and intrusive memories that people cannot forget. Nevertheless, cases such as that of Ross show us that recovered memories of abuse can be true.

- Early memories, especially those of incidents that may have happened in infancy, are quite likely to be fantasies or misattributions. As we have seen, episodic memories of events before age 3 are rare (Schacter, 1996).
- One should be more suspicious of claims for memories that have been "repressed" and then "recovered" years later than for memories that have always been available to consciousness.

Chapter Summary

4.1 What Is Memory?

Core Concept 4.1: Human memory is an information processing system that works constructively to encode, store, and retrieve information.

Human memory, like any **memory** system, involves three important tasks: **encoding, storage,** and **retrieval.** Although many people believe that memory makes a complete and accurate record, cognitive psychologists see human memory as an information processing system that interprets, distorts, and reconstructs information. **Eidetic imagery,** however, is a rare and poorly understood form of memory that produces especially vivid and persistent memories that may interfere with thought. It is not clear how eidetic memory fits with the widely accepted three-stage model of memory.

Eidetic imagery (p. 138)
Encoding (p. 137)
Information-processing model (p. 136)
Memory (p. 135)
Retrieval (p. 137)
Storage (p. 137)

MyPsychLab Resources 4.1:

Explore: Encoding, Storage, and Retrieval in Memory

4.2 How Do We Form Memories?

Core Concept 4.2: Each of the three memory stages encodes and stores memories in a different way, but they work together to transform sensory experience into a lasting record that has a pattern or meaning.

The memory system is composed of three distinct stages: *sensory memory, working memory,* and *long-term memory.* The three stages work together sequentially to convert incoming sensory information into useful patterns or concepts that can be stored and retrieved when needed later.

Sensory memory holds 12 to 16 visual items for about 1/4; second, making use of the sensory pathways. A separate sensory register for each sense holds material just long enough for important information to be selected for further processing.

Working memory, which has the smallest storage capacity of the three stages and a duration of a few seconds, draws information from sensory memory and long-term memory and processes it consciously. Theorists have proposed at least five components of working memory: a *central executive,* a *phonological loop,* a *sketchpad,* an *episodic buffer,* and a *semantic buffer.* We can cope with its limited duration and capacity by **chunking, rehearsal,** and **acoustic encoding.** The biological basis of working memory is not clear, but it is believed to involve actively firing nerve circuits, probably in the frontal cortex.

Long-term memory has apparently unlimited storage capacity and duration. It has two main partitions, **declarative memory** (for facts and events) and **procedural memory** (for perceptual and motor skills). Declarative memory can be further divided into **episodic memory** and **semantic memory.** Semantic information is encoded, stored, and retrieved according to the meaning and context of the material. The case of H. M. showed that the hippocampus is involved in transferring information to long-term memory. Other research has found long-term memories associated with relatively permanent changes at the synaptic level.

Flashbulb memories are common for highly emotional experiences. While most people have a great deal of confidence in such vivid memories, studies have shown that these memories can become distorted over time, especially the material that was not the focus of attention.

Acoustic encoding (p. 145)
Anterograde amnesia (p. 149)
Childhood amnesia (p. 148)
Chunking (p. 143)
Consolidation (p. 149)
Declarative memory (p. 147)
Elaborative rehearsal (p. 144)
Engram (p. 149)
Episodic memory (p. 147)
Flashbulb memory (p. 151)
Levels-of-processing theory (p. 145)
Long-term memory (LTM) (p. 140)
Maintenance rehearsal (p. 144)
Procedural memory (p. 147)
Retrograde amnesia (p. 150)
Schema (p. 148)
Semantic memory (p. 147)
Sensory memory (p. 140)
Working memory (p. 140)

MyPsychLab Resources 4.2:

Explore: Key Processes in Stages of Memory
Simulation: Digit Span

4.3 How Do We Retrieve Memories?

Core Concept 4.3: Whether memories are implicit or explicit, successful retrieval depends on how they were encoded and how they are cued.

