Key Question Chapter Outline

What Is Memory?
Memory's Three Basic Tasks

How Do We Form Memories?
The First Stage: Sensory Memory
The Second Stage: Working Memory
The Third Stage: Long-Term Memory
The Biological Basis of Memory

How Do We Retrieve Memories?
Implicit and Explicit Memory
Retrieval Cues
Other Factors Affecting Retrieval

Why Does Memory Sometimes Fail Us?
Transience: Fading Memories Cause Forgetting
Absent-Mindedness: Lapses of Attention Cause Forgetting
Blocking: Interference Causes Forgetting
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

How Do Children Acquire Language?

What are the Components of Thought?
Concepts
Imagery and Cognitive Maps
Thought and the Brain

What Abilities Do Good Thinkers Possess?
Problem Solving
Judging and Making Decisions

Memory: The State of the Art

CORE CONCEPTS

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

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.

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

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

Infants and children face an especially important developmental task with the acquisition of language.

Thinking is a cognitive process in which the brain uses information from the senses, emotions, and memory to create and manipulate mental representations, such as concepts, images, schemas, and scripts.

Good thinkers not only have a repertoire of effective strategies, called algorithms and heuristics, they also know how to avoid common impediments to problem solving and decision making.

Psychology in Your Life

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.

"Flashbulb" Memories: Where Were You When . . . ?
These especially vivid memories usually involve emotionally charged events. Surprisingly, they aren't always accurate.

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.

Improving Your Memory with Mnemonics
There are lots of tricks for learning lists, but another technique works better for mastering the concepts you'll meet in college.

Learning a New Language
Whether acquiring a new language occurs early in your academic or personal life, the knowledge is invaluable.

Schemas and Scripts Help You Know What to Expect . . .
But sometimes they fill in the blanks—without your knowing it.

On Becoming a Creative Genius
Such individuals have expertise, certain personality traits, and lots of motivation, but their thought processes are essentially the same as everyone else's.

USING PSYCHOLOGY TO LEARN PSYCHOLOGY:
How to Avoid Memory Failure on Exams

Chapter

7

Cognition

SOME 20 YEARS AGO, 12-year-old Donna Smith began to suffer from severe migraine headaches, which left her sleepless and depressed. Her parents, Judee and Dan, agreed to get her psychiatric help. During an evaluation recommended by her therapist, Donna disclosed—for the first time—that she had been sexually molested at the age of 3 by a neighbor. It was 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 with therapy.

As a teenager, Donna began work with a new therapist, a private social worker specializing in child abuse. In their first session, the therapist asked Donna if she had been sexually abused by her father. Donna denied this but did mention the neighbor's assault. The therapist, however, believed there might be more behind Donna's problems. For many months, she repeatedly asked Donna whether her father had abused her. Finally, Donna told her a lie, claiming her father had once "touched" her, hoping this false claim would enable her therapy to move on. The therapist immediately reported Donna's father to the local sheriff and to the Maryland Department of Social Services (ABC News, 1995).

When Donna realized the drastic consequences of her false claim, she tried to set the record straight, but the therapist dismissed the confession, saying that all abuse victims recant their accusations once they learn their therapists are required to report such claims. The therapist was persuasive, and eventually Donna began to entertain the idea that her conscious memory was a self-delusion—a trick of her mind trying to protect itself from the "real" truth. Reluctantly, she concluded that it must have been her father, not the neighbor, who had assaulted her as a toddler. When the therapist convinced her to tell the story to county authorities, Donna was removed from her home and placed in foster care.

To her parents, these sudden accusations were "like a bomb"—and it got worse. Still in therapy, Donna became convinced her father had been a chronic abuser, and she began to hate him "wholeheartedly." Committed to a psychiatric hospital, she was diagnosed as having several different personalities, one of which claimed that her parents practiced ritual satanic abuse of Donna's younger brothers. The courts forbade Donna's parents to have contact with her. Judee Smith lost her license to run a day care center. Dan Smith, a retired naval officer, was arrested at his home and handcuffed in front of their two young sons. Financially ruined, he was tried on charges of abuse, based solely on his daughter's testimony. His two-week trial ended in a hung jury, and Dan Smith went free.

Shortly after the trial, Donna moved to Michigan with her foster family. In these new surroundings, far away from the system that had supported her fabricated story, she gradually regained perspective and found the courage to tell the truth. She admitted the charges had all been fabrications, and her doctor recommended that she be sent back to her family. The Smiths had a tearful reunion and began the slow process of rebuilding lost relationships and trust. "She's been a victim of this system, as much as we've been a victim," says Dan Smith. "You know, there's a lot of healing to be done."

According to Johns Hopkins psychiatrist Paul McHugh, erroneous recovered memories are fabricated from suggestions therapists offer in order to blame psychological problems on long-hidden trauma (ABC News, 1995). Memory expert Elizabeth Loftus agrees, noting that some clinicians are all too ready to accept their clients' memories, even fantastic tales of ritualistic abuse (Loftus, 2003a, b). In the book *Making Monsters,* social psychologist Richard Ofshe argues that 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).

Today Donna and her family are "in wonderful shape, back together." Still, the memories of the Smith family's ordeal will remain painful shadows in the background of their lives forever. Fortunately, the same flexibility in human learning and remembering that created these problems can also provide the key to forgiving and healing.

We should emphasize that sexual abuse of children does occur, and it is a serious problem. While estimates vary considerably, it appears that from 4% to 20% of children in the United States experience at least one incident of sexual abuse (McAnulty & Burnette, 2004; Rathus et al., 2000). The issue raised by Donna's case, however, involves false claims of sexual abuse based on faulty "recovered memories." And, while such problems are relatively rare, they have surfaced often enough to alarm psychologists about the widespread misunderstanding people have about memory. Psychologists know that memory does not always make an accurate record of events—even when people are very confident about their recollections.

KEY QUESTION

WHAT IS MEMORY?

In fact, Donna's memory works very much like your own. Memory is but one of the topics you will learn about in this chapter. As you will discover in this section, everyone has a memory capable of distortion. You will also learn about memory's inner workings and some extraordinary memory abilities. Finally, we will end this discussion on a practical note by considering some steps you can take to improve your memory.

As we have seen in the previous chapters, the operation of the brain and the components of learning are very complex. This chapter will show you how the functions of memory, language, and thought interact to enable people to recall information and to express and develop their individuality. Although this complexity may seem overwhelming to you now, in the remaining chapters you will be applying all of the concepts you have learned thus far about sensation and perception, the biological basis of behavior, consciousness, and motivation.

This chapter includes memory, language, and thought, and although each is presented separately, all work together as an integrated process that we call cognition.

The best defense against the tricks that memory can play comes from an understanding of how memory works. So let's begin building that defense 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, human memory is a *cognitive* system, in the sense of the term's Latin root, *cognoscere,* which means "to know" or "to understand." That is, human memory works closely with the perceptual system, which 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—allowing 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 the memory system this way:

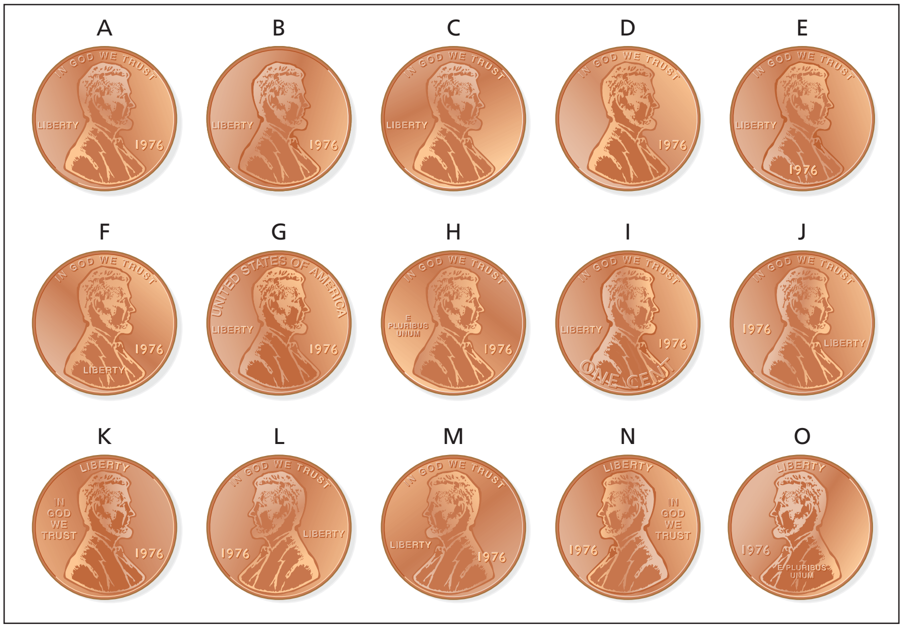
CORE CONCEPT

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

And how is memory related to *learning*? You might think of human memory as the cognitive system that processes, encodes, and stores information as we learn and then allows us to retrieve that learned information later. Accordingly, this chapter is an extension of our discussion of cognitive learning in Chapter 6. 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 studied earlier.

A look at Figure 7.1 will make you aware of the reconstructive process of memory. 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 we are coin collectors, most of us pay little attention to the details of these familiar objects.

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



● **FIGURE 7.1** 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.)

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, we automatically fill in the gaps and missing details—without realizing how much of the memory we are actually creating. (The right answer, by the way, is A.)

Memory's Three Basic Tasks

In simplest terms, human memory takes essentially meaningless sensory information (such as the sound of your professor's voice) and changes it into meaningful patterns (words, sentences, and concepts) that you can store and use later. This process is referred to by cognitive psychologists as the **information-processing model** of memory. To do so, memory must first *encode* the incoming sensory information in a useful format. **Encoding** requires that you *select* some stimulus event from among the vast array of inputs assaulting your senses. Is it a sound, a visual image, or an odor? Then 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. Weber. She's my psychology professor!")

For most of our everyday experiences, encoding can be 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 (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,* in order to establish a usable memory. During this elaboration, you connect a new concept with existing information in memory. One way to do this is to link it with concrete examples, such as when you associate the term *negative reinforcement* with the removal of pain when you take an aspirin. (As an aid to elaboration, this book provides many such examples that we hope will connect with your experience.) In another form of

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

■ **Encoding** One of the three basic tasks of memory, involving the modification of information to fit the preferred format for the memory system.

elaboration, you connect the new idea to old concepts already in memory. This happens, for example, when you realize that "elaboration" is essentially the same process that Piaget called *assimilation.*

CONNECTION: CHAPTER 9

In Piaget's theory, *assimilation* involves absorbing new information into existing schemes.

Storage, the second essential memory task, involves the retention of encoded material over time. But as we get deeper into the workings of memory, you will learn that memory consists of three *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 before the time clock runs out. For example, while listening to a lecture, you have just a few seconds to find some pattern or meaning in the sound of your professor's voice before the information is lost.

Retrieval, the third basic memory task, is 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 comes 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 there are effective techniques that you can use to combat memory's "sins."

■ **Storage** One of the three basic tasks of memory, involving the retention of encoded material over time.

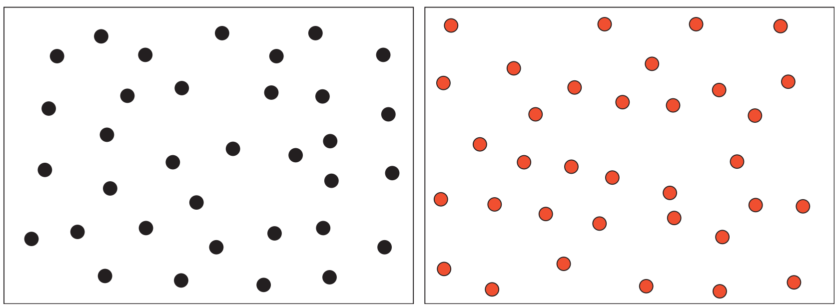
■ **Retrieval** The third basic task of memory, involving the location and recovery of information from memory.

PSYCHOLOGY IN YOUR LIFE: WOULD YOU WANT A "PHOTOGRAPHIC" MEMORY?

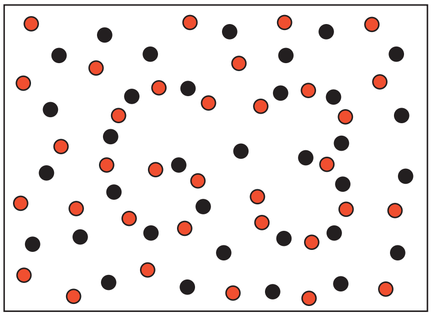
Suppose that your memory were so vivid and accurate that you could use it to "read" paragraphs of this book out of memory during the next psychology exam. Such was the power of a 23-year-old woman tested by Charles Stromeyer and Joseph Psotka (1970). For example, she could look at the meaningless configuration of dots in the left-hand pattern in the accompanying "Do It Yourself!" box and combine it mentally with the right-hand image.

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 7.2.



● **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.



● **FIGURE 7.2** What an Eidetiker Sees

The combined images from the "Do It Yourself" box form a number pattern. (*Source:* From HUMAN MEMORY: Structures and Processes 2nd ed., by Roberta Klatzky. Copyright © 1980. Reprinted by permission of W. H. Freeman and Company/Worth Publishers.)

The combined pattern was the image shown in Figure 7.2. (Did you see the number "63"?) 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 are, in many important respects, different 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." (Even though they see the image "outside," eidetikers realize that it is a mental image.) 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. Remarkable as this is, however, the persistence of eidetic images can be a curse. Eidetikers report that their vivid imagery can clutter their minds and interfere 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 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 formal operational thinking, which often begins at about age 11 or 12.

CONNECTION: CHAPTER 9

In Piaget's theory, the *formal operational stage* marks the appearance of abstract thought.

Alternatively, case studies 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). A cross-cultural study from Nigeria further supports the idea that the loss of eidetic ability may result from a conflict between language skills and visual imagery. In this research, eidetic imagery was found to be common, not only among children, but also among adults of the Ibo tribe who were living in rural villages. Although the villagers could correctly draw details of images seen sometime earlier, tests showed that members of the same tribe who had moved to the city and had learned to read evidenced 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 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, what component of memory is responsible? On the other hand, if it proves to be a unique form of memory, it doesn't fit well with the widely accepted three-stage model of memory—which we will discuss next.

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

CHECK YOUR UNDERSTANDING

1. **ANALYSIS:** Which of the following is a major objection to the "video recorder" theory of memory?
   - **a.** Like perception, memory is an interpretation of experience.
   - **b.** Memories are never accurate.
   - **c.** Unlike a video recorder, memory takes in and stores an enormous quantity of information from all the senses, not just vision.
   - **d.** Unlike a tape-recorded video memory, human memory cannot be edited and changed at a later time.
   - **e.** Memories do not degrade.

2. **RECALL:** Which of the following are the three essential tasks of memory?
   - **a.** eidetic imagery, short-term memory, and recall.
   - **b.** sensory, working, and long-term memory
   - **c.** remembering, forgetting, and repressing
   - **d.** recall, recognition, and relearning
   - **e.** encoding, storage, and retrieval

3. **ANALYSIS:** When you get a new cat, you will 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?
   - **a.** eidetic imagery
   - **b.** encoding
   - **c.** recollection
   - **d.** retrieval
   - **e.** storage

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
   - **e.** eidetic memory.

ANSWERS: 1. a 2. e 3. b 4. b

HOW DO WE FORM MEMORIES?

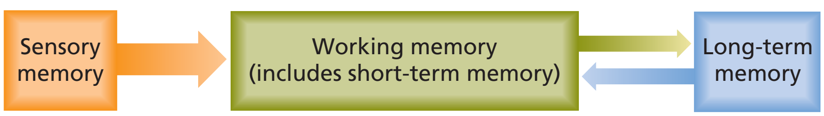
If the information in your professor's lecture is to become a permanent memory, it must be processed in three sequential stages: first in *sensory memory,* then in *working memory,* and finally in *long-term memory.* The three stages work like an assembly line to convert a flow of incoming stimuli into meaningful patterns that can be stored and later remembered. This model, originally developed by Richard Atkinson and Richard Shiffrin (1968), is now widely accepted—with some elaborations and modifications. Figure 7.3 shows how information flows through these three stages. (Please don't get these *stages* confused with the three basic *tasks* of memory that we covered earlier.)

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. You have experienced a sensory memory as you watched a moving Fourth of July sparkler leave a fading trail of light or heard the flow of one note into another as you listen to music. One function of these short-lived images is to maintain incoming sensory information long enough to be screened for possible entry into working memory.

Working memory, the second stage of processing, takes information selectively from the sensory registers and connects it with items already in long-term storage. (It is this connection we mean when we say, "That rings a bell!") Working memory is built to hold information for only a few seconds, making it a useful buffer for temporarily holding items, such as a phone number you

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

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



● **FIGURE 7.3** The Three Stages of Memory (Simplified)

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

have just looked up. Originally, psychologists called this stage short-term memory (STM), a term still in use (Beardsley, 1997b; Goldman-Rakic, 1992). The newer term *working memory* emphasizes some elaborations on the short-term stage originally proposed in Atkinson and Shiffrin's model (Baddeley, 2001; Engle, 2002), as we will discuss below.

It is noteworthy that everything entering consciousness passes into working memory. The opposite is also true: We are conscious of everything that enters working memory. Because of this intimate relationship, some psychologists have suggested that working memory is actually the long-sought seat of consciousness that we discussed in Chapter 5 (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 and holds 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??) Long-term memory holds each person's total knowledge of the world and of the self.

These, then, are the three stages of memory—which this section of the chapter will explore in detail. As you read, you should attend to the differences in the ways each stage processes and stores information. With these differences in mind you will begin to discover ways of exploiting the quirks of each stage to enhance your own memory abilities. In briefer terms, our Core Concept says:

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.

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

In this section you will find out just how each of the three stages makes a unique contribution to the final memory product. (See Table 7.1.) As we consider each stage, we will look at its storage *capacity*, its *duration* (how long it retains information), its *structure and function*, and its *biological basis.*

TABLE 7.1 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	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	Cerebral cortex

The First Stage: Sensory Memory

One of the big problems memory must confront is this: Your senses take in far more information than you can possibly use. While reading this book, your senses 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 do you deal with all of this? It's the job of sensory memory to hold the barrage of incoming sensation just long enough (about ¼ second) for your brain to scan it and decide which stream of information needs attention. But just how much information can sensory 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 found that this first stage of memory holds far more information than ever reaches consciousness. His method involved an array of letters, like the one below, flashed on a screen for a fraction of a second. (You might try glancing at the array briefly and then seeing how many you can recall.)

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

The sensory image of a friend's face is quickly taken into working memory. There it is elaborated with associations drawn from long-term storage.

In the experiment, Sperling first asked volunteers to report as many of the letters as they could remember from the array (as you just did). As expected, most people could remember only three or four items from such a brief exposure.

But, Sperling conjectured, it might be possible that far more information than these three or four items enters a temporary memory buffer and then vanishes before it can be reported. To test this possibility, he modified the task in the following way. Immediately after the array of letters appeared, an auditory cue signaled which row of letters the subject was 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 a flash of letters and hearing a beep, respondents were to report items *from only one row,* rather than items from the whole array.

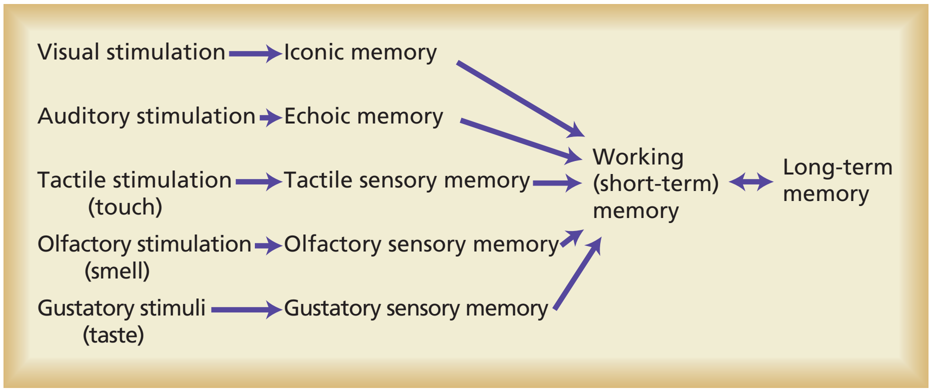
Under this *partial report* condition, most people achieved almost perfect accuracy—no matter which row was signaled. That is, Sperling's subjects could accurately report *any* single row, but not *all* rows. This result suggested that the actual storage capacity of sensory memory can be 12 or more items—even 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. New information is constantly coming in, and it must also be monitored. 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 (Loftus et al., 1992).

