5

CHAPTER FIVE

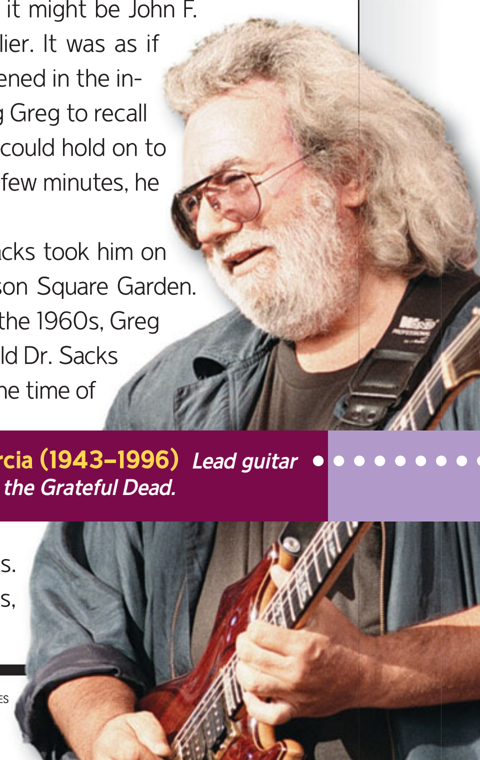
# Memory



**GREG WAS A TEENAGER WHEN THE TROUBLE BEGAN.** Restless and unfulfilled, he quit school, moved to New York City, and spent a few years getting high and listening to rock music. When that lifestyle didn't provide the meaning he sought, he joined the International Society for Krishna Consciousness and moved to their temple in New Orleans. At about that same time, Greg began having trouble with his vision. By the time he sought medical attention, he was completely blind. His doctors discovered a tumor the size of a small orange in Greg's brain, and although they were able to remove it, the damage had already been done. Greg lost his sight, but because the tumor had also destroyed a part of the temporal lobe that is crucial for forming and retaining memories of everyday experience, he lost much of his memory as well.

No longer able to live independently, Greg was admitted to a hospital for patients requiring long-term care. When the neurologist Oliver Sacks interviewed him, Greg had no idea why he was in the hospital but suspected that it might be due to his past drug abuse. Dr. Sacks noticed piles of rock albums in Greg's room and asked him about his interest in music, whereupon Greg launched into a version of his favorite Grateful Dead song, then shared a vivid memory of a time when he had heard the group perform in New York's Central Park. "When did you hear them in Central Park?" asked Dr. Sacks. "It's been a while, over a year maybe," Greg replied. In fact, the concert had taken place 8 years earlier (Sacks, 1995, p. 48). When asked to name the president of the United States (who at that time was Jimmy Carter), he guessed that it might be John F. Kennedy—who had been president over a decade earlier. It was as if Greg were unable to remember anything that had happened in the intervening years. Dr. Sacks conducted more tests, asking Greg to recall lists of words and simple stories. He noticed that Greg could hold on to the information for a few seconds but that within just a few minutes, he would forget nearly everything he had been told.

After Greg had spent 14 years in the hospital, Dr. Sacks took him on an outing, to a Grateful Dead reunion concert at Madison Square Garden. When the band performed their well-known songs from the 1960s, Greg sang along enthusiastically. "That was fantastic," Greg told Dr. Sacks as they left the concert. "I will always remember it. I had the time of my life." When Dr. Sacks saw Greg the next morning, he asked him about the Grateful Dead concert. "I love them. I heard them in Central Park," replied Greg. "Didn't you just hear them at Madison Square Garden?" asked Dr. Sacks. "No," replied Greg, "I've never been to the Garden" (Sacks, 1995, pp. 76–77). ■