H. M.'s case also demonstrated that information can be stored as **explicit** or **implicit memories.** The success of a memory search depends, in part, on the **retrieval cues.** Implicit memories can be cued by **priming.** Explicit memories can be cued by various **recall** or **recognition** tasks, although some tasks require remembering the **gist,** rather than exact details. The accuracy of memory retrieval also depends on **encoding specificity** and **mood.** Relatively little is known about the conditions required for successful **prospective memory.** When there is a poor match between retrieval cues and the encoding, we may experience the **TOT phenomenon.**

Encoding specificity principle (p. 155)
Explicit memory (p. 152)
Gist (p. 154)
Implicit memory (p. 152)
Mood-congruent memory (p. 155)
Priming (p. 153)
Prospective memory (p. 155)
Recall (p. 154)
Recognition (p. 154)
Retrieval cue (p. 153)
TOT phenomenon (p. 156)

MyPsychLab Resources 4.3:

Watch: The Effects of Sleep and Stress on Memory

4.4 Why Does Memory Sometimes Fail Us?

Core Concept 4.4: Most of our memory problems arise from memory's "seven sins"—which are really by-products of otherwise adaptive features of human memory.

Memory failures involve the "seven sins" of memory. These include forgetting, resulting from weakening memory traces (**transience**), lapses of attention (**absent-mindedness**), and inability to retrieve a memory (**blocking**). Much forgetting can also be attributed to a cause of transience known as **interference.** Memory can also fail when recollections are altered through **misattribution, suggestibility,** and **bias.** An important example involves eyewitness memories, which are subject to distortion. Suggestibility can also produce false memories that seem believable to the rememberer. The final "sin" of **persistence** occurs when unwanted memories linger in memory, even though we would like to forget them.

The "seven sins" of memory, however, are by-products of a memory system that is well suited to solving problems of day-to-day living. Some of these problems can be overcome by **mnemonic strategies,** such as the **method of loci, natural language mediators,** and other associative methods. The learning of concepts, however, requires special strategies geared to learning the *gist* of the material and to avoiding the two memory "sins" of transience and blocking.

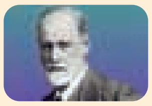
Absent-mindedness (p. 160)
Blocking (p. 160)
Distributed learning (p. 167)
Expectancy bias (p. 163)
Forgetting curve (p. 158)
Method of loci (p. 165)
Misattribution (p. 160)
Misinformation effect (p. 161)
Mnemonic strategy (p. 165)
Natural language mediator (p. 165)
Persistence (p. 164)
Proactive interference (p. 159)
Retroactive interference (p. 159)
Self-consistency bias (p. 164)
Serial position effect (p. 159)
Suggestibility (p. 162)
Transience (p. 157)
Whole method (p. 166)

MyPsychLab Resources 4.4:

Simulation: Creating False Memories
Simulation: Experiencing the Stroop Effect
Simulation: Serial Position Effect
Watch: Elizabeth Loftus

Discovering Psychology Viewing Guide

Watch the following video by logging into MyPsychLab (www.mypsychlab.com). After you have watched the video, complete the activities that follow.



PROGRAM 9: REMEMBERING AND FORGETTING

PROGRAM REVIEW

1. What pattern of remembering emerged in Hermann Ebbinghaus's research?
   a. Loss occurred at a steady rate.
   b. A small initial loss was followed by no further loss.
   c. There was no initial loss, but then there was a gradual decline.
   d. A sharp initial loss was followed by a gradual decline.
2. The way psychologists thought about and studied memory was changed by the invention of
   a. television.
   b. electroconvulsive shock therapy.
   c. the computer.
   d. the electron microscope.
3. What do we mean when we say that memories must be encoded?
   a. They must be taken from storage to be used.
   b. They must be put in a form the brain can register.
   c. They must be transferred from one network to another.
   d. They must be put in a passive storehouse.
4. About how many items can be held in short-term memory?
   a. three
   b. seven
   c. eleven
   d. an unlimited number
5. Imagine you had a string of 20 one-digit numbers to remember. The best way to accomplish the task, which requires increasing the capacity of short-term memory, is through the technique of
   a. selective attention.
   b. peg words.
   c. rehearsing.
   d. chunking.
6. According to Gordon Bower, what is an important feature of good mnemonic systems?
   a. There is a dovetailing between storage and retrieval.
   b. The acoustic element is more important than the visual.
   c. The learner is strongly motivated to remember.
   d. Short-term memory is bypassed in favor of long-term memory.
7. According to Sigmund Freud, what is the purpose of repression?
   a. to protect the memory from encoding too much material
   b. to preserve the individual's self-esteem
   c. to activate networks of associations
   d. to fit new information into existing schemas
8. In an experiment, people spent a few minutes in an office. They were then asked to recall what they had seen. They were most likely to recall objects that
   a. fit into their existing schema of an office.
   b. carried little emotional content.
   c. were unusual within that particular context.
   d. related to objects they owned themselves.
9. The paintings Franco Magnani made of an Italian town were distorted mainly by
   a. repression, causing some features to be left out.
   b. a child's perspective.
   c. sensory gating, changing colors.
   d. false memories of items that were not really there.
10. What was Karl Lashley's goal in teaching rats how to negotiate mazes and then removing part of their cortexes?
    a. finding out how much tissue was necessary for learning to occur
    b. determining whether memory was localized in one area of the brain
    c. discovering how much tissue loss led to memory loss
    d. finding out whether conditioned responses could be eradicated
11. What has Richard Thompson found in his work with rabbits conditioned to a tone before an air puff?
    a. Rabbits learn the response more slowly after lesioning.
    b. Eyelid conditioning involves several brain areas.
    c. The memory of the response can be removed by lesioning.
    d. Once the response is learned, the memory is permanent, despite lesioning.
12. Patients with Alzheimer's disease find it almost impossible to produce
    a. unconditioned responses.
    b. conditioned stimuli.
    c. conditioned responses.
    d. unconditioned stimuli.
13. The best way to keep items in short-term memory for an indefinite length of time is to
    a. chunk.
    b. create context dependence.