The Structure and Function of Sensory Memory You might think of sensory memory as having something like a movie screen, where images are "projected" fleetingly and then disappear. In fact, it is this blending of images in

FIGURE 7.4 Multiple Sensory Stores

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



sensory memory that allows us to have 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. There is a separate *sensory register* for each sense, with each register holding a different kind of sensory information, as you can see in Figure 7.4. The register for vision, called *iconic memory,* stores the encoded light patterns that we see as visual images. Similarly, the sensory memory for hearing, known as *echoic memory,* holds encoded auditory stimuli. Experiments have shown that echoic memory, like iconic memory, holds more information than can pass on into working memory (Darwin et al., 1972).

We should also emphasize that the sensory images have no meaning attached to them, just as an image on photographic film has no meaning to a camera. The job of sensory memory is simply to store the images briefly. As we will see, it's the job of the next stage, working memory, to 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 nerve impulses in the sense organs and their pathways to the brain. In this view, sensory memory consists merely of the rapidly fading trace of stimulation in our sensory systems (Bower, 2000b; Glanz, 1998). Working memory, then somehow "reads" these fading traces, as it decides which information to admit into the spotlight of attention and which to ignore and allow to disappear. It is this transition step—the handoff between sensory and working memory—that we only vaguely understand.

The Second Stage: Working Memory

The second stage, working memory, is where you process conscious experience (LeDoux, 1996). It is the buffer in which you put the new name you have just heard. It is the temporary storage site for the words at the first part of this sentence as you read toward the end. Thus, working memory is the mechanism that selects information from sensory memory.

Working memory also provides a mental "work space" where we sort and encode information before adding it to long-term memory (Shiffrin, 1993). In doing so, it accesses and retrieves information from long-term storage. So, it is also the register into which a long-term memory of yesterday's psychology class can be retrieved 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 spe-

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?

7 4 8 5
3 6 2 1 8
4 7 9 1 0 3
2 3 8 4 9 7 1
3 6 8 9 1 7 5 6
7 4 7 2 1 0 3 2 4
8 2 3 0 1 3 8 4 7 6

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 seven digits. If you remembered more, you may have been using special "chunking" techniques.

cial 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 mental 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 central processing chip in a computer—not only as the center of mental action but also as a go-between for the other components of memory.

The Capacity and Duration of Working Memory This stage of memory is associated with the "magic number" seven (Miller, 1956). That is, working memory holds about seven items (give or take two)—a fact that caused lots of complaints when phone companies began requiring callers to add an area code to the old 7-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. Although there is some variation in STM capacity for different kinds of material, that variation is not large. Whatever your capacity is, it will be roughly the same whether you are dealing with letters, numbers, words, shapes, or sounds. Seven items of nearly any sort will fill up short-term memory for most people.

When we try to overload working memory, earlier items are usually lost to accommodate more recent ones. On the other hand, when working memory is filled with information that demands attention, we may not notice new information that we might otherwise think was important. This limited capacity of working memory, in the opinion of some experts, makes it unsafe to talk on your cell phone while driving (Wickelgren, 2001).

It's important to 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 this part of memory the information "bottleneck" of the memory system. (See Figure 7.5.) As you might have suspected, the twin problems of limited capacity and short duration are 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 below.

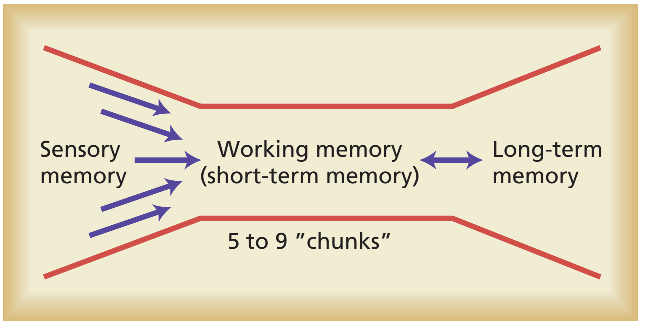


FIGURE 7.5 The STM Bottleneck

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 Structure and Function of Working Memory Three important parts of working memory are shown

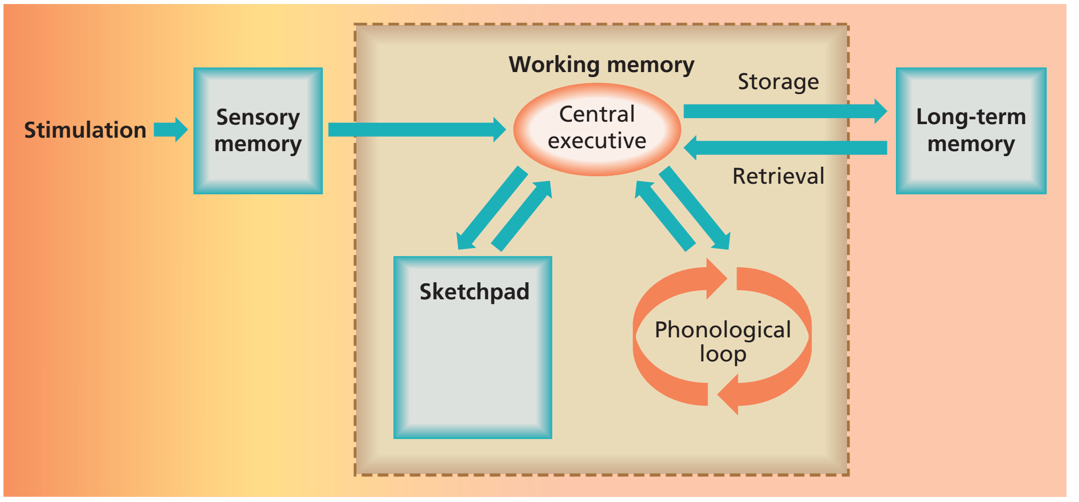


FIGURE 7.6 A Model of Working Memory

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, shown here, includes a *central executive* that directs attention, a *sketchpad* for visual and spatial information, and a *phonological loop* for sounds. (*Source:* Adapted from "Episodic Buffer: A New Component of Working Memory?" by A. Baddeley, *Trends in Cognitive Sciences* (2002), 4, pp. 417–423, American Psychological Association.)

in Figure 7.6. A *central executive* directs attention to material retrieved from long-term memory or to important input from sensory memory, such as someone calling a name. A second component consists of a *phonological loop,* which temporarily stores sounds—helping you to remember the mental "echo" of a name or to follow a melody. The third part of working memory is known as the *sketchpad,* used to store and manipulate visual images, as when you are imagining the route between your home and class.

Even with these tools, however, working memory still must face the twin limitations of limited capacity and short duration. For this purpose, it has two options, known as *chunking* and *rehearsal.* Successful students know how to use both strategies.

Chunks and Chunking In memory, a *chunk* is any pattern or meaningful unit of information. A chunk can be a single letter or number, a name, or even a concept. For example, the sequence 1–4–5–9 consists of four digits that could constitute four chunks. However, if you recognize this sequence as the last four digits of your social security number—which is already available in your long-term memory—the four numbers need occupy only one chunk in STM. By **chunking** you can get more material into the seven slots of working memory.

The phone company figured this out 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 Role of Rehearsal Speaking of phone numbers, suppose that you have just looked up the number mentioned in the preceding paragraph. To keep it alive in working memory, you probably repeat the digits to yourself over and over. This technique is called **maintenance rehearsal,** and it serves well for maintaining information temporarily in working memory. Maintenance rehearsal not only keeps information fresh in working memory but also pre-

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

vents competing inputs from crowding it out. However, it is not an efficient way to transfer information to long-term memory—although it is a strategy commonly used for this purpose by people who don't know how memory operates. So, the student who "crams" for a test using simple repetition (maintenance rehearsal) probably won't remember much of the material.

A better strategy for getting information into long-term memory involves **elaborative rehearsal.** With this method, information is not merely repeated but is actively connected to knowledge already stored. 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," also an auditory sensation.

Acoustic Encoding: The Phonological Loop While reading words like "whirr," "pop," "cuckoo," and "splash," you can hear in your mind the sounds they describe. Much the same thing happens, less obviously, even with words that don't have imitative sounds because working memory converts them into the sounds of spoken language in its phonological loop. There, verbal patterns in working memory acquire an acoustic (sound) form, whether they come through our eyes or our ears (Baddeley, 2001). And this can cause some interesting memory errors. When people are asked to recall lists of letters they have just seen, the mistakes they make tend to involve confusions of letters that have a similar sound—such as D and T—rather than letters that have a similar look—such as E and F (Conrad, 1964). Mistakes aside, however, this **acoustic encoding** has its advantages. Specifically, it seems to have a role in learning and using language (Baddeley et al., 1998; Schacter, 1999).

Visual and Spatial Encoding: The Sketchpad Serving much the same role for visual and spatial information, the sketchpad in working memory encodes visual images and mental representations of objects in space (Baddeley, 2001). For example, it holds the visual images you mentally rummage through when you're trying to imagine where you left your car keys. Neurological evidence suggests that the sketchpad involves the coordination of several brain systems, including the frontal and occipital lobes, while the phonological loop uses the temporal lobes.

Levels of Processing in Working Memory The more connections you can make with new information while it is in working memory, the more likely you are to remember it later (Craik, 1979). 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" processing—establishing more connections with long-term memories—makes new information more meaningful and more memorable. An experiment will illustrate this point.

Craik and his colleague Endel 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 control how deeply subjects processed each word. 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 scanning the word for 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 believed, would

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

■ **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.

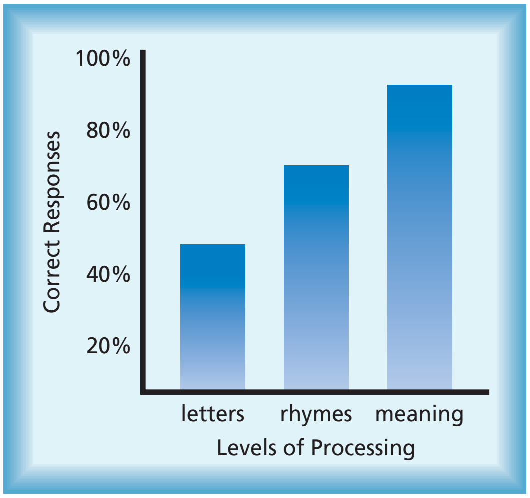


FIGURE 7.7 Results of Levels-of-Processing Experiment
Words that were processed more deeply (for meaning) were remembered better than words examined for rhymes or for target letters.

occur when some aspect of the word's *meaning* was analyzed, as when they asked whether BEAR was an animal. Thus, Craik and Tulving predicted that items processed more deeply would leave more robust traces in memory. And their prediction was correct. When the subjects 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 7.7 shows.

The Biological Basis of Working Memory Although the exact biological mechanism is not clear, working memory probably holds information in actively firing nerve circuits. Brain-imaging studies suggest a likely location for these short-term circuits is in the frontal cortex, regions that are active across a variety of working-memory tasks (Beardsley, 1997b; Smith, 2000). And, as we might expect, the working-memory circuits have connections with all the sensory parts of the brain and to areas known to be involved in long-term storage.

The research also suggests that the frontal regions house some "executive processes" that are involved in focusing attention and thinking about the information in short-term storage. These mental processes involve attention, priorities, planning, updating the contents of working memory, and monitoring the time sequence of events. Brain imaging studies indicate that the executive processes of working memory are anatomically distinct from the sites of short-term storage (Smith & Jonides, 1999).

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 so much of it is so easily accessible. The method behind the marvel involves a special feature of long-term memory: Words and concepts are encoded by their meanings, which interconnects them with other items that have similar meanings. Accordingly, you might picture LTM as a huge web of interconnected associations. The result is that good retrieval cues (stimuli that prompt the activation of a long- term memory) can help you quickly locate the item you want amid all the data stored there. Computer scientists would very much like to understand this feature of LTM and use it to increase the search and retrieval speed of their machines.

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 uses its capacity to store all the experiences, events, information, emotions, skills, words, categories, rules, and judgments that have been transferred to it from working memory. Thus your LTM contains your total knowledge of the world and of yourself. And, unless it falls victim to injury or dementia, long-term memory is potentially capable of storing information for a lifetime—which makes long-term memory clearly the champion in both duration and storage capacity among the three stages of memory. How does LTM manage to have unlimited capacity? That's still an unsolved mystery of memory, but we do know that the metaphor of LTM being like a computer's hard drive is somewhat misleading. Instead, we suggest that you conceive of LTM as a sort of mental scaffold, so the more associations you make, the more information it can hold.

The Structure and Function of Long-Term Memory With a broad overview of LTM in mind, let's look at some of the details. First, let's examine the two main parts of LTM, each distinguished by the sort of information it holds. 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.*

Procedural Memory Mental directions, or "procedures," for how things are done are stored in **procedural memory.** (See Figure 7.8.) We use it to remember the "how to" skills we have learned, such as riding a bicycle, tying shoelaces, or playing a musical instrument (Anderson, 1982; Tulving, 1983). Most often, we are conscious of the details of our performance only during the early phases of acquisition, when we must think about every move we make. Later, after the skill is thoroughly learned, it occurs mainly at or beyond the fringes of awareness, as when a concert pianist performs a piece without consciously recalling the details.

● Procedural memory allows experts like pitcher Pedro Martinez to perform complex tasks automatically, without conscious recall of the details.

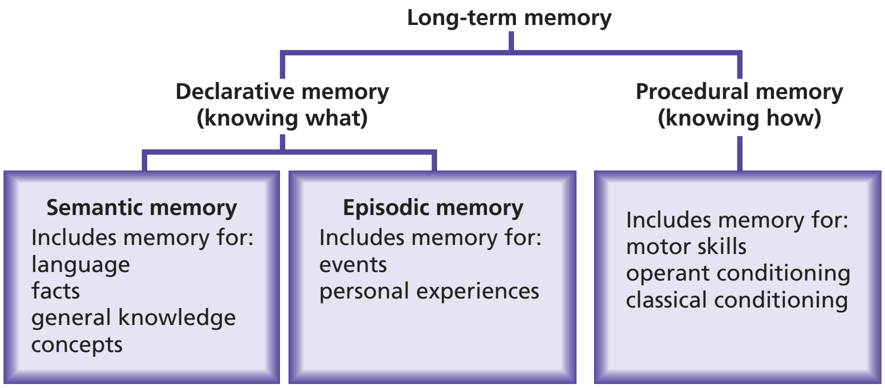
Declarative Memory The other major division of LTM, **declarative memory,** stores specific information, such as facts and events. Recalling the directions for driving to a specific location requires declarative memory (although knowing how to drive a car depends on procedural memory). In contrast with procedural memory, declarative memory more often requires some conscious mental effort. You may be able to see evidence of this when people roll their eyes or make facial gestures while searching their memories. As they do so, they are looking in one of declarative memory's two subdivisions: *episodic memory* and *semantic memory.*

Episodic memory is the portion 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, memories of your recent vacation or of an unhappy love affair are stored in episodic memory, along with codes for where and when these episodes occurred. Thus, episodic memory acts as your internal diary or *autobiographical memory.* You consult it when

■ **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."



● **FIGURE 7.8** 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* involve knowing "how"–particularly motor skills and behavioral learning.

From which division of declarative memory are facts retrieved by *Jeopardy* contestants?

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. (Refer again to Figure 7.8 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 divisions of declarative memory?"

The Biological Basis of Long-Term Memory The search for the **engram,** the biological basis of long-term memory has taken two approaches. One has involved looking for the neural circuitry used by memory in the brain. The other looks on the level of synapses and biochemical changes that are believed to represent the physical *memory trace* in nerve cells.

Using the first tactic, pioneering brain researcher Karl Lashley searched surgically for the engram by removing portions of rats' brains and later testing the animals to see if they had lost memory for a task learned prior to the operation. After years of such work, a frustrated Lashley finally gave up his quest for a special locus in the brain for the engram, in the belief that any part of the brain could store memories (Bruce, 1991; Lashley, 1950).

Clues from the Tragic Case of H. M. A breakthrough came in the form of a tragic figure, known only by his initials. H. M. lost most of his ability to form new declarative memories as a result of a botched brain operation (Hilts, 1995). Since 1953, he has been unable to create new memories of the events in his life. New experiences slip away before he can store them in long-term memory—although his memory for events prior to the operation remains normal. Ironically, one of the few things he has been able to learn is that he has a memory problem. At this writing, H. M. still lives in a nursing home near Boston, where he has resided for decades. Throughout his post-operative life, he has maintained generally good spirits and worked extensively with psychologist Brenda Milner (whom he still cannot recognize). We owe much of our understanding of memory to their relationship.

On H. M.'s medical record, the condition is called **anterograde amnesia,** but to put the problem in cognitive terms, H. M.'s ability to transfer new concepts and experiences from short-term storage to long-term memory is severely impaired. From a biological perspective, the cause was removal of the hippocampus and amygdala on both sides of the brain. This was done during surgery for the severe epileptic seizures from which he suffered as a young man (see Figure 7.9). Although his seizures diminished, he was left with a terrible and permanent disability. H. M. has never been able to recognize the people who have taken care of him in the 50+ years after his surgery. The 9/11 attacks, the moon landings, the computer revolution—all have left no apparent trace in his mind. Likewise, he is always shocked to see an aging face when he looks in the mirror, expecting to see the younger man he was a half century ago (Milner et al., 1968; Rosenzweig, 1992). In brief, H. M. is a man caught in the present moment—which fades away without being captured by memory.

CONNECTION: CHAPTER 12

Retrograde amnesia involves loss of memory for information acquired in the past.

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

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

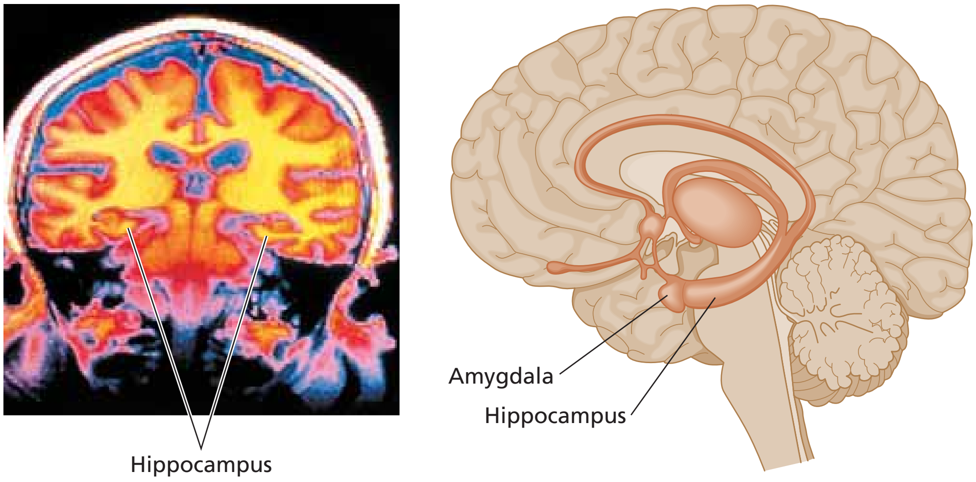


FIGURE 7.9 The Hippocampus and Amygdala

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.

What have we learned from H. M.? Again speaking biologically, H. M. has taught us that the hippocampus and amygdala that were removed from H. M.'s brain 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, Milner has been able to show that H. M. retains the ability to form some *procedural* memories, even though he cannot lay down new *episodic* traces. Just as important, H. M.'s case also brought renewed interest in finding the biological underpinnings of memory.

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 (Eichenbaum, 1997; Schacter, 1996). We now know that deterioration of the hippocampus accounts for many symptoms of Alzheimer's disease—which, as we saw in Chapter 3, involves loss of ability to make new memories. We have also learned that most long-term memories make an intermediate stop in the hippocampus on their way to their final destination in long-term storage (McClelland et al., 1995). In a process called **consolidation,** the intermediate hippocampal memories are gradually changed into relatively permanent memories stored in the cortex.