**Jerry Garcia (1943–1996)** *Lead guitar player for the Grateful Dead.*

TIM MOSENFELDER/IMAGEDIRECT/GETTY IMAGES

**memory** The ability to store and retrieve information over time.

**encoding** The process by which we transform what we perceive, think, or feel into an enduring memory.

**storage** The process of maintaining information in memory over time.

**retrieval** The process of bringing to mind information that has been previously encoded and stored.

**Memory** is *the ability to store and retrieve information over time,* and as Greg's story suggests, it is more than just a handy device that allows us to find our car keys and schedule our dental appointments. In a very real way, our memories define us. Each of us has a unique identity that is intricately tied to the things we have thought, felt, done, and experienced. Memories are the residue of those events, the enduring changes that experience makes in our brains and leaves behind when it passes. If an experience passes without leaving a trace, it might just as well not have happened. For Greg, the last 20 years of his life have come and gone without a trace, leaving him forever frozen in 1969. He can revisit old memories, but he cannot make new ones, and so he himself can never change.

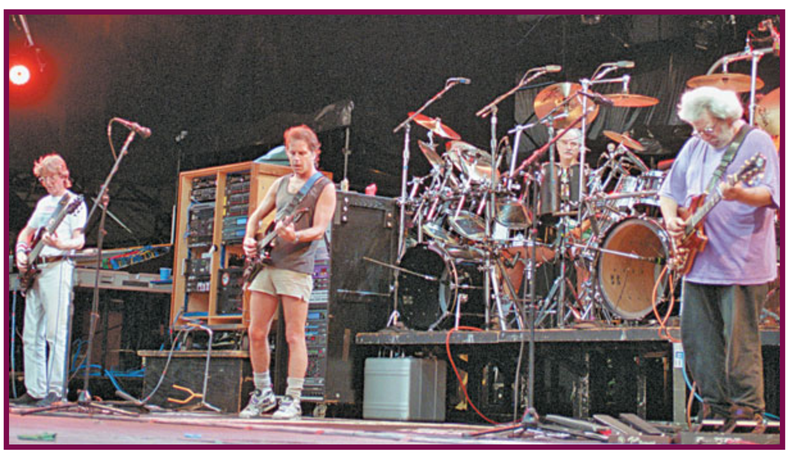
Those of us who *can* remember what we did yesterday often fail to appreciate just how complex that act of remembering really is because it occurs so easily. But just consider the role that memory plays in the simplest act, such as arranging to meet a friend at the movies. You must recall your friend's name and telephone number and how to make a call. You need to remember which movies are currently playing, as well as the types of movies that you and your friend enjoy. Eventually, you will need to remember how to get to the theater, how to drive your car, and what your friend looks like so you can recognize her among the people standing in front of the theater. And finally, you'll have to remember which movie you just saw so that you don't accidentally do this all this over again tomorrow. These are ordinary tasks, tasks so simple that you never give them a second thought. But the fact is that the most sophisticated computer could not even begin to accomplish them as efficiently as any average human.

Because memory is so remarkably complex, it is also remarkably fragile (Schacter, 1996). We all have had the experience of forgetting something we desperately wanted to remember or of remembering something that never really happened. Why does memory serve us so well in some situations and play such cruel tricks on us in other cases? When can we trust our memories and when should we view them skeptically? Is there just one kind of memory, or are there many? These are among the questions that psychologists have asked and answered.

As you've seen in other chapters, the mind's mistakes provide key insights into its fundamental operation, and there is no better illustration of these mind bugs than in the realm of memory. In this chapter, we shall consider the three key functions of memory: **encoding**, *the process by which we transform what we perceive, think, or feel into an enduring memory;* **storage**, *the process of maintaining information in memory over time;* and **retrieval**, *the process of bringing to mind information that has been previously encoded and stored.* We shall then examine several different kinds of memory and focus on the ways in which errors, distortions, and imperfections can reveal the nature of memory itself.