c. use the peg-word system.
d. rehearse.

14. Long-term memory is organized as
a. a complex network of associations.
b. a serial list.
c. a set of visual images.
d. a jumble of individual memories with no clear organizational scheme.

15. You remember a list of unrelated words by associating them, one at a time, with images of a bun, a shoe, a tree, a door, a hive, sticks, Heaven, a gate, a line, and a hen. What mnemonic technique are you using?
a. method of loci
b. peg-word
c. link
d. digit conversion

16. What did Karl Lashley conclude about the engram?
a. It is localized in the brain stem.
b. It is localized in the right hemisphere only.
c. It is localized in the left hemisphere only.
d. Complex memories cannot be pinpointed within the brain.

17. Long-term memories appear to be stored in the
a. cortex.
b. occipital lobe.
c. hippocampus.
d. parietal lobe.

18. How has Diana Woodruff-Pak utilized Richard Thompson's work on eyeblink conditioning?
a. as a precursor to early-onset dementia
b. as a predictor of musical genius
c. as a mechanism for growing brain cells in intact animals
d. as a tool for training long-term visual memories

19. Which neurotransmitter(s) is/are disrupted in Alzheimer's patients?
a. scopolamine
b. acetylcholine
c. both of the above
d. none of the above

20. Alzheimer's disease is associated with the loss of
a. memory.
b. personality.
c. life itself.
d. all of the above.

QUESTIONS TO CONSIDER

1. What memory strategies can you apply to help you better retain the information in this course? Why is rote rehearsal not the optimal strategy?
2. What is your earliest memory? How accurate do you think it is? Can you recall an experience that happened before you could talk? If not, why not? How does language influence what people remember? How do photographs and other mementos aid memory?
3. Most American kids learn their ABCs by singing them. Why does singing the ABCs make it easier to remember the alphabet?
4. Many quiz shows and board games, such as Trivial Pursuit, are based on recalling items of general knowledge that we do not use every day. Why is it so much fun to recall such trivia?
5. As a member of a jury, you are aware of the tendency to reconstruct memories. How much weight do you give to eyewitness testimony? Is it possible ever to get "the whole truth and nothing but the truth" from an eyewitness? Do you think memory distortions (for details of what was said during a trial) occur in jurors as well?

ACTIVITIES

1. Do you have an official family historian? In individual interviews, ask family members to recall and describe their memories of a shared past event, such as a wedding or holiday celebration. Perhaps a photograph or memento will trigger a story. Compare how different people construct the event and what kind of details are recalled. What do different people reveal about their personal interests, needs, and values when they describe the experience?
2. Try to recall an experience from your childhood that at least one friend or family member also recalls. Have each person write down details of his or her memory, and then compare notes. Are there any details you hadn't remembered that you now do, based on other people's mention of them? Are there any details that you have contradictory memories for? How do you resolve the disagreement?
3. Make up a list of ten unrelated words. Have five friends study the list for one minute with only the instruction to "remember as many of them as you can." After one minute, have your friends write down as many as they can remember. Have another five friends learn the list for one minute after you teach them the peg-word mnemonic. Do they outperform the control group? What sort of strategies, if any, did the control group tend to use?