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

CONNECTION: CHAPTER 12

Lasting biological changes may occur in the brains of individuals having *posttraumatic stress disorder.*

As we have seen, the brain uses some of the same circuits for memory that it uses for sensation, perception, and motor responses (Kandel & Squire, 2000). For example, studies show that the brain's visual cortex is involved in generating visual memory images (Barinaga, 1995; Ishai & Sagi, 1995, 1997; Kosslyn et al., 1995). Further, neuroscientists have found that a person who sustains damage to a part of the brain involving sensations may lose memories for those sensations. For example, as we saw in artist Jonathan I.'s case (Chapter 4), damage to the regions that process color vision may cause memory loss for colors—even to the point of being incapable of imagining what colors might look like (Sacks, 1995; Zeki, 1992). The general principle seems to be

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

that memories of sensory experiences involve the same parts of the brain used to perceive those experiences in the first place (Martin et al., 1995; Wheeler et al., 2000).

In the preceding paragraphs, then, we have explored one fruitful approach to locating the engram—the physical trace of memory. In that approach, which has focused on brain structures, H. M. and a few others like him have played a central role. The discoveries made by studying H. M., plus all the subsequent research on the brain, have shown that different aspects of memory clearly involve different parts of the brain. Now, let's turn to another approach—one requiring that we zoom in closer to see memory at the level of neurons, synapses, and chemicals.

Memories, Neurons, and Synapses The second approach to the engram has concentrated on the biology and chemistry of neurons and their synapses. We'll spare you the details, but the big picture shows long-term memories forming at the synapse as fragile chemical traces that gradually consolidate into more permanent synaptic changes over time (Balter, 2000; Beardsley, 1997b; Haberlandt, 1999; Kandel, 2001; McGaugh, 2000; Travis, 2000a). This explains why a blow to the head or an electric shock to the brain can cause loss of recent memories that have not yet consolidated. (The diagnosis in this case would be **retrograde amnesia,** or loss of prior memory traces.) Certain drugs. too, can interfere with the formation of long-term memories (Lynch & Staubli, 1991). The picture that emerges from such observations shows that memories form when activity in nerve circuits causes biochemical changes that make those circuits in the brain more likely to respond again in the future. We called this *long-term potentiation* in the previous chapter. Many thousands, if not millions, of neurons are probably involved in encoding and storing a single memory.

● Memories can be enhanced by emotional arousal: It is unlikely that Halle Berry will forget this moment.

While memories are consolidating, they can also be strengthened by the person's emotional state—which accounts for our especially vivid memories of emotionally arousing experiences. From an evolutionary perspective, this is highly adaptive. 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 (Cahill et al., 1994; LeDoux, 1996; McGaugh, 2000).

PSYCHOLOGY IN YOUR LIFE: "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 emotion-packed event—a very vivid episodic memory (Brown & Kulik, 1977). You probably have a few such memories: a tragic accident, a death, a graduation, a 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 new "flashbulb" for each picture.)

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

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

Many people have formed essentially the same flashbulb memories of certain events in the news, such as the December 2004 tsunami, the September 11 attacks, Princess Diana's death, or the shootings at Columbine high school. Researchers have also found that the attempted assassination of President Reagan (Pillemer, 1984) and the O. J. Simpson trial verdict (Schmolck et al., 2000) caused large numbers of people to develop flashbulb memories. Typically, these memories record precisely where the individuals were at the time they received the news, what they were doing, and the emotions they felt.

Despite their strong emotional involvement, flashbulb memories can be remarkably accurate (Schmolck et al., 2000). Yet studies have shown that 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 also noteworthy that even those whose recollections were erroneous 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.

CHECK YOUR UNDERSTANDING

1. **RECALL:** Which part of memory has the smallest capacity? (That is, which part of memory is considered the "bottleneck" in the memory system?)
   - **a.** sensory memory
   - **b.** working memory
   - **c.** long-term memory
   - **d.** implicit memory
   - **e.** explicit memory

2. **RECALL:** Which part of long-term memory stores autobiographical information?
   - **a.** semantic memory
   - **b.** procedural memory
   - **c.** recognition memory
   - **d.** episodic memory
   - **e.** eidetic memory

3. **RECALL:** In order to get material into permanent storage, it must be made meaningful while it is in
   - **a.** sensory memory.
   - **b.** working memory.
   - **c.** long-term memory.
   - **d.** recall memory.
   - **e.** immediate memory.

4. **APPLICATION:** As you study the vocabulary in this book, which method 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*
   - **e.** glossing over it , knowing you will see it later

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
   - **a.** important.
   - **b.** meaningful.
   - **c.** interesting.
   - **d.** accurate.
   - **e.** astute.

ANSWERS: 1. b 2. d 3. b 4. c 5. b

HOW DO WE RETRIEVE MEMORIES?

The whole point of encoding and storing memories in meaningful categories is to facilitate their speedy and accurate retrieval. But, as we will see, memory has several surprising tricks 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 our 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, H. M. has retained the ability to learn new motor skills, according to Brenda Milner, the psychologist who has become his guardian and protector (Milner et al., 1968; Raymond, 1989). For example, Milner has taught H. M. the difficult skill of mirror writing—writing while looking at his hands in a mirror. In general, his *procedural* memory for such motor tasks is quite normal, even though he cannot remember learning these skills and doesn't 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 (Roediger, 1990). Psychologist Daniel Schacter (1992, 1996) calls this **implicit memory:** memory that can affect your behavior but which you did not deliberately learn or of which you currently have no awareness. By contrast, **explicit memory** involves 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 a procedural memory. But implicit memories are not limited to procedural memory—nor is explicit memory synonymous with 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 fully conscious. Explicit memories, on the other hand, always involve consciousness during retrieval.

Retrieval Cues

For accurate retrieval, both implicit and explicit memories require good *cues.* You have some feeling for these if you've 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,** which are the "search terms" used to activate 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 asso-

■ **Implicit memory** A memory that was 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** Stimuli that are used to bring a memory to consciousness or into behavior.

ciated 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 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 thought about the material as you were studying—that is if the question isn't a good retrieval cue for the associations you made in memory. As you can see, then, whether a retrieval cue is a good one 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 is often hard to say what cues an implicit memory to surface. Psychologists have, however, developed ways to "prime" implicit memories in the laboratory (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:

ch _ _ _ _ nk, o _ t _ _ _ us, _ og _ y _ _ _, _ l _ m _ te

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.

CONNECTION: CHAPTER 4

Priming is also a technique for studying nonconscious processes.

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 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.

■ **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.

Meaningful Organization Remembering the *gist* of an idea rather than the actual words you heard demonstrates the role that *meaning* has in long-term memory. For example, you may hear the sentence "The book was returned to the library by Mary." Later, you are asked if you heard the sentence "Mary returned the book to the library." You may indeed mistakenly remember having "heard" the second sentence, because even though the two sentences are different utterances, they mean the same thing. This again shows that human LTM stores meaning, rather than an exact replica of the original event (Bransford & Franks, 1971). This is exactly what you would expect from a memory system that relies on the same cognitive processes and brain pathways as our perceptual system.

If you'll forgive us for repeating ourselves, your authors want to underscore the practical application of LTM being organized according to meaning: *If you want to store new information in your LTM, you must make it meaningful while it is in working memory.* This requires you to associate new information with things you already know. That's why it is important in your classes (such as your psychology class) to think of personal examples of the concepts you want to remember.

Recall and Recognition Retrieval of explicit memories can be cued in two main ways. One involves the retrieval method required on essay tests, the other involves the method needed on multiple choice tests. **Recall** (on an essay test) is a retrieval task in which you must create an answer almost entirely from memory, with the help of only minimal cues from the question. This is a recall question: "What are the three memory stages?" **Recognition,** on another hand, is the method required by multiple-choice tests. It is a retrieval task in which 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 why people say, "I'm terrible with names, but I never forget a face" is that recall (names) is much tougher than recognition (faces).

Recognition is also the method used by police 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 influences related to the context in which you encoded a memory and also the context in which you are remembering.

Encoding Specificity Perhaps you have encountered your psychology professor at the grocery store, and you needed a moment to recognize who it was. On the other hand, you may have been talking to a childhood friend, and something she said cued a flood of memories that you hadn't thought about for years. These experiences are contrasting examples of the **encoding specificity principle.** That is, they involve situations in which the context affected the way a memory was encoded and stored—influencing its retrieval at a later time. In general, researchers have found that *the more closely the retrieval cues*

■ **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.

■ **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.

match the form in which the information was encoded, the better the information will be remembered.

It seems that context has a bigger effect under some circumstances than others (Bjork & Richardson-Klavehn, 1989). Happily, you don't have to worry about context effects when you study in one setting and take a test in another (Fernandez & Glenberg, 1985; Saufley et al., 1985). Of far more importance are the kinds of test questions you face and the approach to learning you have used. If the exam questions are quite different from anything you have thought about, then you may find the exam difficult. For this reason, psychologist Robert Bjork (2000) suggests that teachers introduce "desirable difficulties" into their courses. By this he 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 is helping 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.

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. Our moods can also affect what we pull out of memory. If you have ever had an episode of uncontrollable giggling (usually in a totally inappropriate situation), 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. Thus depression perpetuates itself through biased retrieval of depressing memories. In general, the kind of information we retrieve from memory heavily depends on our moods (Bower, 1981; Gilligan & Bower, 1984; Lewinsohn & Rosenbaum, 1987; MacLeod & Campbell, 1992). This phenomenon is known as **mood-congruent memory** (Terry, 2000).

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

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.

PSYCHOLOGY IN YOUR LIFE: 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 the large metal urns used in Russia to dispense tea?
- What is the name of a small Chinese boat usually propelled with a single oar or pole?

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"?

Our guess is that your responses to these questions were of three kinds: (a) you recalled the correct word, (b) you didn't have a clue, or—most interesting for our purposes—(c) you couldn't retrieve the word, but you had a strong sense that you have it somewhere in memory. In the last case, the answer was "on the tip of your tongue," an experience that psychologists call the **TOT phenomenon** (Brown, 1991). Surveys show that most people have this experience about once a week.

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 subjects report that the experience is uncomfortable (Brown & McNeill, 1966).

What accounts for the TOT phenomenon? A likely explanation involves *interference:* when another memory blocks access or retrieval, as when you were thinking of Jan when you unexpectedly meet Jill (Schacter, 1999). (You will read more about interference and other causes of forgetting in the next section of the chapter.) And, even though you were unable to *recall* some of the correct words (caribou, palette, obelisk, sextant, samovar, sampan), you could probably *recognize* most of them. 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 poor 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 their tongue."

CHECK YOUR UNDERSTANDING

1. **APPLICATION:** Remembering names is usually harder than remembering faces because names require _______, while faces require _______.
   a. short-term memory/long-term memory
   b. declarative memory/procedural memory
   c. encoding/retrieval
   d. recall/recognition
   e. storage/recall

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?
   a. implicit memory
   b. anterograde amnesia
   c. encoding specificity
   d. the TOT phenomenon
   e. retrograde amnesia

3. **RECALL:** A person experiencing the TOT phenomenon is unable to _______ a specific word.
   a. recognize
   b. recall
   c. encode
   d. learn
   e. store

4. **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. recalled.
   c. stored.
   d. chunked.
   e. learned.

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

WHY DOES MEMORY SOMETIMES FAIL US?

KEY QUESTION

We forget appointments and anniversaries. During today's test we can't remember the terms we studied the night before. Or a familiar name seems just out of our mental reach. Yet, ironically, we sometimes cannot rid memory of an unhappy event. 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. They are features that stood our ancestors in good stead and so are passed down and preserved in our own memory system. Our Core Concept puts this notion more succinctly:

CORE CONCEPT

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

As we look into the "seven sins," we will also have the opportunity to consider such practical problems as the reliability of eyewitness testimony and ways in which memory contributes to certain mental disorders, such as depression. In this section we will also revisit the "memory wars," involving disputes about recovered memories of trauma and sexual abuse—the problem that we encountered in Donna Smith's case at the beginning of the chapter. Finally, we will look at some strategies for improving our memories by overcoming some of Schacter's "seven sins." We begin, however, with the frustration of fading memories.

Transience: Fading Memories Cause Forgetting

Memories seem to weaken with time. (How would you do on a rigorous test of the course work you took a year ago?) Although no one has directly observed a human memory trace fade and disappear, much circumstantial evidence points to the **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.

In a classic study of transience, pioneering psychologist Hermann Ebbinghaus (1908/1973) learned lists of *nonsense syllables* (such as POV, KEB, and RUZ) and tried to recall them over varying time intervals. This worked well to assess his retention 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 that measured the number of trials required to *relearn* the original list. If it took fewer trials to relearn the list than were required 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 his data is shown in Figure 7.10. There you can see how the graph initially plunges steeply and then flattens out over longer intervals. This represents one of Ebbinghaus's most important discoveries: *For relatively meaningless material, there is a rapid initial loss of memory, followed by a declining rate of loss.* Subsequent

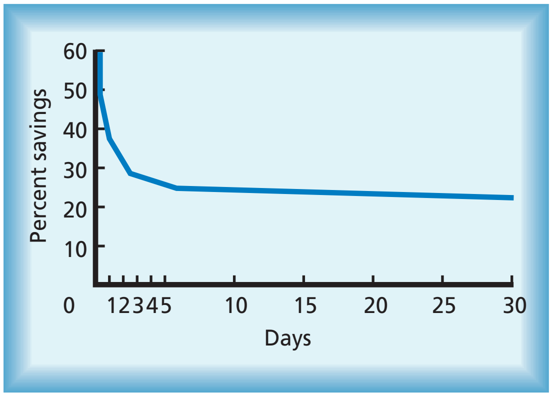


FIGURE 7.10 Ebbinghaus's Forgetting Curve
Ebbinghaus's forgetting curve shows that the savings demonstrated by relearning drops rapidly and reaches a plateau, below which little more is forgotten. The greatest amount of forgetting occurs during the first day after learning. (*Source:* From PSYCHOLOGY AND LIFE 15th ed. by P. G. Zimbardo and R. J. Gerrig. Copyright © 1999 by Pearson Education. Reprinted by permission of Allyn & Bacon, Boston, MA.)

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 are now more interested 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. Much of this modern work uses brain scanning techniques, such as fMRI and PET, to visualize diminishing brain activity during forgetting (Schacter, 1996, 1999).

CONNECTION: CHAPTER 3

PET and *fMRI* are brain scanning techniques that form images of especially active regions in the brain.

Some memories, however, do not follow the classic forgetting curve as closely. Motor skills, for example, are often retained substantially intact in procedural memory for many years, even without practice—"just like riding a bicycle." The same goes for certain especially memorable emotional experiences, such as "flashbulb" incidents or certain childhood events (although they may become distorted, as we have seen). Obviously, the transience hypothesis—that memories fade over time—doesn't describe the fate of all our memories. As we will see next, even some memories that seem to be forgotten haven't faded away completely. Instead, they may only be temporarily lost.

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.** 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.

For a demonstration of this sort of encoding error, please see our magic trick in Figure 7.11. The same process was at work in the "depth of processing" experiments, in which people who encoded information shallowly (retrieval cue: Does the word contain an *e*?) were less able to recall the target word (Craik & Lockhart, 1972). 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).

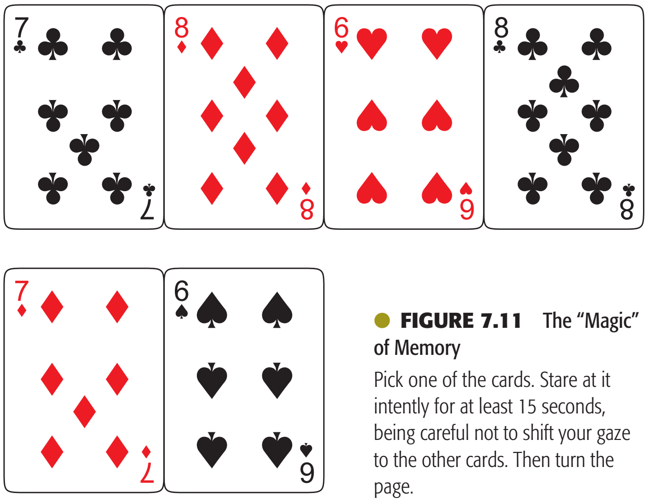


FIGURE 7.11 The "Magic" of Memory

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.

Blocking: Interference Causes Forgetting

You are most likely to notice this next memory "sin" when you have a "tip-of-the-tongue" experience. It also occurs when you attempt to learn two conflicting things in succession, such as would happen if you had a French class followed by a Spanish class. In general, **blocking** occurs when information has encountered *interference*—that is, when one item acts as an obstacle to accessing and retrieving another memory. And what is likely to cause interference? Three main factors top the list:

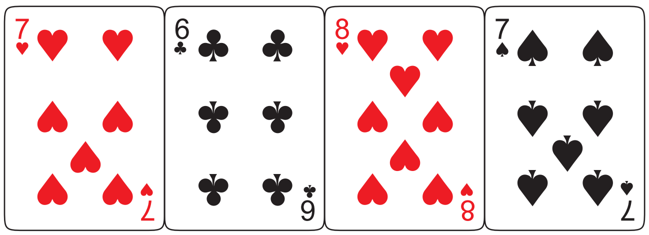
1. The greater the similarity between two sets of material to be learned, the greater the interference between them is likely to be. French and Spanish classes are more likely to interfere with each other than are psychology and accounting.
2. Meaningless material is more vulnerable to interference than meaningful material. Because LTM is organized by meaning, you will have more trouble remembering your locker combination than you will a news bulletin.
3. Emotional material is a 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.

A common source of interference comes from an old habit getting in the way of a new one. This can happen, for example, when people switch from one word-processing program to another. Interference also 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*.

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 when, after moving to a new home, you still look for items in the old places where you used to store them, although no such locations exist in your new environment. *Pro-* means "forward," so in *pro*active interference, old memories act forward in time to block your attempts at new learning.

Retroactive Interference When the opposite happens—when newly learned information prevents the retrieval of previously learned material—we can blame forgetting on **retroactive interference.** *Retro-* means "backward"; the newer material reaches back into your memory to block access to old material. Retroactive interference explains what happens when you drive a car with an automatic transmission and then forget to use the clutch when you return to one with a "stick shift." That is, recent experience retroactively interferes with your ability to retrieve an older memory. (See Figure 7.12.)

The Serial Position Effect In yet another example of blocking, you may have noticed that the first and last parts of a poem or a vocabulary list are easier to learn and remember than the middle portion—which receives interference from both ends. 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.** You can see it at work when you meet a series of people: You are more likely to remember the names of those you met first and last than you are those you met in between (other factors being equal, such as the commonness of their names, the distinctiveness of their appearance, and their personalities).



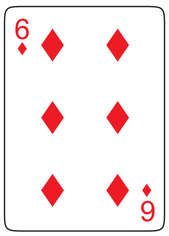


FIGURE 7.11 The "Magic" of Memory (*continued*)

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.

■ **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.

■ **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*.

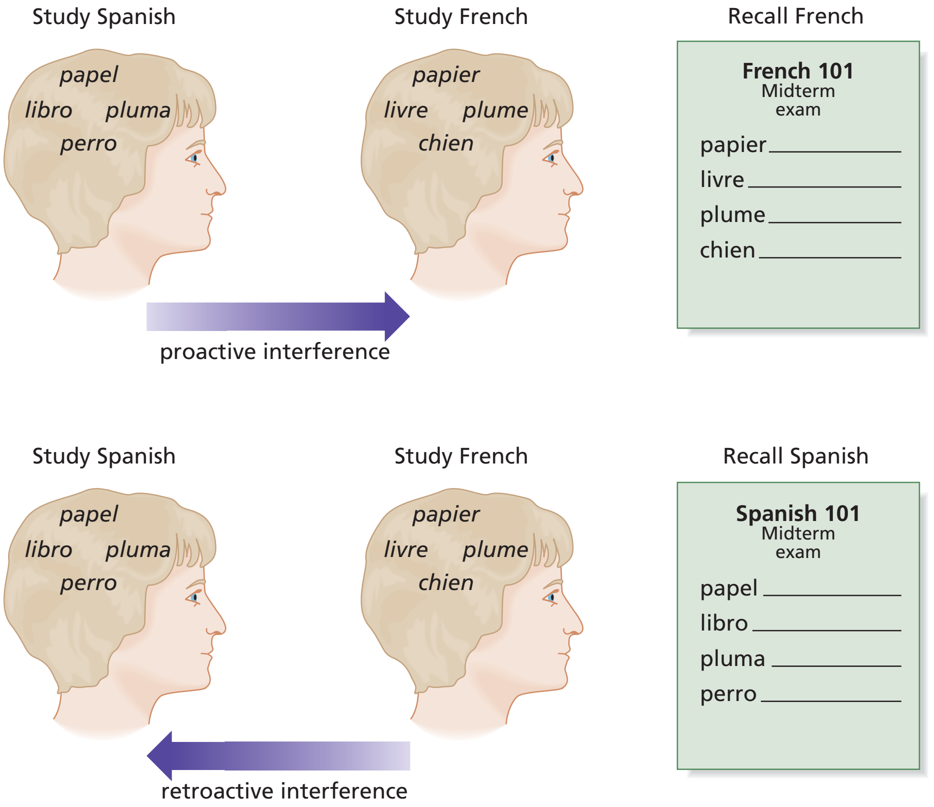
■ **Proactive interference** A cause of forgetting by which previously stored information prevents learning and remembering new information.