*Greg's brain damage interfered with his ability to form new memories, so he was able to remember the Grateful Dead only as they sounded and performed in the early 1970s, not as they appeared more recently.*


MONARCH FILMS/PHOTOFEST


MATTHEW MENDELSOHN/CORBIS

# Encoding: Transforming Perceptions into Memories

For at least 2,000 years, people have thought of memory as a recording device that makes exact copies of information that comes in through our senses, and then stores those copies for later use. This idea is simple and intuitive. It is also thoroughly and completely incorrect. Consider the case of Bubbles P., a professional gambler with no formal education, who spent most of his time shooting craps at local clubs or playing high-stakes poker. Most people can listen to a list of numbers and then repeat them from memory—as long as the list is no more than about seven items long (try it for yourself using **FIGURE 5.1**). But Bubbles had no difficulty rattling off 20 numbers, in either forward or backward order, after just a single glance (Ceci, DeSimone, & Johnson, 1992). You might conclude that Bubbles must have had a "photographic memory" that allowed him to make an instant copy of the information that he could "look at" later. In fact, that isn't at all how he did it.

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

**FIGURE 5.1** **Digit Memory Test** *How many digits can you remember? Start on the first row and cover the rows below it with a piece of paper. Study the numbers in the row for 1 second and then cover that row back up again. After a couple of seconds, try to repeat the numbers. Then uncover the row to see if you were correct. If so, continue down to the next row, using the same instructions, until you can't recall all the numbers in a row. The number of digits in the last row you can remember correctly is your digit span. Bubbles P. could remember 20 random numbers, or about 5 rows deep. How did you do?*

To understand how Bubbles accomplished his astounding feats of memory, we must abandon the notion that memories are copies of sensory experience. On the contrary, memories are made by combining information we *already* have in our brains with new information that comes in through our senses. In this way memory is much less like photography and much more like cooking. Like starting from a recipe but improvising along the way, we add old information to new information, mix, shake, bake, and out pops a memory. Memories are *constructed,* not recorded, and encoding is the process by which we transform what we perceive, think, or feel into an enduring memory. Let's look at three types of encoding processes: elaborative encoding, visual imagery encoding, and organizational encoding.

● How is making a memory unlike taking a photograph?

## Elaborative Encoding

Memories are a combination of old and new information, so the nature of any particular memory depends as much on the old information already in our memories as it does on the new information coming in through our senses. In other words, how we remember something depends on how we think about it at the time. In one study, researchers presented participants with a series of words and asked them to make one of three types of judgments (Craik & Tulving, 1975). *Semantic judgments* required the participants to think about the meaning of the words ("Is *hat* a type of clothing?"), *rhyme judgments* required the participants to think about the sound of the words ("Does *hat* rhyme with *cat*?"), and *visual judgments* required the participants to think about the appearance of the words ("Is *HAT* written uppercase or lowercase?"). The type of judgment task influenced how participants thought about each word—what old information they combined with the new—and thus had a powerful impact on their memories (**FIGURE 5.2** on the next page). Those participants who made semantic judgments (i.e., had thought about the meaning of the words) had much better memory for the words than did participants who had thought about how the word looked or sounded. The results of these and many other studies have shown that long-term retention is greatly enhanced by **elaborative encoding**, which involves *actively relating new information to knowledge that is already in memory* (Brown & Craik, 2000).

● How do old memories influence new memories?