■ **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.

● **FIGURE 7.12** 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).



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. (This suggests that you might find it helpful to pay special attention to the material in the middle of this chapter.)

Misattribution: Memories in the Wrong Context

All three "sins" discussed so far make memories inaccessible. Sometimes, however, memories are retrievable, but they are associated with the wrong time, place, or person. Schacter (1999) calls this **misattribution.** This is caused by the reconstructive nature of long-term memory. In the penny demonstration at the beginning of the chapter, you learned that memories are typically retrieved as fragments that we reassemble in such a way as to make them meaningful to us. This opens the way to connecting information with the wrong, but oh-so-sensible, context.

Here's an example: 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.

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

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. It also demonstrates how people tend to create and retrieve memories based on meaning.

Suggestibility: External Cues Distort or Create Memories

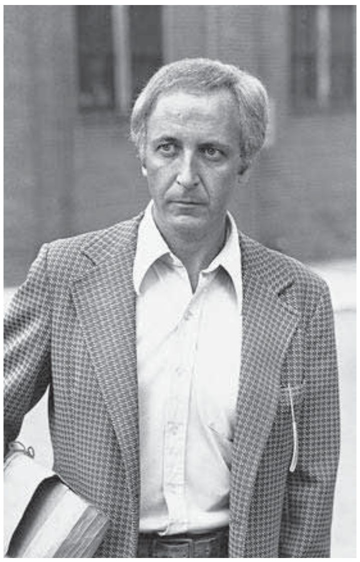
Memories can also be distorted or created by suggestion, a possibility of particular importance to the law. Witnesses may be interviewed by attorneys or by the police, who may make suggestions about the facts of a case—either deliberately or unintentionally—which might alter a witness's testimony. Such concerns about **suggestibility** prompted Elizabeth Loftus and John Palmer to investigate the circumstances under which eyewitness memories can be distorted.

Memory Distortion Participants in the classic 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. The witnesses' responses depended heavily on how the questions were worded (Loftus, 1979, 1984; Loftus & Palmer, 1973). Half 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 is known, appropriately enough, as the **misinformation effect.**

Clearly, the Loftus and Palmer study shows that memories can be distorted and embellished by cues and suggestions given at the time of recall. Memories can even be created by similar methods—all without the individual's awareness that memory has been altered. We'll show you how.

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

■ **Misinformation effect** The distortion of memory by suggestion or misinformation.



● Our criminal justice system relies heavily on eyewitness identifications and descriptions. How well does this system work? You can judge for yourself in the case of a Catholic priest, Father Pagano (right), who was arrested and accused of a series of robberies. The police and the prosecutor were certain that they had the right man, because seven witnesses had identified him as the culprit. Father Pagano was finally exonerated during his trial, when the real robber (left)—hardly a look-alike—confessed.

Fabricated Memories To create entirely false memories, Elizabeth Loftus and her colleagues contacted the parents of college students and obtained lists of childhood events, which the students were asked to recall. Added to 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 (Braun et al., 2002; Hyman et al., 1995; Loftus, 1997a, 1997b; Loftus & Ketcham, 1994). After repeated recall attempts over a period of several days, many of the students claimed to remember the bogus events. All that was required were some credible suggestions.

Factors Affecting the Accuracy of Eyewitnesses In the wake of studies such as these, much attention has focused on the accuracy of eyewitness recall. You can verify this by typing "eyewitness" into the PsychInfo database or looking up the following sources: Bruck and Ceci, 1997; Lindsay, 1990, 1993; Loftus, 1992, 1993, 2003b; Loftus and Ketcham, 1991, 1994; and Weingardt and colleagues, 1995. Here are the most important factors this research has identified:

- People's recollections are less influenced by leading questions if they are forewarned that interrogations can create memory bias.
- When the passage of time allows the original memory to fade, people are more likely to misremember information.
- Each time a memory is retrieved, it is reconstructed and then restored (much like a word-processing document that is retrieved, modified, and saved), increasing the chances of error.
- The age of the witness matters: Younger children and adults over 65 may be especially susceptible to influence by misinformation in their efforts to recall.
- 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.

The Recovered Memory Controversy At the beginning of the chapter, the Smith family's ordeal began with Donna Smith's claim that she had been sexually abused by her father. Subsequently, Donna came to believe her own claims, although she later stated that they were all fabrications. And now we see that research on eyewitness memory confirms the notion that suggestion can lead people not only to report false memories but to believe them (Hyman et al., 1995; Loftus, 1997a, 1997b).

Are all recovered memories suspect? The truth is that we frequently 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. The ones to be especially suspicious of, however, are memories cued by suggestion or leading questions—as were Donna Smith's recollections.

One notorious source of suggestion that pops up in many recovered memory cases is a book: *The Courage to Heal.* This book suggests repeatedly 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).

The belief that buried memories of traumatic experiences can cause mental and physical symptoms was originally proposed by Sigmund Freud. In his theory of *repression,* Freud taught that threatening or traumatic memories can be stored in the unconscious mind, where they indirectly influence our thoughts and behavior. He also taught that the only way to be free of these repressed memories is to root them out during therapy—bringing them into

CONNECTION: CHAPTER 10

Psychoanalyst *Sigmund Freud* taught that most of the mind is not accessible to consciousness.

the daylight of consciousness, where they could be dealt with rationally. Freud, however, never offered more than anecdotes and testimonials to support his repression theory.

In fact, modern cognitive research suggests just the opposite. Emotionally arousing events, including threatening ones, are usually remembered vividly (McNally et al., 2003; Shobe & Kihlstrom, 1997). Most people, however, are unaware of this fact, retaining a strong but unfounded belief in repression and in the Freudian unconscious. Likewise, many people also hold a strong belief that memory makes an accurate record of events, even though psychological science has abundant evidence showing that memory is prone to error (Neimark, 2004).

We are not suggesting that all therapists use suggestive techniques to recover repressed memories, although some still do (Poole et al., 1995). Patients should be especially wary of therapists who go "fishing" for unconscious causes of mental problem, using such techniques as hypnosis, dream analysis, and repeated leading questions about early sexual experiences. There is no evidence to support the validity of these methods for the recovery of accurate memories.

We should also note that the issue of recovered memories is both complex and charged with emotion. It is also one that strikes many people close to home. Thus, it remains controversial, even among psychologists, where it has caused bitter dispute between therapists and experimental psychologists. Yet, despite the controversy, most experts agree on the following points.

- Sexual abuse of children *does* occur, and it is more prevalent than most professionals had suspected just a generation ago (McAnulty & Burnette, 2004).
- Memories cued by suggestion are particularly vulnerable to distortion and fabrication (Loftus, 2003a).
- Early memories, especially those of incidents that may have happened in infancy, are likely to be fantasies or misattributions. Episodic memories of events before age 3 are extremely rare (Schacter, 1996).
- There is no infallible way to be sure about memories of sexual abuse (or any other memories) without independent supporting evidence (Ceci & Bruck, 1993).
- Although traumatic events can be forgotten, they are much more likely to form persistent and intrusive memories that people would rather forget. Moreover, such events can permanently alter the structure of the hippocampus (Teicher, 2002).
- There is no solid evidence for repression, in the Freudian sense of an unconscious memory that can cause physical and mental symptoms (Schacter, 1996).

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. Naturally, it's easier to see in another person than in ourselves. Here are two other, more subtle forms that memory bias can take.

Expectancy Bias Suppose that you are among a group of volunteers for an experiment in which you read a story about 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 how Margie is going to take this disclosure. When he does tell her, Margie is shocked, because she desperately wants children. Then, after reading the story, you are informed that Bob and Margie did get married. Another group of volunteers is told that the couple ended their relationship. Will those in the two groups remember the Bob and Margie story differently?

Those who heard the unexpected ending (the condition in which Bob and Margie decided to get married) gave the most erroneous reports. Their errors made sense, however because what they recalled made the outcome fit their 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. This **expectancy bias** stems from an unconscious tendency to remember events as being congruent with our expectations.

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.** It showed itself, for example, in one study that found people are less consistent than they remembered themselves being in their support for political candidates (Levine, 1997). Another study showed that people believe themselves to be more consistent than they actually are on their stands concerning equality of women, aid to minority groups, and the legalization of marijuana (Marcus, 1986).

The self-consistency bias appears in emotional memories, as well as in memories for attitudes and beliefs (Levine & Safer, 2002). Earlier in the chapter we saw that our moods could affect which memories we retrieve. Here, however, we are more interested in how our emotions can distort our memories. For example, a study of dating couples who were interviewed twice, two months apart, found that memories could be biased by how well the relationship had progressed over the interval. Those who had grown to like each other more remembered their initial evaluations of their partners as more positive than they actually were, while those whose relationships had become more negative had the opposite response (Scharfe & Bartholomew, 1998). In each 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.

Persistence: When We Can't Forget

The seventh "sin" of memory, **persistence,** reminds us that memory sometimes works all too well, especially when intense negative emotions are involved. In fact, intrusive recollections of unpleasant events lie at the heart of certain psychological disorders. Depressed people can't stop ruminating about unhappy events 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. Neuroscientists believe that it does so by strengthening the physical changes in the synapses that hold our memories (LeDoux, 1996).

CONNECTION: CHAPTER 12

People with *phobias* have extreme and unreasonable fears of specific objects or situations.

- **Expectancy bias** In memory, a tendency to distort recalled events to make them fit one's expectations.
- **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.

The Advantages of the "Seven Sins" of Memory

Despite the grief they cause us, the "seven sins" are actually by-products of adaptive features of memory, argues Daniel Schacter (1999). Thus, transience—maddening as it is to the student taking a test—is actually a way the memory system prevents itself from being overwhelmed by information that is no longer needed. Similarly, blocking may be viewed as a process that usually 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.

In contrast, absent-mindedness is the by-product of the useful ability to shift our attention. Similarly, misattributions, biases, and suggestibility result from a memory 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 that is especially responsive to emotional experiences, particularly those involving fear. In general, then, the picture that emerges of memory's "failures" is also one of a system that is well adapted to the conditions people have faced for thousands of years.

PSYCHOLOGY IN YOUR LIFE: IMPROVING YOUR MEMORY WITH MNEMONICS

To improve your memory, try using some mental strategies called *mnemonics* (pronounced *ni-MON-ix,* from the Greek word meaning "remember"). **Mnemonics** are methods memory experts use for encoding 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.*

Mnemonic strategies help us remember things by making them meaningful. Here an elementary school teacher helps students remember the letter *K* by showing that "*K* does karate."

The Method of Loci Dating back to the ancient Greeks, the **method of loci** (pronounced *LOW-sye,* from the Latin *locus,* "place"), is literally one of the oldest tricks in this book. It was originally devised to help orators remember the major points of their speeches. You will also find it a practical means of learning and remembering lists.

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 your room, and as you go, imagine putting one item from your 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; 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 this technique 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, her 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. For instance, you can make up a story to help you remember a grocery list (the same one, consisting of tuna, shampoo, and eggs). The story might link the items this way: "The cat discovers I'm out of *tuna* so she interrupts

Mnemonics Techniques 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 mediators Words associated with new information to be remembered.

me while I'm using the *shampoo* and meows to *egg* me on." 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 order: "Roy G. Biv" stands for red, orange, yellow, green, blue, indigo, violet.

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 associations between a name and some characteristic of the person—the more unusual the association, the better.

Suppose, for example, you have just met a man whose name is Bob. You might visualize his face framed in a big "O," taken from the middle of his name. To remember his friend Ann, think of her as "Queen Ann," sitting on a throne. And, as for their companion Phil, you might visualize putting a hose in Phil's mouth and "fill"-ing him with water. (It is usually best not to tell people about the mnemonic strategy you are using 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.

CHECK YOUR UNDERSTANDING

1. **RECALL:** Which one of the following statements best describes forgetting, as characterized by Ebbinghaus's forgetting curve?
   - **a.** We forget at a constant rate.
   - **b.** We forget slowly at first and then more rapidly as time goes on.
   - **c.** We forget rapidly at first and then more slowly as time goes on.
   - **d.** Ebbinghaus's method of relearning showed that we never really forget.
   - **e.** We never forget.

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?
   - **a.** proactive interference
   - **b.** retroactive interference
   - **c.** decay
   - **d.** retrieval failure
   - **e.** heuristics

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?
   - **a.** interference
   - **b.** repression
   - **c.** persistence
   - **d.** absent-mindedness
   - **e.** transience

4. **RECALL:** Which one of the seven "sins" of memory is disputed by those who believe that memories of childhood abuse can, in many cases, be recovered during adulthood?
   - **a.** transience
   - **b.** persistence
   - **c.** absent-mindedness
   - **d.** suggestibility
   - **e.** decay

5. **UNDERSTANDING THE CORE CONCEPT:** Which one of the "sins" of memory probably helps us avoid dangerous situations we have encountered before?
   - **a.** suggestibility
   - **b.** bias
   - **c.** persistence
   - **d.** misattribution
   - **e.** absent-mindedness

ANSWERS: 1. c 2. a 3. b 4. d 5. c

KEY QUESTION

HOW DO CHILDREN ACQUIRE LANGUAGE?

One of the defining characteristics of humans is the use of complex *language*—our ability to communicate through spoken and written words and gestures. From a developmental perspective, human language acquisition is awe-inspiring: Newborn children know no words at all, yet in only a few years virtually all of them become fluent speakers of any language they hear spoken regularly—or *see,* in the case of gestural languages such as American Sign Language. What makes them such adept language learners? Developmental specialists believe that human infants possess innate (inborn) abilities that help them with this task (Pinker, 1994). Here's how our Core Concept states the main idea of this section:

CORE CONCEPT

Infants and children face an especially important developmental task with the acquisition of language.

Language Structures in the Brain According to the *innateness theory of language,* children acquire language not merely by imitating but also by following an inborn program of steps to acquire the vocabulary and grammar of the language in their environment. Psycholinguist Noam Chomsky (1965, 1975) has proposed that children are born with mental structures—built into the brain—that make it possible to comprehend and produce speech. Many experts agree with Chomsky that innate mental machinery orchestrates children's language learning (Hauser, Chomsky, & Fitch, 2002). Indeed, research based on the Human Genome Project has provided evidence that the foundations of language are, in part, genetic (Liegeois et al., 2001). One such mechanism, we have seen, lies in Broca's area, the motor speech "controller" in the cerebral cortex. Chomsky refers to these speech-enabling structures collectively as a **language acquisition device** or **LAD.**

In Chomsky's theory, the LAD—like a computer chip—contains some very basic rules, common to all human languages. One such rule might be the distinction between nouns (for names of things) and verbs (for actions). These innate rules, Chomsky argues, make it easier for children to discover patterns in languages to which they are exposed.

What other evidence does Chomsky have to suggest that the foundations of language are innate? Children worldwide proceed through very similar stages of learning their native languages. A logical hypothesis for explaining this pattern would be that children possess inborn "programs" for language development that automatically run at certain times in the child's life. Despite the cross-cultural similarities in the sequence, however, language learning is not precisely the same across cultures. Such variations suggest that children's built-in capacity for language is not a rigid device but a set of "listening rules" or guidelines for perceiving language (Bee, 1994; Slobin, 1985a, b). For example, babies pay attention to the sounds and rhythms of the sound strings they hear others speak (or, in sign language, see), especially the beginnings, endings, and stressed syllables. Relying on their built-in "listening guides," young children deduce the patterns and rules for producing their own speech.

In general, language researchers have been impressed with the fact that most young children are both ready to acquire language and flexible about its final form and context. This is equally true for children exposed to any of the world's 4000 spoken languages, as well as to gestural communication systems, such as American Sign Language. Such adaptability suggests that the LAD in children is flexible, not rigidly programmed (Goldin-Meadow & Mylander, 1990; Meier, 1991). Recent research also suggests that the effect can go the other

■ **Language acquisition device or LAD** A biologically organized mental structure in the brain that facilitates the learning of language because (according to Chomsky) it is innately programmed with some of the fundamental rules of grammar.

way as well: The language we learn as children also fine-tunes the structure of the brain, as when English speakers "wire" their brains to distinguish the sounds /r/ and /l/, sounds that cannot be distinguished by many Japanese speakers (Iverson et al., 2003).

Babbling: A Foundation for Language Besides their ability to perceive speech sounds, infants have a natural ability to produce language sounds. Part of this tendency arises from a vocal apparatus that is biologically adapted for speech. As a result, infants babble, producing speechlike sounds and syllables such as "mamama" or "beebee" well before they begin to use true words. Infants at this stage may also follow conversational "rules," such as taking turns with vocalizations (Jaffe et al., 2001). Amazingly, during this *babbling stage,* babies make nearly all sounds heard in all languages. Eventually, however, learning narrows the repertoire down to the sounds of the language that the baby hears (Clark & Clark, 1977; Mowrer, 1960).

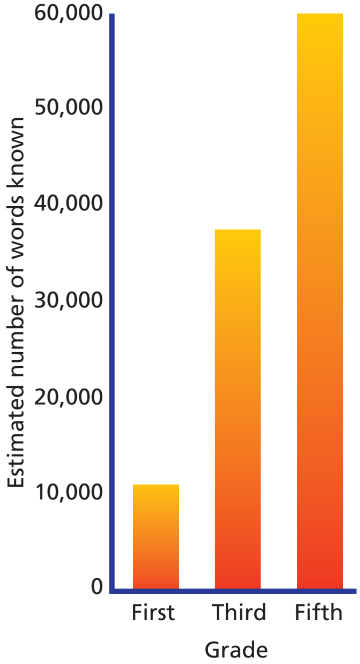


FIGURE 7.13 Growth in Grade-School Children's Vocabulary

The number of words in a child's vocabulary increases rapidly during the grade school years—an even faster rate of increase than during the preschool years. The chart shows total vocabulary, including words that a child can use (production vocabulary) and words that a child can understand (comprehension vocabulary). These data were reported in 1995 by J. M. Anglin of the University of Waterloo, Ontario, Canada.

Acquiring Vocabulary and Grammar Inborn language abilities don't tell the whole story, for children must *learn* the words and the structure of a particular language. Accordingly, learning the basic grammar and vocabulary in the native language represents an important project for children in their first few years of life—and they are excellent language learners. At age 2, the average child has a vocabulary of nearly a thousand different words (Huttenlocher et al., 1991). By the age of 6, that number has burgeoned to an astounding 10,000 words (Anglin, 1993, 1995). Assuming that most of these words are learned after the age of 18 months, this works out to about nine new words a day, or almost one word per waking hour (Bower, 1998c; Carey, 1978). Even more surprising, the pace of vocabulary acquisition picks up between about ages 6 and 10, as you can see in Figure 7.13.

What is the pattern by which children develop vocabulary and grammar? Developmental psychologists recognize three initial stages: the *one-word stage,* the *two-word stage,* and *telegraphic speech.* During the *one-word stage,* which begins at about 1 year of age, children utter single concrete nouns or verbs, such as *Mama* or *drink*. Later, they learn to put words together to express more complex ideas.

The Naming Explosion At around 18 months of age, children's word learning accelerates rapidly. At this age, children may delight in pointing to objects and naming them. Researchers have called this phase the "naming explosion" because children begin to acquire new words, especially names for objects, at a rapidly increasing rate. Soon they also discern that some words are not names but actions (verbs) that describe how named objects and persons affect each other.

After about six months, the naming explosion subsides and children begin to use one-word utterances in different sequences to convey more complex meanings. When these words come in pairs, they are said to enter the *two-word stage,* and the range of meanings children can convey increases tremendously. Studies of different languages show that, around the world, children's two-word utterances begin to divide their experience into certain categories. For example, children speaking languages as diverse as English, Samoan, Finnish, Hebrew, and Swedish were found to talk mostly about three categories of ideas: movers, movable objects, and locations (Braine, 1976). When young Alexis kicks a ball, for example, the mover is Alexis and the movable object is the ball. Alexis can express this relationship in the two-word sequence, "Alexis ball." It is in the two-word stage, at about 2 years, that children first develop the language rules called *grammar.* This allows them to move past simple naming and combine words into sentences.

The Rules of Grammar: Putting Words Together Even if you have a limited vocabulary, you can combine the same words in different sequences to convey a rich variety of meanings. For example, "I saw him chasing a dog" and "I saw a dog chasing him" both use exactly the same words, but switching the order of the words *him* and *dog* yields completely different meanings. **Grammar** makes this possible: It is a language's set of rules about combining and ordering words to make understandable sentences (Naigles, 1990; Naigles & Kako, 1993). Different languages may use considerably different rules about grammatical combinations. In Japanese, for example, the verb always comes last, while English is much more lax about verb position.

In their early two- and three-word sentences, children's speech is *telegraphic:* short, simple sequences of nouns and verbs without plurals, tenses, or function words like *the* and *of*. For example, "Ball hit Evie cry" is *telegraphic speech.* To develop the ability to make full sentences, children must learn to use other forms of speech, such as modifiers (adjectives and adverbs) and articles (the, those), and they must learn how to put words together—grammatically. In English, this means recognizing and producing the familiar subject-verb-object order, as in "The lamb followed Mary."

Finally, children need to acquire grammatical skill in using **morphemes,** the meaningful units that make up words. Morphemes mark verbs to show tense (walk*ed,* walk*ing*) and mark nouns to show possession (Maria*'s,* the people*'s*) and plurality (fox*es,* child*ren*). Often, however, children make mistakes because they do not know the rule or apply an inappropriate one (Marcus, 1996). One common error, known as **overregularization,** applies a rule too widely and creates incorrect forms. For example, after learning to make past tense verb forms by adding *-d* or *-ed,* children may apply this "rule" even to its exceptions, the irregular verbs, creating such nonwords as *hitted* and *breaked.* Learning to add *-s* or *-es* to make plurals, children may apply the rule to irregular nouns, as in *foots* or *mouses.*

Other Language Skills Words and the grammatical rules for combining them are only some of the ingredients of communication. To communicate well, children also need to learn the social rules of conversation. They must learn how to join a discussion, how to take turns talking and listening, and how to make contributions that are relevant. Adult speakers use body language, intonation, and facial expressions to enhance their communication. They also use feedback they get from listeners and are able to take the perspective of the listener. Children must master these skills in order to become successful communicators—to become part of a human language community.

As they grow older, children also begin to express abstract meanings, especially as their thoughts extend beyond the physical world and into their psychological world. For example, after the age of 2, children begin to use words such as *dream, forget, pretend, believe, guess,* and *hope,* as they talk about internal states (Shatz et al., 1983). They also use words such as *happy, sad,* and *angry* to refer to emotional states. Finally, after cognitive advances that occur later in childhood, they understand and use highly abstract words such as *truth, justice,* and *idea.*

PSYCHOLOGY IN YOUR LIFE: LEARNING A NEW LANGUAGE

Learning a new language is something that (almost) every high school student has to do. Some schools require two years of a language, some three, while some may even require four. The developmental perspective suggests that children learn languages best early in life, long before they reach high

■ **Grammar** The rules of a language, specifying how to use words, morphemes, and syntax to produce understandable sentences.
■ **Morphemes** The meaningful units of language that make up words. Some whole words are morphemes (example: *word*); other morphemes include grammatical components that alter a word's meaning (examples: *-ed, -ing,* and *un-*).
■ **Overregularization** Applying a grammatical rule too widely and thereby creating incorrect forms.

school. Lennenberg (1967) argued that languages should be learned early in life when people are most receptive to acquiring languages. This explains why adolescents and adults who learn languages speak it with an accent, whereas those who learn non-native languages before puberty have no accent!

Given the research and findings on learning languages, the question becomes, "Why do we teach languages so late (comparatively) in the educational program?" Although second languages have been taught beginning in 7th or 8th grade for years, the recent focus on testing competes with time in the day spent teaching languages at the elementary and middle school levels. There are some schools and school systems, such as Fairfax County, Virginia, that have immersion programs beginning in kindergarten which extend through middle school. These schools and systems have committed to bilingual education to the extent that at least half of the instructional day is taught in a second language (usually a school focuses on one particular language). Whether you learned a second language earlier or later in your academic career, the knowledge remains a valuable asset to your future endeavors.

CHECK YOUR UNDERSTANDING

1. **RECALL:** Noam Chomsky has presented evidence supporting his theory that
   - **a.** children learn language by imitating their parents.
   - **b.** children are born with some rules of grammar programmed into their brains.
   - **c.** vocabulary is innate, but grammar is learned.
   - **d.** different languages may have entirely different rules of grammar.
   - **e.** grammar interferes with a child's ability to learn languages.

2. **RECALL:** A child's acquisition of grammar first becomes apparent at
   - **a.** the babbling stage.
   - **b.** the one-word stage.
   - **c.** the two-word stage.
   - **d.** the concrete operational stage.
   - **e.** adolescence.

3. **UNDERSTANDING THE CORE CONCEPT:** There are many developmental tasks that children must face in the area of language. Can you name two?

ANSWERS: 1. b 2. c 3. Vocabulary and grammar.

A Look Ahead

In the next section of the chapter, we will focus on the processes underlying thought, especially in decision making and problem solving. One of the most common methods used to describe how thinking and problem solving work is called the **computer metaphor.** This metaphor likens the brain to an information processor such as those found in a computer hard drive. While this may seem simple and logical to some, as we progress through this section, you will see that the brain and its capabilities go far beyond the "plugging and chugging" of information that computers provide. Our brains can create *concepts* and new thoughts and ideas that are more than simply a regurgitation of information from our long-term memory. We will examine the building blocks of cognition, called *concepts, images, schemas,* and *scripts.* You will also find that the tools psychologists use to study cognition include both time-honored psychological methods and the rapidly developing techniques of brain imaging. This excursion into thinking will also give us the opportunity to look at the related topic of creativity and that mysterious quality known as "genius."

■ **Computer metaphor** The idea that the brain is an information-processing organ that operates, in some ways, like a computer.

WHAT ARE THE COMPONENTS OF THOUGHT?

KEY QUESTION

Solving a math problem, deciding what to do Friday night, and indulging a private fantasy all involve *thinking.* More generally, we can conceive of thinking as a complex act of information processing in the brain, by which we deal with our world of ideas, feelings, desires, and experience. Our Core Concept notes that this information can come from within and from without, but it always involves some form of mental representation:

CORE CONCEPT

Thinking is a cognitive process in which the brain uses information from the senses, emotions, and memory to create and manipulate mental representations, such as concepts, images, schemas, and scripts.

These mental representations, then, are the building blocks of cognition, which thinking organizes in meaningful ways. The ultimate results can be the higher thought processes that we call reasoning, imagining, judging, deciding, problem solving, expertise, creativity, and—sometimes—genius.

Concepts

You may have had an experience known as *déjà vu* (from the French for "seen before"). The term refers to the strange feeling that your present experience jibes with a previous experience, even though you cannot retrieve the explicit memory. Perhaps you have visited a new place that seems oddly familiar or had a social conversation that seemed repetitive. While this *déjà vu* feeling can be an illusion, it also reflects the brain's ability to treat new stimuli as instances of familiar categories, even if the stimuli are slightly different from anything it has encountered before. Here's the point: The ability to assimilate experiences into familiar mental categories—and to take the same action toward them or give them the same label—is regarded as one of the most basic attributes of thinking organisms (Mervis & Rosch, 1981).

Only humans—because of their ability for thinking about what might be—can indulge in flights of fancy.

The mental categories that we form in this way are called **concepts.** Concepts are among the building blocks of thinking, because they enable us to organize knowledge in systematic ways (Goldman-Rakic, 1992). Concepts may be mental representations for classes of objects, activities, or living organisms, such as "chairs," "birthday parties," or "birds." They may also represent properties (such as "red" or "large"), abstractions (such as "truth" or "love"), relations (such as "smarter than"), procedures (such as how to tie your shoes), or intentions (such as the intention to break into a conversation) (Smith & Medin, 1981). Because concepts are mental structures, researchers cannot observe them directly but have had to infer their influence in people's thinking indirectly by studying their observable effects on behavior or on brain activity. For example, you cannot be sure that another person shares your concept of "red," but you can observe whether he or she responds in the same way you do to stimuli that you both call "red." Likewise, in Google, an index consisting of a huge set of search terms represents the concepts on which a user can run a search.

Two Kinds of Concepts Everyone conceptualizes the world in a unique way, so our concepts define who we are. Yet behind this individual uniqueness lie similarities in the ways that people form concepts. Many cognitive psychologists believe that we all distinguish between two different types of concepts: *natural concepts* and *artificial concepts* (Medin et al., 2000).

Concepts Mental representations of categories of items or ideas, based on experience.

Natural concepts are rather imprecise mental classifications that develop out of our everyday experiences in the world. You may possess a natural concept of "bird" based on your experiences with birds. You probably also have natural concepts associated with Chevrolets, your mother's face, artichokes, and the Statue of Liberty. While each of these examples may involve words, natural concepts also can involve visual images, emotions, and other nonverbal memories.

Your own natural concept of "bird" invokes a mental **prototype,** a generic image that represents a typical bird from your experience (Hunt, 1989; Medin, 1989; Mervis & Rosch, 1981; Rosch & Mervis, 1975). To determine whether some object is a bird or not, you mentally compare the object to your bird prototype. The more sophisticated your prototype, the less trouble you will have with flightless birds, such as ostriches and penguins, or with birdlike flying creatures, such as bats, or with turtles and platypuses, which lay eggs, as do birds. Natural concepts are sometimes called "fuzzy concepts" because of their imprecision (Kosko & Isaka, 1993).

Research support for the idea of a prototype comes from studies showing that people respond more quickly to typical members of a category than to more unusual ones—that is, their reaction times are faster. For example, it takes less time to say whether a robin is a bird than to say whether an ostrich is a bird, because robins resemble most people's prototype of a bird more closely than ostriches do (Kintsch, 1981; Rosch et al., 1976). The prototype is formed on the basis of frequently experienced features. These features are stored in memory, and the more often they are perceived, the stronger their overall memory strength is. Thus, the prototype can be rapidly accessed and recalled.

By comparison, **artificial concepts** are those defined by a set of rules or characteristics, such as dictionary definitions or mathematical formulas. The definition of "rectangle" that you learned in math class is an example. Artificial concepts represent precisely defined ideas or abstractions, rather than actual objects in the world. So, if you are a zoology major, you may also have an artificial concept of "bird," which defines it as a "feathered biped." Like these textbook definitions of birds and rectangles, most of the concepts you learn in school are artificial concepts. "Cognitive psychology" is also an artificial concept; so is the concept of "concept"!

Most of the concepts in our everyday lives, however, are natural concepts. We can identify clusters of properties that are shared by different instances of a concept (for example, robins, penguins, and ostriches all are birds and all have feathers), but there may be no one property that is present in all instances. Still, we consider some instances as more representative of a concept—more typical of our mental prototype (more "birdlike")—than others.

Concept Hierarchies We organize much of our declarative memories into **concept hierarchies,** from general to specific, as seen in Figure 7.14. For most people, the broad category of "animal" has several subcategories, such as "bird" and "fish," which are subdivided, in turn, into their specific forms, such as "canary," "ostrich," "shark," and "salmon." The "animal" category may itself be a subcategory of the still larger category of "living beings." We can think of these concepts and categories as arranged in a hierarchy of levels, with the most general and abstract at the top and the most specific and concrete at the bottom, as shown in Figure 7.14. They are also linked to many other concepts: Some birds are edible, some are endangered, some are national symbols. It may help you to understand this if you use the following conceptual model: The connections among concepts seem to work much like the links you see on web pages.

Culture, Concepts, and Thought Most of the research on concept formation has been done by Euro-American psychologists, who have studied how con-

■ **Natural concepts** Mental representations of objects and events drawn from our direct experience.

■ **Prototype** An ideal or most representative example of a conceptual category.

■ **Artificial concepts** Concepts defined by rules, such as word definitions and mathematical formulas.

■ **Concept hierarchies** Levels of concepts, from most general to most specific, in which a more general level includes more specific concepts—as the concept of "animal" includes "dog," "giraffe," and "butterfly."

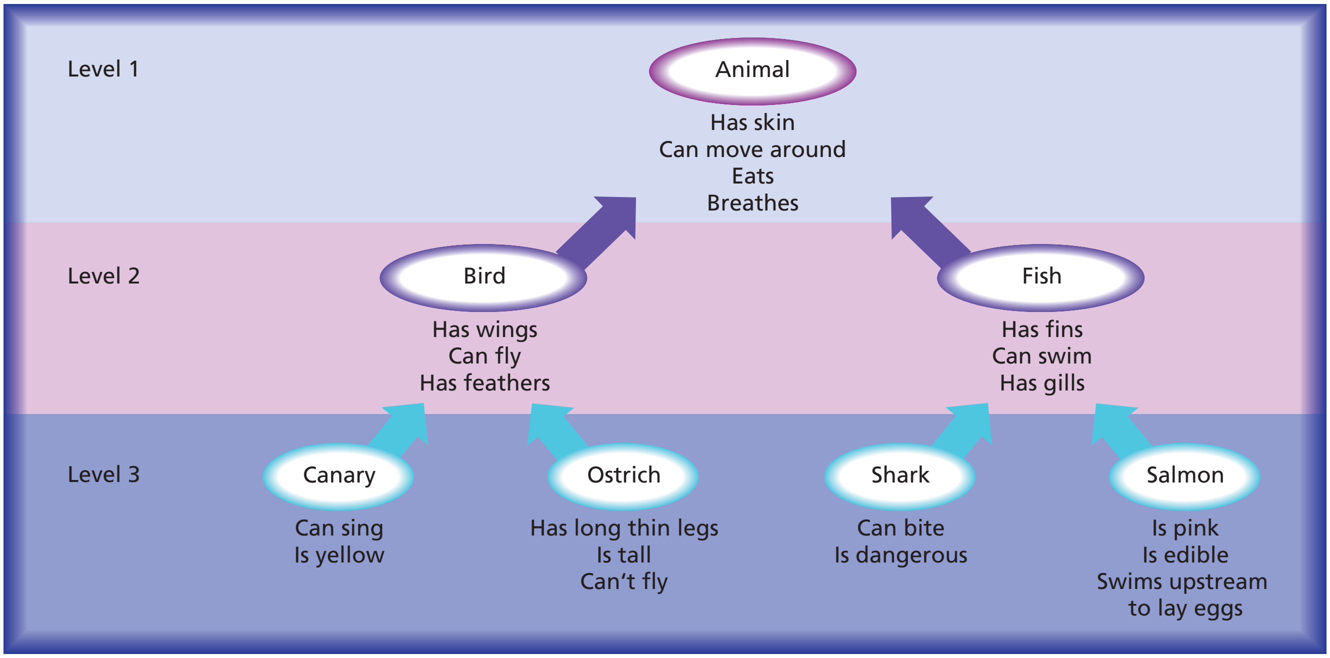


FIGURE 7.14 Hierarchically Organized Structure of Concepts

cepts are used in their own culture. But recent work by cross-cultural psychologists cautions us not to assume that thinking works exactly the same way in all parts of the globe. For example, Americans have learned from recent conflicts with cultures in the Middle East that the concepts of "democracy" and "freedom" may carry vastly different connotations in different parts of the world.

One big cultural difference involves the use of logic: Many groups do not value the use of logical reasoning as much as do Europeans and North Americans (Bower, 2000a; Nisbett et al., 2001). Even in the United States, many people place higher value on qualities variously known as "common sense" or "intuition"—which refer to thinking based on experience, rather than on logic.

Another cultural difference involves concept formation. Although people everywhere do form concepts, most Asian cultures tend to place less importance on precise definitions and clear-cut conceptual categories than do the dominant cultures of Europe and North America (Nisbett, 2000; Peng & Nisbett, 1999). From an Asian perspective, conceptual boundaries tend to be more fluid, and the focus is more on the relationships among concepts, rather than on their definitions. Thus, a person who grew up in Bankok might be more interested than would a native of Boston in the ways in which the terms "masculine" and "feminine" are contrasting ideas, rather than defining the exact meaning of each term.

Imagery and Cognitive Maps

Do you think only in words, or do you sometimes think in pictures and spatial relationships or other sensory images? If you take a moment to think of a face, a tune, or the smell of fresh bread, the answer is obvious. Sensory mental imagery revives information you have previously perceived and stored in memory. This revival may take place without immediate sensory input, yet it produces internal representations of events and concepts in sensory forms, such as visual images.

Consider, for example, the following question: What shape are a German shepherd's ears? Assuming you answered correctly, how did you know? You probably have not intentionally memorized the shapes of dog ears or ever expected to be quizzed about such knowledge. To answer that a German shepherd has pointed ears, you probably consulted a visual image of a German shepherd stored in your memory. In general, thought based on imagery differs from verbal thought because it involves sensory information that is stored in sensory pathways of the brain (Kosslyn, 1983; Paivio, 1983).

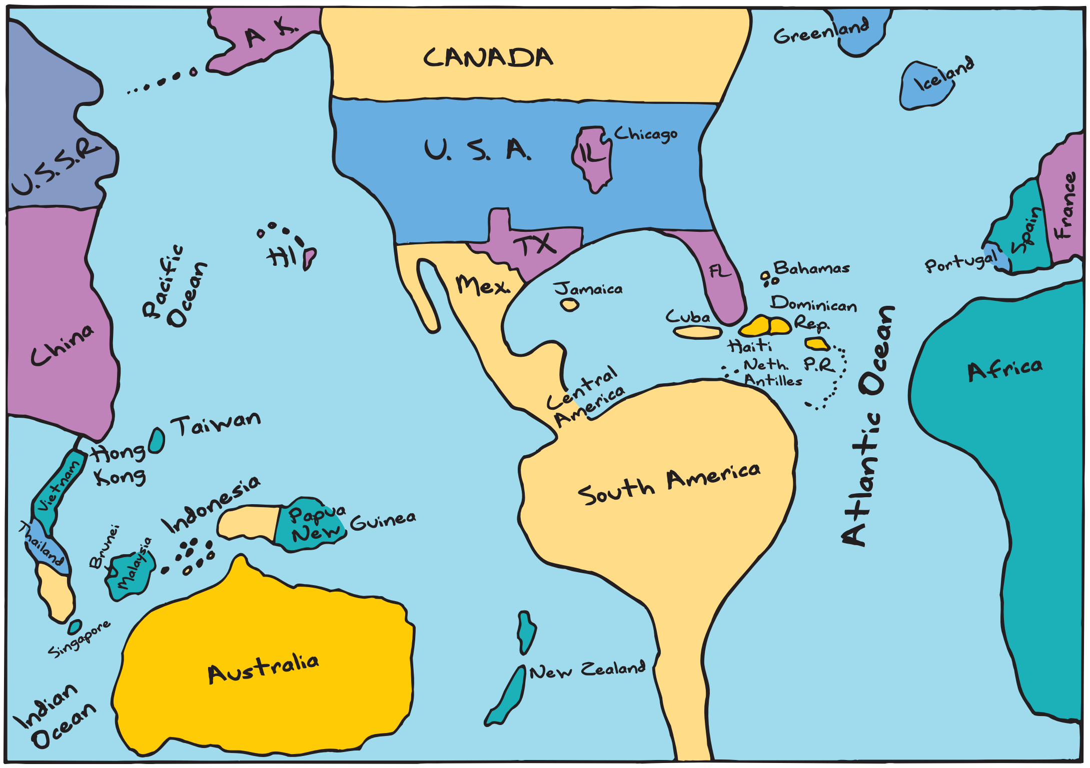
Visual Thinking Visual imagery adds complexity and richness to our thinking, as do images that involve the other senses (sound, taste, smell, and touch). Visual thinking can be useful in solving problems in which relationships can be grasped more clearly in an image rather than in words. That is why books such as this one often encourage visual thinking with pictures and diagrams.

A cognitive representation of physical space is a special form of visual concept called a *cognitive map.* You will remember that learning theorist Edward C. Tolman was the first to hypothesize that people (and other animals) form mental maps of their environment, which they use to guide their actions toward desired goals. Cognitive maps help you get to your psychology class, and they enable you to give another person directions to a nearby theater or deli. By using cognitive maps, people can move through their homes with their eyes closed or go to familiar destinations even when their usual routes are blocked (Hart & Moore, 1973; Thorndyke & Hayes-Roth, 1979).