**elaborative encoding** The process of actively relating new information to knowledge that is already in memory.

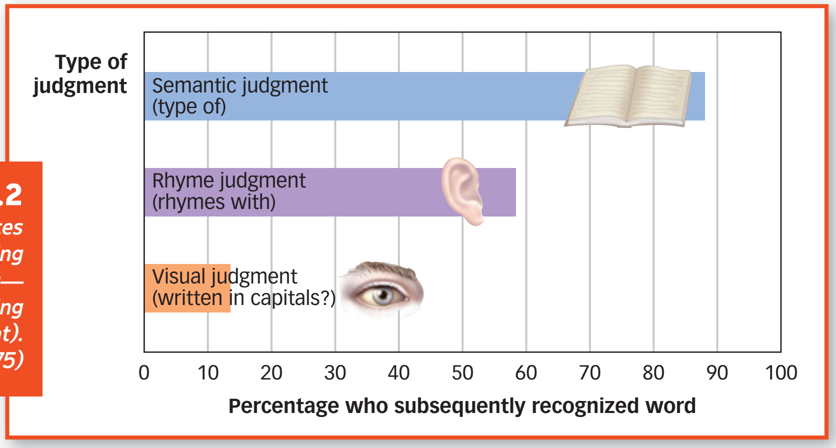
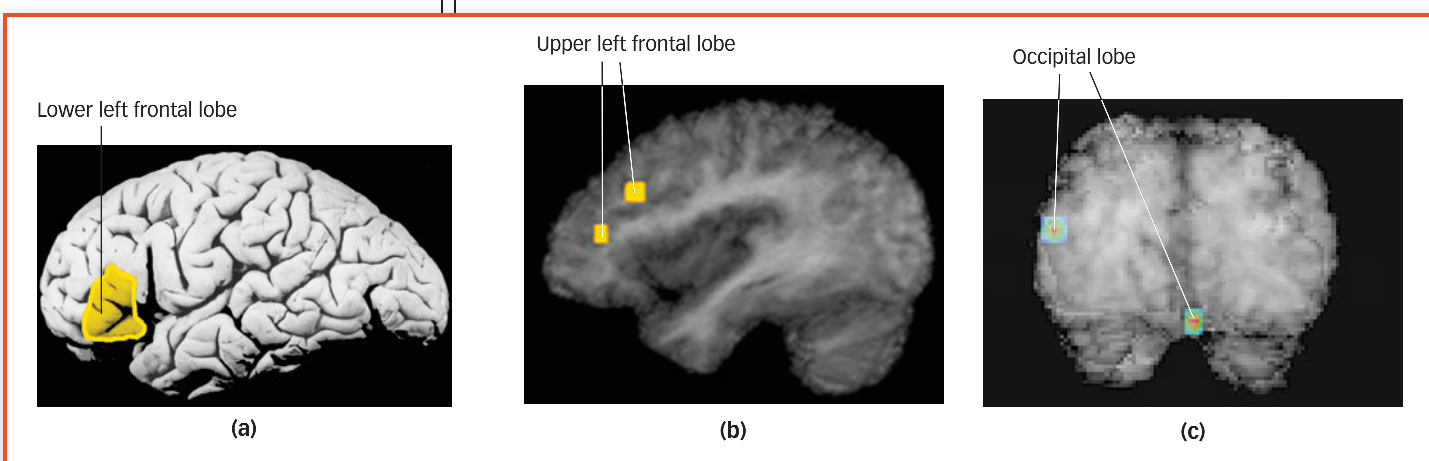



**FIGURE 5.2**
**Levels of Processing** *Elaborative encoding enhances subsequent retention. Thinking about a word's meaning (making a semantic judgment) results in deeper processing—and better memory for the word later—than merely attending to its sound (rhyme judgment) or shape (visual judgment). (From Craik & Tulving, 1975)*

These findings would not have surprised Bubbles P. As a professional gambler, Bubbles found numbers unusually meaningful, so when he saw a string of digits, he tended to think about their meanings. For example, he might have thought about how they related to his latest bet at the racetrack or to his winnings after a long night at the poker table. Whereas you might try to memorize the string 22061823 by saying it over and over, Bubbles would think about betting $220 at 6 to 1 odds on horse number 8 to place 2nd in the 3rd race. Indeed, when Bubbles was tested with materials other than numbers—faces, words, objects, or locations—his memory performance was no better than average. You may consciously use Bubbles's strategy when you study for exams ("Well, if Napoleon was born in 1769, that would have made him 7 years old when America declared independence"), but you also use it automatically every day. Have you ever wondered why you can remember 20 experiences (your last summer vacation, your 16th birthday party, your first day at college) but not 20 digits? The reason is that most of the time we think of the meaning behind our experiences, and so we elaboratively encode them without even trying to (Craik & Tulving, 1975). Bubbles's amazing memory for numbers was due to elaborative encoding and not to some mysterious kind of "photographic memory."