Cultural Influences on Cognitive Maps Mental maps also seem to reflect our subjective impressions of physical reality. And thus the maps we have in our minds mirror the view of the world that we have developed from the perspective of our own culture. For example, if you were asked to draw a world map, where would you begin and how would you represent the size, shape, and relations between various countries? This task was given to nearly 4000 students from 71 cities in 49 countries as part of an international study of the way people of different nationalities visualize the world. The study found that the majority of maps had a Eurocentric world view: Europe was placed in the center of the map, and the other countries were arranged around it (probably due to the dominance for many centuries of Eurocentric maps in geography books). But the study also yielded many interesting culture-biased maps, such as the ones by a Chicago student (Figure 7.15) and an Australian student (Figure 7.16). American students, incidentally, did poorly on this task, often misplacing countries. Students from the former Soviet Union and Hungary made the most accurately detailed maps (Saarinen, 1987).

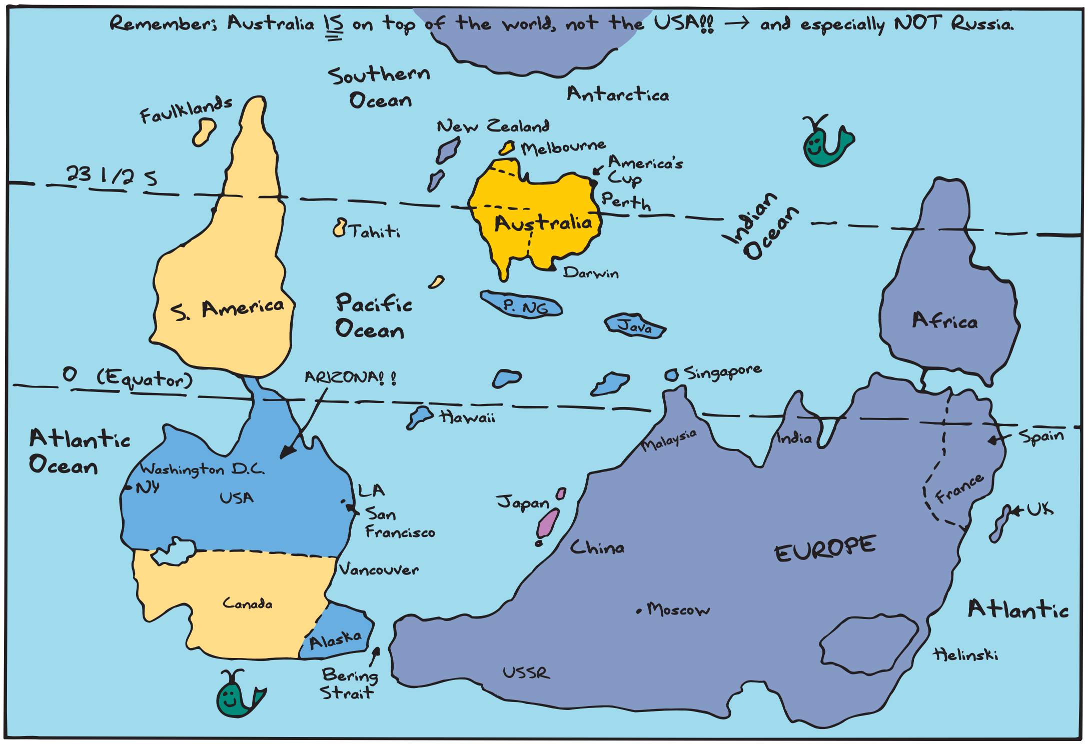
Thought and the Brain

As they have studied the inner world of thought, cognitive researchers have been forced to invent ways of mapping the mind itself. We will see that these methods can now bring us close to the long-standing goal of connecting mental activity to brain activity (Ashby & Waldron, 2000; Beardsley, 1997a; Behrmann, 2000; Freedman et al., 2001; Thorpe & Fabre-Thorpe, 2001). For example, with the help of the computer, biological scientists have demonstrated that certain thoughts, such as "dog" or "pencil," can be associated with specific electrical wave patterns in the brain (Garnsey, 1993; Osterhout & Holcomb, 1992). They have demonstrated this by presenting a repeated stimulus (such as the word *dog* flashed on a screen) to a volunteer "wired" to record the brain's electrical responses. While the brain waves on just one trial may show no clear pattern, a computer can average many brain wave responses to



● **FIGURE 7.15** Chicagocentric View of the World

How does this sketch compare with your view of the world? (*Source:* From COGNITIVE PSYCHOLOGY 5th ed. by Robert L. Solso. Copyright © 1998 by Allyn & Bacon. Reprinted by permission of Allyn and Bacon, Boston, MA.)



● **FIGURE 7.16** Australiocentric View of the World

Now who's "down under"? It probably would not occur to most Americans to draw a map "upside down" like this one, with Australia near the center of the world. (*Source:* From COGNITIVE PSYCHOLOGY 5th ed. by Robert L. Solso. Copyright © 1998 by Allyn & Bacon. Reprinted by permission of Allyn and Bacon, Boston, MA.)

a single, repeated stimulus, eliminating the random background "noise" of the brain and isolating the unique brain wave pattern evoked by that stimulus (Kotchoubey, 2002). These EEG patterns associated with particular stimuli are called **event-related potentials.**

Other methods can also tell us which parts of the brain switch on and off while we think. With PET scans and magnetic resonance imaging (MRI) neuroscientists have identified brain regions that become active during various mental tasks. Two broad findings have come from this work. First, thinking is an activity involving widely distributed areas of the brain—not just a single "thinking center." Second, brain scans have revealed the brain as a community of highly specialized modules, each of which deals with different components of thought (Cree & McRae, 2003; Posner & McCandliss, 1993; Raichle, 1994; Solso, 2001). As we have seen, the brain generates many of the images used in thought with the same modular circuitry it uses for sensation and perception. Thus, visual imagery drawn from memory arises from the visual cortex, and auditory memories come from the auditory cortex (Behrmann, 2000). Even thinking with language involves different regions, depending on the topic. For example, a brain-imaging study of humor demonstrated that most jokes crack us up mainly in the language processing areas of the cortex, while puns also tickle the brain's sound-processing circuits (Goel & Dolan, 2001). In general, the picture of thought coming out of this work reveals thinking as a process composed of many elements.

Recent neuroscience research shows that the frontal lobes of the brain are especially important in coordinating mental activity when we think, make decisions, and solve problems (Helmuth, 2003a; Koechlin et al., 2003). To do so, the prefrontal cortex takes on three different tasks: keeping track of the *episode* (the situation in which we find ourselves), understanding the *context* (the meaning of the situation), and responding to a specific *stimulus* in the situation. Here's how it works: Suppose that the phone rings (the stimulus). Normally—at your own house—you would answer it. But suppose further that you are at a friend's house (a different context). Under those conditions, you would probably let the phone ring without answering it. Now suppose that your friend, who has just hopped into the shower, has asked you to take a message if the phone happens to ring (the episode); you will answer it. From a neuroscience perspective, the interesting thing is that each of these tasks is performed cooperatively by different combinations of modules in the prefrontal cortex. It's an impressive and sophisticated system.

Another exciting development involves the location of brain circuits that seem to be associated with what we often call "common sense," or the ability to act on "intuition" (Bechara et al., 1997; Gehring & Willoughby, 2002; Vogel, 1997). Psychologists have long known that when people make decisions—whether about buying a house or choosing a spouse—they draw on feelings as well as reason. This emotional component of thinking apparently involves regions of the frontal lobes just above the eyes. These structures allow us unconsciously to add emotional "hunches" to our decisions in the form of information about past rewards and punishments. Individuals with severe damage to this area of the brain seem to display little emotion. They may also lack "intuition"—the ability to know the value of something without conscious reasoning—and they frequently make unwise choices when faced with decisions (Damasio, 1994).

In brief, various forms of brain scanning provide glimpses of cognitive processes through new windows. The task ahead is to figure out what this new information is telling us about cognition. The "big picture" of human cognitive processes is thus still emerging, piece by piece, just as one might assemble a jigsaw puzzle.

Event-related potentials
Brain waves shown on the EEG in response to stimulation.

PSYCHOLOGY IN YOUR LIFE: SCHEMAS AND SCRIPTS HELP YOU KNOW WHAT TO EXPECT

Much of your knowledge is stored in your brain as schemas (Oden, 1987). A **schema** is a cluster of related concepts that provides a general conceptual framework for thinking about a topic, an event, an object, people, or a situation in one's life. You probably have schemas that represent "college" and "music," for example. Some of these schemas could contain an entire hierarchy of concepts. Let's look at some important ways in which schemas are used.

CONNECTION: CHAPTER 9

Piaget said that cognitive development involves changes in *schemas.*

Expectations Schemas are one of the attributes that Google and other search engines lack, so they have no real understanding of "birthday" or "psychology" or "nonfat mocha." But for us, schemas provide contexts and expectations about the features likely to be found when you encounter familiar people, situations, images, and ideas (Baldwin, 1992). For example, to an airline passenger the word *terminal* probably conjures up a schema that includes scenes of crowds, long corridors, and airplanes. For a heart attack victim, however, the schema for *terminal* might include feelings of anxiety and thoughts of death. And for an auto mechanic, *terminal* might mean a connection for a battery cable.

Making Inferences New information, which is often incomplete or ambiguous, makes more sense when you can relate it to existing knowledge in your stored schemas. So schemas enable you to make inferences about missing information, as the following example will demonstrate. Consider this statement:

> Tanya was upset to discover, upon opening the basket, that she'd forgotten the salt.

With no further information, what can you infer about this event? *Salt* implies that the basket is a picnic basket containing food. The fact that Tanya is upset that the salt is missing suggests that the food in the basket is food that is usually salted, such as hard-boiled eggs or vegetables. You automatically know what other foods might be included and, equally important, what definitely is not: Everything in the world that is larger than a picnic basket and anything that would be inappropriate to take on a picnic—from a boa constrictor to bronze-plated baby shoes. The body of information you now have has been organized around a "picnic-basket" schema. Relating the statement about Tanya to your preestablished schema gives the statement meaning.

How important are schemas to you? According to researchers Donald Norman and David Rumelhart, schemas are the primary units of meaning in the human information-processing system (1975). You comprehend new information by integrating new input with what you already know, as when your favorite pizza parlor advertises a new spicy Thai chicken curry pizza. (Piaget called this *assimilation.*) If you find a discrepancy between new input and existing schemas, you overcome it by changing what you know (*accommodation*) or ignoring the new input, as when the concept of "telephone" was revolutionized by the introduction of cell phones.

Scripts as Event Schemas We have schemas not only about objects and events but also about persons, roles, and ourselves. These schemas help us to decide what to expect or how people should behave under specific circumstances. An *event schema* or **script** consists of knowledge about sequences of interrelated, specific events and actions expected to occur in a certain way in particular settings (Baldwin, 1992). We have scripts for going to a restaurant, using the library, listening to a lecture, going on a first date, and even making love.

■ **Schema** A knowledge cluster or general conceptual framework that provides expectations about topics, events, objects, people, and situations in one's life.

■ **Script** A cluster of knowledge about sequences of events and actions expected to occur in particular settings.

DO IT YOURSELF! Your Memory for Concepts

Read the following passage carefully:

> Chief Resident Jones adjusted his face mask while anxiously surveying a pale figure secured to the long gleaming table before him. One swift stroke of his small, sharp instrument and a thin red line appeared. Then the eager young assistant carefully extended the opening as another aide pushed aside glistening surface fat so that the vital parts were laid bare. Everyone stared in horror at the ugly growth too large for removal. He now knew it was pointless to continue.

Now, without looking back, please complete the following exercise: Circle below the words that appeared in the passage:

patient	scalpel	blood	tumor
cancer	nurse	disease	surgery

In the original study, most of the subjects who read this passage circled the words *patient, scalpel,* and *tumor.* Did you? However, none of the words were there! Interpreting the story as a medical story made it more understandable, but also resulted in inaccurate recall (Lachman et al., 1979). Once the subjects had related the story to their schema for hospital surgery, they "remembered" labels from their schema that were not present in what they had read. Drawing on a schema not only gave the subjects an existing mental structure to tie the new material to but also led them to change the information to make it more consistent with their schema-based expectations.

Even though they may not be prejudiced, people may avoid interactions with those of other ethnic groups because they don't understand each other's scripts.

Cultural Influences on Scripts Scripts used in other cultures may differ substantially from ours. For example, during the Persian Gulf War, American women stationed in Arab locales discovered that many behaviors they might take for granted at home—such as walking unescorted in public, wearing clothing that showed their faces and legs, or driving a car—were considered scandalously inappropriate by citizens of their host country. To maintain good relations, these servicewomen had to change their habits and plans to accommodate local customs. We can see from such examples that the scripts found in diverse cultures have developed from distinct schemas for viewing the world.

Conflicting Scripts When people who follow similar scripts get together, they feel comfortable because they have comprehended the "meaning" of the situation in the same way and have the same expectations of each other (Abelson, 1981; Schank & Abelson, 1977). When people do not all follow similar scripts, however, they may be made uncomfortable by the script "violation" and may have difficulty understanding why the scene was "misplayed." Unfortunately, when scripts clash, people may say, "I tried to interact, but it was so awkward that I don't want to try again" (Brislin, 1993).

CHECK YOUR UNDERSTANDING

1. **APPLICATION:** A dictionary definition would be an example of
   - **a.** an artificial concept.
   - **b.** a natural concept.
   - **c.** a core concept.
   - **d.** an abstract concept.
   - **e.** a concrete concept.

2. **APPLICATION:** Which one of the following lists represents a concept hierarchy?
   - **a.** cat, dog, giraffe, elephant
   - **b.** animal, mammal, dog, cocker spaniel
   - **c.** woman, girl, man, boy
   - **d.** lemur, monkey, chimpanzee, human
   - **e.** beaver, fox, cat, cougar

3. **APPLICATION:** Knowing how to check out a book at the library is an example of
   - **a.** a natural concept.
   - **b.** an event-related potential.
   - **c.** a cognitive map.
   - **d.** a script.
   - **e.** a core concept.

4. **UNDERSTANDING THE CORE CONCEPT:** All of the following are components of thought, *except*
   - **a.** concepts.
   - **b.** images.
   - **c.** schemas.
   - **d.** stimuli.
   - **e.** scripts.

ANSWERS: 1. a 2. b 3. d 4. d

KEY QUESTION

WHAT ABILITIES DO GOOD THINKERS POSSESS?

The popularity of lotteries and casino games, in which our chances of winning are small, shows us that human thought is not always purely logical. Nevertheless, our psychological nature has some advantages: Departures from logic allow us to fantasize, daydream, act creatively, react unconsciously, respond emotionally, and generate ideas that cannot be tested against reality.

We are, of course, capable of careful reasoning. After all, our species did invent that most logical of devices, the computer. Still, the psychology of thinking teaches us that we should not expect people always to behave in a strictly logical manner or that good judgment will be based on reason alone. This ability to think *psycho*logically enhances our ability to solve problems and make effective decisions. And, as we will see, good thinkers also know how to use effective thinking strategies and the avoidance of ineffective or misleading strategies. Our Core Concept puts this in more technical language:

CORE CONCEPT

Good thinkers not only have a repertoire of effective strategies, called algorithms and heuristics, they also know how to avoid the common impediments to problem solving and decision making.

We will see that thinking is more useful than mere logic, because it helps us make decisions rapidly in a changing world that usually furnishes us incomplete information.

Problem Solving

Artists, inventors, Nobel Prize winners, great presidents, successful business executives, world-class athletes, and successful college students—all must be effective problem solvers. And what strategies do these effective problem solvers use? No matter what their field, those who are most successful share certain characteristics. They, of course, possess the requisite knowledge for solving the problems they face. In addition, they are skilled at (a) *identifying the problem* and (b) *selecting a strategy* to attack the problem. In the next few pages we will examine these two skills, with the aid of some examples.

Identifying the Problem A good problem solver learns to consider all the relevant possibilities, without leaping to conclusions. Suppose that you are driving along the freeway, and your car suddenly begins sputtering and then quits. As you coast over to the shoulder, you notice that the gas gauge says "empty." What do you do? Your action in this predicament depends on the problem you think you are solving. If you assume that you are out of fuel, you may hike to the nearest service station for a gallon of gas. But you may be disappointed. By representing the problem as "out of gas," you may fail to notice a loose battery cable that interrupts the supply of electricity both to the spark plugs and to the gas gauge. The good problem solver considers all the possibilities before committing to one solution.

Selecting a Strategy The second ingredient of successful problem solving requires selecting a strategy that fits the problem at hand (Wickelgren, 1974). For simple problems, a trial-and-error approach will do—as when you search in the dark for the key to open your front door. More difficult problems require better methods. Problems in specialized fields, such as engineering or medicine, may require not only specialized knowledge but special procedures or formulas. Such step-by-step procedures and formulas are called *algorithms.* In addition, expert problem-solvers have a repertoire of more intuitive, but less precise, strategies called *heuristics.* Let's look more closely at both of these methods.

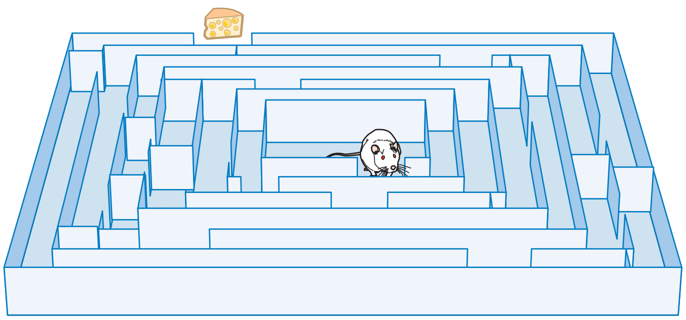
Algorithms Whether you are a psychology student or a rocket scientist, selecting the right algorithms will guarantee correct solutions for many of your problems. And what are these never-fail strategies? **Algorithms** are nothing more than formulas or procedures, like those you learned in math classes or in science labs. They are designed to solve particular kinds of problems for which you have all the necessary information. For example, you can use algorithms to balance your checkbook, figure your gas mileage, and calculate your grade-point average. If applied correctly, an algorithm *always* works because you merely follow a step-by-step procedure that leads directly from the problem to the solution.

Despite their usefulness, however, algorithms cannot solve every problem you face. Problems that involve subjective values or have too many unknowns (Will you be happier with a red car or a white car? Or which is the best airline to take to Denver?) and problems that are just too complex for a formula (How can you get a promotion? What will the fish bite on today?) do not lend themselves to the use of algorithms. And that is why we also need the more intuitive and flexible strategies called heuristics.

Heuristics Everyone makes a collection of heuristics while going through life. Examples: "Don't keep bananas in the refrigerator." "If it doesn't work, see if it's plugged in." "Feed a cold and starve a fever" (or is it the other way around?). **Heuristics** are simple, basic rules—so-called "rules of thumb" that help us cut through the confusion of complicated situations. Unlike algorithms, heuristics do not guarantee a correct solution, but they often give us a good start in the right direction. Some heuristics require special knowledge, such as training in medicine or physics or psychology. Other heuristics, such as those you will learn in the following paragraphs, are more widely applicable—and well worth remembering.

■ **Algorithms** Problem-solving procedures or formulas that guarantee a correct outcome, if correctly applied.

■ **Heuristics** Cognitive strategies or "rules of thumb" used as shortcuts to solve complex mental tasks. Unlike algorithms, heuristics do not guarantee a correct solution.



● **FIGURE 7.17** Working Backward

Mazes and math problems often lend themselves to the heuristic of working backward. Try solving this maze, as the mouse must do, by starting at what would normally be the finish (in the center) and working backward to the start.

Some Useful Heuristic Strategies Here are three essential heuristics that should be in every problem solver's tool kit. They require no specialized knowledge, yet they can help you in a wide variety of puzzling situations. The common element shared by all three of these heuristics involves getting the problem solver to approach a problem from a different perspective.

Working Backward Some problems, such as the maze seen in Figure 7.17, may baffle us because they present so many possibilities we don't know where to start. A good way to attack this sort of

Watson and Crick used the analogy of a spiral staircase to help them understand the structure of the DNA molecule and crack the genetic code.

puzzle is by beginning at the end and *working backward.* (Who says that we must always begin at the beginning?) This strategy can eliminate many of the false starts and dead ends that we would otherwise stumble into by trial and error.

In general, working backward is an excellent strategy for problems in which the end-state or goal is clearly specified, such as mazes or certain math problems. This approach can be especially valuable when the initial conditions are vague.

Searching for Analogies If a new problem is similar to another you have faced before, you may be able to employ a strategy that you learned previously. For example, if you are an experienced cold-weather driver, you use this strategy to decide whether to install tire chains on a snowy day: "Is the snow as deep as it was the last time I needed chains?" The trick is to recognize the similarity, or *analogy,* between the new problem and the old one—a skill that takes practice (Medin & Ross, 1992).

Breaking a Big Problem into Smaller Problems Are you facing a huge problem, such as an extensive term paper? The best strategy may be to break the big problem down into smaller, more manageable steps, often called *subgoals.* In writing a paper, for example, you might break the problem into the steps of selecting a topic, doing your library research, outlining the paper, writing the first draft, and revising the paper. In this way, you will begin to organize the work and develop a plan for attacking each part of the problem. And tackling a problem in a step-by-step fashion makes big problems seem more manageable. Any large, complex problem—from writing a paper to designing an airplane—may benefit from this approach. In fact, the Wright Brothers deliberately used this heuristic to break down their problem of powered human flight into its components. By using a series of kites, gliders, and models, they studied the component problems of lift, stability, power, and directional control. Later they put their discoveries together to solve the larger problem of powered human flight (Bradshaw, 1992).

Obstacles to Problem Solving Having a good repertoire of strategies is essential to successful problem solving, but people may also get stuck because they latch onto an ineffective strategy. For this reason, problem solvers must learn to recognize when they have encountered an obstacle that demands a new approach. In fact, becoming a successful problem solver has as much to do with recognizing such obstacles as it does with selecting the right algorithm or heuristic. Here are some of the most troublesome of the obstacles problem solvers face.

Mental Set Sometimes you may persist with a less-than-ideal strategy simply because it has worked on other problems in the past. In psychological terms, you have an inappropriate **mental set—**the tendency to respond to a new problem in the same way you approached a similar problem previously. You have "set" your mind on a single strategy, but this time you've chosen the wrong analogy or algorithm. Let's illustrate this with the following puzzle.

Each of the groups of letters in the columns below is a common, but scrambled, word. See if you can unscramble them:

nelin	frsca	raspe	tnsai
ensce	peshe	klsta	epslo
sdlen	nitra	nolem	naoce
lecam	macre	dlsco	tesle
slfal	elwha	hsfle	maste
dlchi	ytpar	naorg	egran
neque	htmou	egsta	eltab

(adapted from Leeper & Madison, 1959)

Check your answers against the key in Figure 7.18.

Most people, whether they realize it or not, eventually solve the scrambled word problem with an algorithm by rearranging the order of the letters in all the words in the same way, using the formula 3-4-5-2-1. Thus,

n e l i n	becomes	l i n e n
12345		34521

■ **Mental set** The tendency to respond to a new problem in the manner used for a previous problem.

■ **Functional fixedness** The inability to perceive a new use for an object associated with a different purpose; a form of mental set.

linen	scarf	pears	stain
scene	sheep	talks	poles
lends	train	melon	canoe
camel	cream	colds	steel
falls	whale	shelf	meats
child	party	groan	anger
queen	mouth	gates	bleat

● **FIGURE 7.18** Unscrambled Words

The words you found to solve the scrambled word problem may not jibe with the ones listed here—especially in the third and fourth columns. Most people, whether they are aware of it or not, develop an algorithm as they work on the first two columns. While the formula will work on all the words, it interferes with the problem solver's ability to see alternative solutions for the words in the last two columns.

Notice, however, that when you use that algorithm, your answers for the last two columns won't agree with the "correct" ones given in Figure 7.18. The mental set that you developed while working on the first two columns prevented you from seeing that there is more than one answer for the last 14 items. The lesson of this demonstration is that a mental set can make you approach new problems in old but restricted ways. While a mental set often does produce results, you should occasionally stop to ask yourself whether you have slipped into a rut that prevents your seeing another answer. (Now can you find some other possible answers to the scrambled words in the last two columns?)

Functional Fixedness A special sort of mental set occurs when you think you need a screwdriver, but you don't realize that you could tighten the bolt with a dime. Psychologists call this **functional fixedness.** Under this condition, the function of a familiar object becomes so set, or fixed, in your mind that you cannot see a new function for it. To illustrate, consider this classic problem:

> Your psychology professor has offered you $5 if you can tie together two strings dangling from the

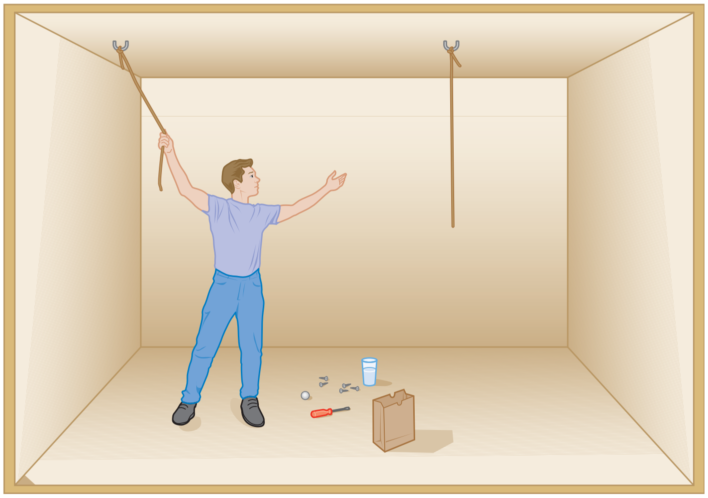
ceiling (see Figure 7.19) without pulling them down. But when you grab the end of one string and pull it toward the other one, you find that you cannot quite reach the other string. The only objects available to you in the room are on the floor in the corner: a Ping-Pong ball, five screws, a screwdriver, a glass of water, and a paper bag. How can you reach both strings at once and tie them together?

Read the following if you want a hint: In this problem you may have had functional fixedness with regard to the screwdriver. Did you realize that you could use the screwdriver as a pendulum weight to swing one of the strings toward you?

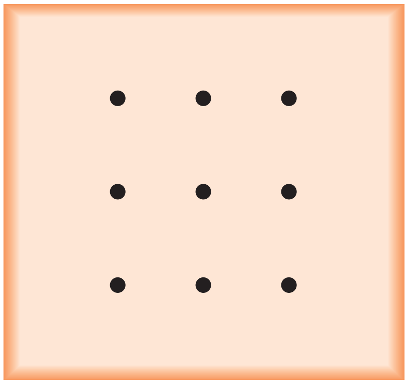
Self-Imposed Limitations We can be our own worst enemies when we impose unnecessary limitations on ourselves. The classic nine-dot problem in Figure 7.20 illustrates this neatly. To solve this one, you must connect all nine dots with no more than four connecting straight lines—that is, drawn without lifting your pencil from the paper. The instructions allow you to cross a line, but you may not retrace a line.

Most people who confront this problem impose an unnecessary restriction on themselves by assuming that they cannot draw lines beyond the square made by the dots. Literally, they don't "think outside the box." Figure 7.21 gives two possible correct answers. Translating this into personal terms, we can find many instances in which people impose unnecessary restrictions on themselves. Students may assume that they have no talent for math or science—thereby eliminating the possibility of a technical career. Or, because of gender stereotypes, a man may never consider that he could be a nurse or a grade school teacher, and a woman may assume that she must be a secretary, rather than an administrator. What real-life problems are you working on in which you have imposed unnecessary limitations on yourself?

Other Obstacles There are many other obstacles to problem solving that we will simply mention, rather than discuss in detail. These include lack of specific knowledge required by the problem, lack of interest, low self-esteem,



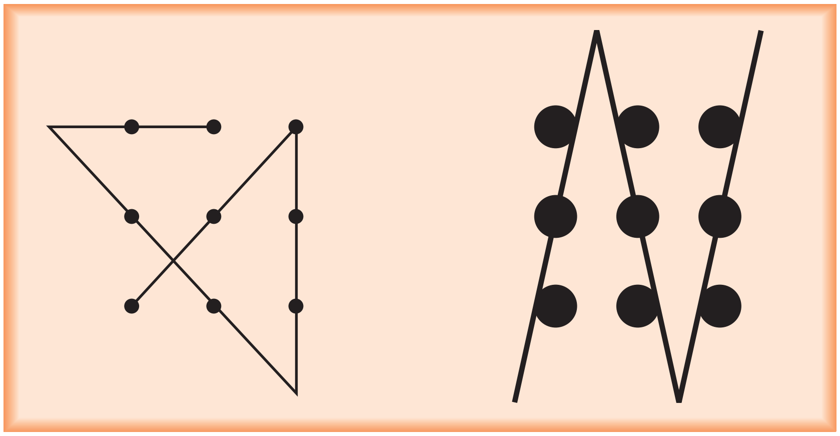
● **FIGURE 7.19** The Two-String Problem
How could you tie the two strings together, using only the objects found in the room?



● **FIGURE 7.20** The Nine-Dot Problem
Can you connect all nine dots with four connecting straight lines without lifting your pencil from the paper? (*Source:* Adapted from "Can You Solve It?" in HOW TO SOLVE MATHEMATICAL PROBLEMS: Elements of a Theory of Problems and Problem Solving by Wayne A. Wickelgren. Copyright © 1974 by W. H. Freeman and Company. Reprinted by permission of Dover Publications and the author.)

● **FIGURE 7.21** Two Solutions to the Nine-Dot Problem

(*Source:* From HOW TO SOLVE MATHEMATICAL PROBLEMS: Elements of a Theory of Problems and Problem Solving by Wayne A. Wickelgren. Copyright © 1974 by W. H. Freeman and Company. Reprinted by permission of Dover Publications and the author.)



fatigue, and drugs (even legal drugs, such as cold medicines or sleeping pills). Arousal and the accompanying stress represent another important stumbling block for would-be problem solvers. When you study emotion and motivation in the next chapter, you will see that there is an optimum arousal level for any task, be it basketball, brain surgery, or making a presentation in class. Beyond that critical point, further arousal causes performance to deteriorate. Thus, moderate levels of arousal actually facilitate problem solving, but high stress levels can make problem solving impossible.

In general, our discussion of problem solving shows that we humans are thinkers who readily jump to conclusions, based on our knowledge and biased by our motives, emotions, and perceptions. In view of this, it is surprising that our thinking so often serves us well in day-to-day life. Yet, from another perspective, it makes perfect sense: Most of our problem-solving efforts involve drawing on past experience to make predictions about future rewards and punishments. If you think about this for a moment, you will realize that this is exactly what operant conditioning is all about—which suggests that this mode of thinking is a fundamental part of our nature. Many of the "flaws" in our reasoning abilities, such as functional fixedness, are actually part of an adaptive (but necessarily imperfect) strategy that helps us use our previous experience to solve new problems.

CONNECTION: CHAPTER 6

Operant conditioning involves the control of behavior by rewards and punishments.

Judging and Making Decisions

Whether you are a student, a professor, or a corporate president, you will make decisions every day. "How much should I invest?" "What grade does this paper deserve?" "How much time do I need to study tonight?" You can think of each decision as the solution to a problem—a problem for which there may not be a clearly right answer, but a problem requiring judgment. Unfortunately, especially for those who have not studied the psychology of decision making, judgment can be clouded by biases—which are really just faulty heuristics. Let's examine the most common of these causes of poor judgment.

The Confirmation Bias Suppose that Fred has strong feelings about raising children: "Spare the rod and spoil the child," he says. How do you suppose Fred will deal with the news that punishment can actually encourage aggressive behavior? Chances are that he will be swayed by the *confirmation bias* to ignore or find fault with information that doesn't fit with his opinions and to seek information with which he agrees. He will probably give you examples of spoiled children who didn't get much punishment for their transgressions or

CONNECTION: CHAPTER 1

The *confirmation bias* makes us pay attention to events that confirm our beliefs and ignore evidence that contradicts them.

upstanding adults, like himself, who owe their fine character to harsh discipline. A great deal of evidence shows that the confirmation bias is a powerful and all-too-human tendency (Aronson, 2004; Nickerson, 1998). In fact, we all act like Fred sometimes, especially on issues on which we hold strong opinions.

The Hindsight Bias A friend tells you that she lost money investing in "dot-com" stocks. "I thought the Internet was the wave of the future," she says. "I knew the boom in Internet stocks would turn into a bust," you reply. You are guilty of the **hindsight bias,** sometimes called the "I-knew-it-all-along effect" (Fischhoff, 1975; Hawkins & Hastie, 1990). Just as guilty of hindsight bias are the Monday morning quarterbacks who know what play should have been called at the crucial point in yesterday's big game. This form of distorted thinking appears after an event has occurred and people overestimate their ability to have predicted it. Hindsight bias can flaw the judgment of jurors, historians, newscasters, and anyone else who second-guesses other people's judgments after all the facts are in.

The Anchoring Bias Ask a few of your friends, one at a time, to give a quick, off-the-top-of-the-head guess at the answer to the following simple math problem:

$$1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8 = ?$$

Make them give you an estimate without actually doing the calculation; give them only about five seconds to think about it. Then pose the problem in reverse to some other friends:

$$8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 = ?$$

Are the results different for the two groups?

Nobody will give precisely the right answer, of course, but it's likely that your friends will respond as volunteers did in Amos Tversky and Daniel Kahneman's experiment (Kahneman & Tversky, 2000; Tversky & Kahneman, 1973, 1974). (See also Jacowitz & Kahneman, 1995.) It turns out that the answers to such questions, where people usually don't have a good "ballpark" answer, depend on whether the problem begins with larger or smaller numbers. Those who saw the first problem gave a lower estimate than did those who were given the second problem. In Tversky and Kahneman's study, the average answer for the first group was 512, while the average for the second group was 2250. Apparently, their "first impression"—larger or smaller numbers at the beginning of the problem—biased their responses.

Tversky and Kahneman have explained the difference between the two groups on the basis of an **anchoring bias.** That is, people apparently use this flawed heuristic to "anchor" their thinking to the higher or lower numbers that appear at the beginning of the problem. The anchoring bias can also influence what we decide to pay for a car or a house, depending on the price of the first one we are shown.

The Representativeness Bias If you assume that blondes are mentally challenged or ministers are prudish or math professors are nerdish, you not only have some prejudices but your judgment has been clouded by **representativeness bias.** One reason why people succumb to such prejudices is that the representativeness bias simplifies the task of social judgment. Once something is "categorized," it shares all the features of other members in that category. The fallacy in this heuristic, of course, is that people, events, and objects do not "belong" to categories simply because we find it mentally convenient to

■ **Hindsight bias** The tendency, after learning about an event, to "second guess" or believe that one could have predicted the event in advance.

■ **Anchoring bias** A faulty heuristic caused by basing (anchoring) an estimate on a completely unrelated quantity.

■ **Representativeness bias** A faulty heuristic strategy based on the presumption that once people or events are categorized, they share all the features of other members in that category.

give them labels. By relying on category memberships to organize our experiences, we risk ignoring or underestimating the tremendous diversity of individual cases and complexity of people.

When estimating the likelihood that a specific individual belongs to a certain category—"vegetarian," for example—we look to see whether the person possesses the features found in a typical category member. For example, is your new acquaintance, Holly, a vegetarian? Does she resemble your prototype of a "typical" vegetarian? Perhaps you believe that most vegetarians wear sandals, ride bicycles, and support liberal social causes. If so, you might judge that Holly represents enough of the characteristics of your concept of "vegetarians" to belong to the same group.

But such an analysis is not entirely reasonable. Although some—perhaps many—vegetarians wear sandals, ride bicycles, and hold liberal views, the opposite may not be true: Because vegetarians are a minority group in the general population, it is unlikely that any particular individual who supports liberal social causes, wears sandals, and rides a bicycle is also vegetarian. That is, by ignoring the base rate information—the probability of a characteristic occurring in the general population—you have drawn an erroneous conclusion. Holly may in fact be an omnivore like most of your acquaintances, although if you invite her to dinner she will probably accept the cheese pizza and salad you offer her without complaint. While your representativeness bias—judging Holly by what seems to be her "type"—may not be especially important in this case, the same error underlies the more serious prejudices that result when people classify others solely on the basis of group membership.

The Availability Bias Yet another faulty heuristic comes from our tendency to judge probabilities of events by how readily examples come to mind. Psychologists call this the **availability bias.** We can illustrate this by asking you: Do more English words begin with *r* than have *r* in the third position? Most people think so because it is easier to think of words that begin with *r.* That is, words beginning with *r* are more available to us from long-term memory. Similarly, through observational learning, people who watch a lot of violent crime on television have violent images readily *available* in their memories. As a result, such people usually judge their chances of being murdered or mugged as being much higher than do people who watch little television (Singer et al., 1984).

PSYCHOLOGY IN YOUR LIFE: ON BECOMING A CREATIVE GENIUS

Everyone would agree that Einstein was a creative genius. So were Aristotle and Bach. And we can make a case that Brin and Page, the Google guys, are geniuses, too. But what about your Aunt Mabel who does watercolors? Such questions illustrate the big problem in creativity research: The experts cannot agree on an exact definition of creativity. Most, however, would go along with the slightly fuzzy notion that **creativity** is a process that produces novel responses that contribute to the solutions of problems. Most would also agree that a "genius" is someone whose insight and creativity are so great that they set that individual apart from ordinary folk. As with the idea of creativity, the boundary for genius is not well defined.

Let's follow the lead of psychologist Robert Weisberg, who offers a view of "genius" that goes against the commonly held assumption that geniuses are completely different from the rest of us. In brief, he argues that geniuses are merely good problem solvers who also possess certain helpful—but entirely human—characteristics.

■ **Availability bias** A faulty heuristic strategy that estimates probabilities based on information that can be recalled (made available) from personal experience.

■ **Creativity** A mental process that produces novel responses that contribute to the solutions of problems.

Creative Genius as Not So Superhuman Here's how Weisberg (1986) characterizes most people's assumptions about the quality we call "genius":

> Our society holds a very romantic view about the origins of creative achievements. . . . This is the genius view, and at its core is the belief that creative achievements come about through great leaps of imagination which occur because creative individuals are capable of extraordinary thought processes. In addition to their intellectual capacities, creative individuals are assumed to possess extraordinary personality characteristics which also play a role in bringing about creative leaps. These intellectual and personality characteristics are what is called "genius," and they are brought forth as the explanation for great creative achievements. (p. 1)

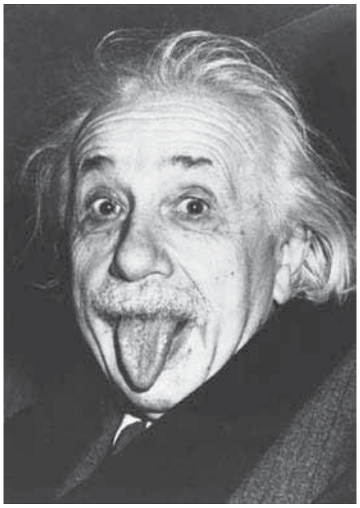
But, according to Weisberg and some other scholars in this area (Bink & Marsh, 2000), there is surprisingly little evidence supporting this view. In fact, the notion that creative geniuses are a breed apart may actually discourage creativity by making people feel that it is out of their reach. A more productive portrait, suggests Weisberg, views the thinking of people we call geniuses to be "ordinary thought processes in ordinary individuals" (p. 11). What produces extraordinary creativity, he says, is extensive knowledge, high motivation, and certain personality characteristics—not superhuman talents.

Everyone agrees with Weisberg on one point: The most highly creative individuals have a highly developed understanding of the basic knowledge in their fields (Gardner, 1993; Klahr & Simon; Who Wants to Be a Genius?, 2001). In fact, you cannot become highly creative without first becoming an *expert:* having extensive and organized knowledge of the field in which you will make your creative contribution. But such mastery is not easily achieved, because it requires a high level of motivation that can sustain the individual through years of intense training and practice. Studies indicate that about 10 years of work are required to master the knowledge and skills required for full competence in virtually any field, be it skiing, sculpture, singing, or psychology (Ericsson et al., 1993; Sternberg & Lubart, 1991, 1992). Further, such factors as time pressures and a hypercritical supervisor, teacher, or parent can suppress the creative flow (Amabile et al., 2002).

Aptitudes, Personality Characteristics, and Creativity In opposition to Weisberg, psychologist Howard Gardner (1993) argues that the extraordinary creativity that we see in the work of Freud, Einstein, Picasso, and others is a combination of several factors that include not only expertise and motivation but certain patterns of abilities and personality characteristics. Highly creative individuals, he says, have **aptitudes**—largely innate potentialities—specific to certain domains. (These potentialities, of course, must be developed by intensive study and practice.) Freud, for example, had a special facility for creating with words and understanding people; Einstein was remarkably good at logic and spatial relationships; and Picasso's creativity arose from a combination of aptitudes comprising spatial relationships and interpersonal perceptiveness.

But at the same time, creative people usually possess a certain cluster of personality traits. The literature emphasizes the following ones (Barron & Harrington, 1981; Csikszentmihalyi, 1996):

- *Independence:* Highly creative people have the ability to resist social pressures to conform to conventional ways of thinking, at least in their area of creative interest (Amabile, 1983, 1987). That is, they have the confidence to



There was no question but that Albert Einstein was bright. He also had an independent streak, a sense of humor, an intense interest in the complex problem of gravity, and a willingness to restructure the problem. He also sought the stimulation of other physicists. But he probably did not use thought processes that were altogether different from those used by other thinkers.

Aptitudes Innate potentialities (as contrasted with abilities acquired by learning).

strike out on their own. Because of this, perhaps, many creative people describe themselves as loners.

- *Intense interest in a problem:* Highly creative individuals also must have an all-consuming interest in the subject matter with which they will be creative (Amabile, 2001). They are always tinkering, in their minds, with problems that fascinate them (Weisberg, 1986). External motivators, such as money or a Nobel Prize, may add to their motivation, but the main motivators are internal, otherwise they could not sustain the long-term interest in a problem necessary for an original contribution.
- *Willingness to restructure the problem:* Highly creative people not only grapple with problems, but they often question the way a problem is presented. (Recall our earlier discussion about identifying the problem.) For example, students from the School of the Art Institute of Chicago who later became the most successful creative artists among their class members had one striking characteristic in common: They were always changing and redefining the assignments given by their instructors (Getzels and Csikszentmihalyi, 1976).
- *Preference for complexity:* Creative people seem drawn to complexity—to what may appear messy or chaotic to others. Moreover, they revel in the challenge of looking for simplicity in complexity. Thus highly creative people may be attracted to the largest, most difficult, and most complex problems in their fields (Sternberg & Lubart, 1992).
- *A need for stimulating interaction:* Creativity of the highest order almost always grows out of an interaction of highly creative individuals. Early in their careers, creative people usually find a mentor—a teacher who brings them up to speed in their chosen field. Highly creative individuals then go on to surpass their mentors and then find additional stimulation from the ideas of others like themselves. Often, this means leaving behind family and former friends (Gardner, 1993).

What, then, is the take-home message for our understanding of creativity? Those who have looked closely at this domain agree on two main points. First, creativity requires well-developed knowledge of the field in which the creative contribution will be made. Second, high-level creativity requires certain personal characteristics, such as independence and the motivation required to sustain an interest in an unsolved problem over a very long period of time. That is your formula for becoming a creative genius.

Oh . . . and what about intelligence: Is a high IQ necessary for creativity or genius? The answer to that question is a bit complicated. Low intelligence inhibits creativity—although we will see that there are some special cases, known as *savants,* who may have a highly developed skill despite their mental handicaps. On the other end of the IQ spectrum, we find that having high intelligence does not necessarily mean that the individual will be creative: There are lots of very bright people who never produce anything that could be called groundbreaking or highly original and insightful. In general, we can say that intelligence and creativity are distinct abilities (Barron & Harrington, 1981; Kershner & Ledger, 1985). We can find plodding, unimaginative persons at all IQ levels, and we can find highly creative persons with only average IQ scores. To understand the reasons why creativity and intelligence are different, it will be helpful to know what intelligence is and how it is measured.

CHECK YOUR UNDERSTANDING

1. **RECALL:** What is the first step in problem solving?
   - **a.** selecting a strategy
   - **b.** avoiding pitfalls
   - **c.** searching for analogies
   - **d.** identifying the problem
   - **e.** developing algorithms

2. **APPLICATION:** A math problem calls for finding the area of a triangle. You know the formula, so you multiply $^{1}/_{2}$ the base times the height. You have used
   - **a.** an algorithm.
   - **b.** a heuristic.
   - **c.** functional fixedness.
   - **d.** intuition.
   - **e.** an analogy.

3. **RECALL:** Good problem solvers often use "tricks of the trade" or "rules of thumb" known as
   - **a.** algorithms.
   - **b.** heuristics.
   - **c.** trial and error.
   - **d.** deductive reasoning.
   - **e.** scripts.

4. **APPLICATION:** Which one of the following would be an example of confirmation bias at work?
   - **a.** Mary ignores negative information about her favorite political candidate.
   - **b.** Aaron agrees with Joel's taste in music.
   - **c.** Natasha refuses to eat a food she dislikes.
   - **d.** Bill buys a new RV, even though his wife was opposed to the purchase.
   - **e.** Frank buys a lottery ticket because he read about a lotto winner.

5. **RECALL:** Which of the following is *not* a characteristic that is consistently found among highly creative people?
   - **a.** independence
   - **b.** a high level of motivation
   - **c.** willingness to restructure the problem
   - **d.** extremely high intelligence
   - **e.** open-mindedness

6. **UNDERSTANDING THE CORE CONCEPT:** Heuristic strategies show that our thinking is often based on
   - **a.** logic rather than emotion.
   - **b.** experience rather than logic.
   - **c.** trial and error rather than algorithms.
   - **d.** common sense rather than learning.
   - **e.** logic rather than creativity.

ANSWERS: 1. d 2. a 3. b 4. a 5. d 6. b

MEMORY: THE STATE OF THE ART

The three-stage model, with the modifications we have discussed, gives a good snapshot of memory taken from the information-processing perspective. It is widely accepted by cognitive psychologists but relatively unknown by the general public. What surprises and frightens the public most, however, are the distortions and errors that our memories are heir to. In fact, these "sins" of memory are among the hottest topics for research at the moment.

Two other topics can also be found at the cutting edge of current memory research. One involves the apparently vast and poorly explored domain of implicit memory. What, cognitive psychologists wonder, does memory do while it is "off line"? The other hot topic centers on the biological basis of memory, especially the changes that take place as our synapses lay down long-term memories. And, once the biology of memory becomes clearer, the ultimate goal of memory researchers will come into view: making a connection between the biology and all the quirks of memory we have studied in this chapter.

USING PSYCHOLOGY TO LEARN PSYCHOLOGY

How to Avoid Memory Failure on Exams

Mnemonic strategies designed for 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." 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 meaningful to you.* Many studies have shown that memories will remain stronger if the information is approached in a way that makes it meaningful, rather than as just a collection of facts and definitions (Baddeley, 1998; Haberlandt, 1999; Terry, 2000). One strategy for doing this involves using the **whole method,** a technique often used by actors who must learn a whole 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. 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 are resistant to transience involves **distributed learning** (Baddeley, 1998; Terry, 2000). In less technical terms, the research suggests that you should study your psychology frequently (distributed, or spaced, learning), rather than trying to learn it all at once in a single "cram" session ("massed" learning). This approach avoids the lowered efficiency of learning brought about by fatigue and seems to strengthen 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).

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 four ideas you have learned in this chapter: *interference theory, repetition, elaborative rehearsal,* and *encoding specificity:*

- *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.
- *Rehearse and relearn what you have already learned.* Students often think that, just because they have read and understood the material, they will remember it. With complex concepts and ideas, you will probably need to use *repetition* in a form called **overlearning.** With this method, you continue to review the material, even after you think you understand it. Overlearning not only boosts the strength of a memory but also gives you repeated opportunities to link it with other ideas in LTM (which is our next point).
- *Elaborate on the material by thinking of examples and other associations.* One of the best ways of doing *elaborative rehearsal* when studying for a test is to

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.

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

Overlearning A strategy whereby the learner continues to study and rehearse the material after it has been initially brought to mastery.

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 in which the material can be accessed when you need it.

- *Test yourself with retrieval cues you expect to see on the examination.* Finally, 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 also recommend that you get together for this purpose a day or two before the test, 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 up and answer as many questions as you can 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 "Chapter Review" tests, as well as 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.

CHAPTER SUMMARY

KEY QUESTION ?

CORE CONCEPT

WHAT IS MEMORY?

Any memory system involves three important processes: encoding, storage, and retrieval. Eidetic imagery is a rare and poorly understood form of memory that produces especially vivid and persistent memories that may interfere with thought.

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

HOW DO WE FORM MEMORIES?

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 retrieved for later use.

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

Working memory draws information from sensory memory and long-term memory and processes it consciously. It has at least three components: a central executive, a phonological loop, and a sketch pad. We can cope with its limited duration and capacity by chunking, rehearsal, and acoustic encoding.

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.

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

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.

HOW DO WE RETRIEVE MEMORIES?

H.M.'s case demonstrates that information can be stored as explicit or implicit memories. Implicit memories can be cued by priming. Explicit memories can be cued by recall or recognition tasks. The accuracy of memory retrieval depends on several factors, including specificity and mood.

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

WHY DOES MEMORY SOMETIMES FAIL US?

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 form of blocking called interference. The final "sin" occurs when unwanted memories persist in memory, even though we would like to forget them.

Some causes of forgetting can be overcome by mnemonic strategies such as the method of loci, natural language mediators, and other associative methods.

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

HOW DO CHILDREN ACQUIRE LANGUAGE?

Young children are biologically equipped to learn language and motivated to communicate. Many experts believe that children have "language acquisition devices" hard-wired into their brains. Psychologists find that language development proceeds in a predictable sequence, involving the babbling stage, the one- and two-word stages, and telegraphic speech, as children acquire vocabulary at an almost unbelievable rate. Grammar appears when the child begins to put words together.

Infants and children face an especially important task in the area of language acquisition.

WHAT ARE THE COMPONENTS OF THOUGHT?

Cognitive scientists often use the computer metaphor to conceive of the brain as an information-processing organ. Natural concepts and artificial concepts are building blocks of thinking; they are formed by identifying properties that are common to a class of objects or ideas. Concepts are often arranged in hierarchies ranging from general to specific. Other mental structures that guide thinking include schemas, scripts, and visual imagery such as mental maps.

Thinking is a cognitive process in which the brain uses information from the senses, emotions, and memory to create and manipulate mental representations, such as concepts, images, schemas, and scripts.

WHAT ABILITIES DO GOOD THINKERS POSSESS?

Two of the most crucial thinking skills involve identifying the problem and selecting a problem-solving strategy. Useful strategies include algorithms, which produce a single correct answer, and heuristics, or "rules of thumb." Among the most useful heuristics are working backward, searching for analogies, and breaking a bigger problem into smaller ones. Common obstacles to problem solving include mental set, functional fixedness, and self-imposed limitations. Moreover, judging and decision making can be flawed by biases and faulty heuristics. These include confirmation bias, hindsight bias, anchoring bias, representativeness bias, and availability bias (heuristic). Those who are often called creative geniuses are highly motivated experts who often have a certain cluster of traits, such as independence and a need for stimulating interaction. They appear, however, to use ordinary thinking processes, although the role of natural talent is the subject of dispute.

Good thinkers not only have a repertoire of effective strategies, called algorithms and heuristics, but also know how to avoid the common impediments to problem solving and decision making.

REVIEW TEST

For each of the following items, choose the single correct or best answer. The correct answers appear at the end.

1. Unlike a video recorder, human memory is
   a. accurate.
   b. digital.
   c. fast.
   d. reconstructive.
   e. temporary.
2. Which of the following is one of the three essential tasks of memory?
   a. accuracy
   b. consistency
   c. elaboration
   d. encoding
   e. misattribution
3. H. M.'s ________ memory was more profoundly affected by the surgery than his __________ memory.
   a. eidetic/sensory
   b. episodic/procedural
   c. implicit/explicit
   d. recognition/recall
   e. short-term/long-term
4. Elise used to live in a house with a large kitchen, where all the silverware was stored in a drawer to the right of the sink. Since she moved to her new apartment, she finds that she habitually looks for the silverware in a drawer to the right of the sink, although no such drawer exists. Her behavior reflects forgetting due to
   a. absence of retrieval cues.
   b. availability heuristic.
   c. proactive interference.
   d. repression.
   e. retroactive interference.
5. Studies of eyewitness testimony and recovery of "repressed" memories show that
   a. distorted memories are a sign of mental disorder.
   b. memories can be severely distorted, even when we have confidence in them.

c. memory is infallible.
d. our unconscious minds remember events as they actually happened.
e. the more confident we are of a memory, the more likely it is to be true.

6. Which of the following utterances illustrates overregularization in language development?
   a. "babababa."
   b. "Drink milk, all gone."
   c. "House."
   d. "Me gots two foots and two handses."
   e. "Want cookie."
7. Which of the following statements about thinking is true?
   a. It cannot be observed from observable behavior.
   b. It stores, but does not manipulate, knowledge.
   c. It transforms available information into new mental representations.
   d. All of the above.
   e. None of the above.
8. An alien being from another galaxy has landed on Earth and is overwhelmed by the sensory input it must process. Eventually the alien simplifies its thinking by categorizing sets of experiences and objects according to common features. In other words, the alien learns to form
   a. algorithms.
   b. concepts.
   c. heuristics.
   d. hypotheses.
   e. scripts.
9. A mental _________ outlines the proper sequence in which actions and reactions might be expected to happen in a given setting, such as when you visit a new grocery store.
   a. algorithm
   b. heuristic
   c. map
   d. prototype
   e. script
10. Because you watch a lot of violent videos, you think your chances of being mugged are quite high. Your judgment is flawed by
   a. anchoring bias.
   b. functional fixedness.
   c. hindsight bias.
   d. availability bias.
   e. stereotyping.

ANSWERS: 1. d 2. e 3. b 4. c 5. a 6. d 7. c 8. b 9. e 10. d

KEY TERMS

Memory (p. 235)
Information-processing model (p. 236)
Encoding (p. 236)
Storage (p. 237)
Retrieval (p. 237)
Eidetic imagery (p. 238)
Sensory memory (p. 239)
Working memory (p. 239)
Long-term memory (LTM) (p. 240)
Chunking (p. 244)
Maintenance rehearsal (p. 244)
Elaborative rehearsal (p. 245)
Acoustic encoding (p. 245)
Levels-of-processing theory (p. 245)
Procedural memory (p. 247)
Declarative memory (p. 247)
Episodic memory (p. 247)
Semantic memory (p. 248)
Engram (p. 248)
Anterograde amnesia (p. 248)
Consolidation (p. 249)
Retrograde amnesia (p. 250)
Flashbulb memory (p. 250)
Implicit memory (p. 252)
Explicit memory (p. 252)
Retrieval cues (p. 252)
Priming (p. 253)
Recall (p. 254)
Recognition (p. 254)
Encoding specificity principle (p. 254)
Mood-congruent memory (p. 255)
TOT phenomenon (p. 256)
Transcience (p. 257)
Forgetting curve (p. 259)
Absent-mindedness (p. 259)
Blocking (p. 259)
Proactive interference (p. 259)
Retroactive interference (p. 259)
Serial position effect (p. 259)
Misattribution (p. 260)
Suggestibility (p. 261)
Misinformation effect (p. 261)
Expectancy bias (p. 264)
Self-consistency bias (p. 264)
Persistence (p. 264)
Mnemonics (p. 265)
Method of loci (p. 265)
Natural language mediators (p. 265)
Language acquisition device (LAD) (p. 267)
Grammar (p. 269)
Morphemes (p. 269)
Overregularization (p. 269)
Computer metaphor (p. 270)
Concepts (p. 271)
Natural concepts (p. 272)
Prototype (p. 272)
Artificial concepts (p. 272)
Concept hierarchies (p. 272)
Event-related potentials (p. 276)
Schemas (p. 277)
Script (p. 277)
Algorithms (p. 280)
Heuristics (p. 280)
Mental set (p. 282)
Functional fixedness (p. 282)
Hindsight bias (p. 285)
Anchoring bias (p. 285)
Representativeness bias (p. 285)
Availability bias (p. 286)
Creativity (p. 286)
Aptitudes (p. 287)
Whole method (p. 290)
Distributed learning (p. 290)
Overlearning (p. 290)

AP* REVIEW: VOCABULARY

Match each of the following vocabulary terms to its definition.

1. Maintenance rehearsal
2. Elaborative rehearsal
3. Procedural memory
4. Episodic memory
5. Morpheme
6. Overregularization
7. Concepts
8. Prototype
9. Schema
10. Functional fixedness

_____ **a.** Meaningful units of language that make up words.

_____ **b.** A most representative example of a conceptual category.

_____ **c.** A working-memory process in which information is merely repeated to keep it from fading.

_____ **d.** Mental representations of categories of items or ideas.

_____ **e.** The inability to perceive a new use for an object.

_____ **f.** A knowledge cluster that provides expectations about topics, objects, people, and the like in one's life.

_____ **g.** A working-memory process in which information is actively related to information already in LTM.

_____ **h.** A subdivision of declarative memory that stores memory for personal events.

_____ **i.** A division of LTM that stores memories for how things are done.

_____ **j.** Applying a grammatical rule too widely.

AP* REVIEW: ESSAY

Use your knowledge of the chapter concepts to answer the following essay question.

Describe the information-processing model of memory, and provide a specific example of each of the following: sensory storage, short-term memory, and long-term memory.

OUR RECOMMENDED BOOKS AND VIDEOS

BOOKS

Gardner, H. (1999). *Intelligence reframed: Multiple intelligences for the 21st century.* New York: Basic Books. Psychologist Howard Gardner elaborates and suggests how to apply his theory that each of us possesses seven or more basic types of intelligence to varying degrees: the familiar linguistic and logical-mathematical types that are the focus of traditional education and testing, but also intelligences of music, movement, spatial awareness, and other abilities—including new discoveries such as naturalistic intelligence (awareness of the living environment).

Gould, S. J. (1981). *The mismeasure of man.* New York: Norton. Stephen Jay Gould's book is a classic indictment of flawed assessment and testing, especially when used to discriminate against or oppress social groups.

Kerr, P. (1992). *A philosophical investigation.* New York: Penguin. In the future world of this mystery novel, governments test all men for a sex-linked gene predicting whether one might become a serial killer—until one unidentified suspect uses his expertise in computers and philosophy to kill those who test positive.

Keyes, D. (1995). *Flowers for Algernon.* New York: Harcourt Brace. The reissued novelization of the classic 1960 science fiction story that inspired the 1968 Oscar-winning movie *Charly* and the 2000 TV movie *Flowers for Algernon.* A young retarded man undergoes experimental surgery to increase his intelligence—with astonishing and tragic results.

Perkins, D. (2000). *Archimedes' bathtub: The art and logic of breakthrough thinking.* New York: W. W. Norton. Ancient Greek philosopher Archimedes shouted "Eureka!" ("I have found it") when, lowering himself into a bath, he recognized the process of water displacement. This author explains practical and entertaining strategies for producing creative inspiration in our own lives.

Plous, S. (1993). *The psychology of judgment and decision making.* Philadelphia: Temple University Press. Psychologist Scott Plous argues that common sense is an unreliable guide in modern living, showing the silly choices we make and recommending how judgments can be more logical and successful.

VIDEOS

i am sam. (2001, color, 132 min.). Directed by Jessie Nelson; starring Sean Penn, Michelle Pfeiffer. A gentle retarded man, threatened by a social services agency with losing custody of his young daughter, is helped in his battle by a high-powered attorney whose own life is also troubled. (*Rating PG-13*)

Little Man Tate. (1991, color, 99 min.). Directed by Jodie Foster; starring Jodie Foster, Dianne Wiest, Adam Hann-Byrd, David Hyde Pierce, Harry Connick, Jr. A single, working-class mother must decide how best to bring up her young son, a child genius whose abilities challenge the good intentions and abilities of the adults who care about him. (*Rating PG*)

The Luzhin Defense. (2000, color, 112 min.). Directed by Marleen Gorris; starring John Turturro, Emily Watson. In the 1920s, a socially naive but intellectually brilliant Grand Master of chess, protected all his life by his manager, attends a world tournament where he meets the love of his life but finds he is emotionally unprepared to face the real world. (*Rating PG-13*)

Searching for Bobby Fischer. (1993, color, 110 min.). Directed by Steve Zaillian; starring Joe Mantegna, Max Pomeranc, Joan Allen, Ben Kingsley. In this absorbing drama based on true story, a father encourages his talented son to compete for a championship title, revealing the rewards and risks of child genius. (*Rating PG*)