So where does this elaborative encoding take place? What's going on in the brain when this type of information processing occurs? Studies reveal that elaborative encoding is uniquely associated with increased activity in the lower left part of the frontal lobe and the inner part of the left temporal lobe (**FIGURE 5.3 a, b**) (Demb et al., 1995; Kapur et al., 1994; Wagner et al., 1998). In fact, the amount of activity in each of these two regions during encoding is directly related to whether people later remember an item. The more activity there is in these areas, the more likely the person will remember the information.

**FIGURE 5.3**
**Brain Activity during Different Types of Judgments** *fMRI studies reveal that different parts of the brain are active during different types of judgments: (a) During semantic judgments, the lower left frontal lobe is active; (b) during organizational judgments, the upper left frontal lobe is active; and (c) during visual judgments, the occipital lobe is active.*



## Visual Imagery Encoding

In Athens in 477 BC, the Greek poet Simonides had just left a banquet when the ceiling collapsed and killed all the people inside. Simonides was able to name every one of the dead simply by visualizing each chair around the banquet table and recalling the person who had been sitting there. Simonides wasn't the first, but he was among the most proficient, to use **visual imagery encoding**, *a form of categorization that involves storing new information by converting it into mental pictures.*

If you wanted to use Simonides' method to create an enduring memory, you could simply convert the information that you wanted to remember into a visual image and then "store it" in a familiar location. For instance, if you were going to the grocery store and wanted to remember to buy Coke, popcorn, and cheese dip, you could use the rooms in your house as locations and imagine your living room flooded in Coke, your bedroom pillows stuffed with popcorn, and your bathtub as a greasy pond of cheese dip. When you arrived at the store, you could then take a "mental walk" around your house and "look" into each room to remember the items you needed to purchase.

● **How does visual encoding influence memory?**

Numerous experiments have shown that visual imagery encoding can substantially improve memory. In one experiment, participants who studied lists of words by creating visual images of them later recalled twice as many items as participants who just mentally repeated the words (Schnorr & Atkinson, 1969). Why does visual imagery encoding work so well? First, visual imagery encoding does some of the same things that elaborative encoding does: When you create a visual image, you relate incoming information to knowledge already in memory. For example, a visual image of a parked car might help you create a link to your memory of your first kiss.

Second, when you use visual imagery to encode words and other verbal information, you end up with two different mental "placeholders" for the items—a visual one and a verbal one—which gives you more ways to remember them than just a verbal placeholder alone (Paivio, 1971, 1986). Visual imagery encoding activates visual processing regions in the occipital lobe (see FIGURE 5.3c), which suggests that people actually enlist the visual system when forming memories based on mental images (Kosslyn et al., 1993).

**visual imagery encoding** The process of storing new information by converting it into mental pictures.

**organizational encoding** The act of categorizing information by noticing the relationships among a series of items.

## Organizational Encoding

Have you ever ordered dinner with a group of friends and watched in amazement as your server took the order without writing anything down? To find out how this is done, one researcher spent 3 months working in a restaurant where waitresses routinely wrote down orders but then left the check at the customer's table before proceeding to the kitchen and *telling* the cooks what to make (Stevens, 1988). The researcher wired each waitress with a microphone and asked her to think aloud—that is, to say what she was thinking as she walked around all day doing her job. The researcher found that as soon as the waitress left a customer's table, she immediately began *grouping* or *categorizing* the orders into hot drinks, cold drinks, hot foods, and cold foods. The waitresses grouped the items into a sequence that matched the layout of the kitchen, first placing drink orders, then hot food orders, and finally cold food orders. The waitresses remembered their orders by relying on **organizational encoding**, *a form of categorization that involves noticing the relationships among a series of items.*

*Ever wonder how a server remembers who ordered the pizza and who ordered the fries without writing anything down? Some have figured out to use organizational encoding.*

JEFF GREENBERG/ALAMY

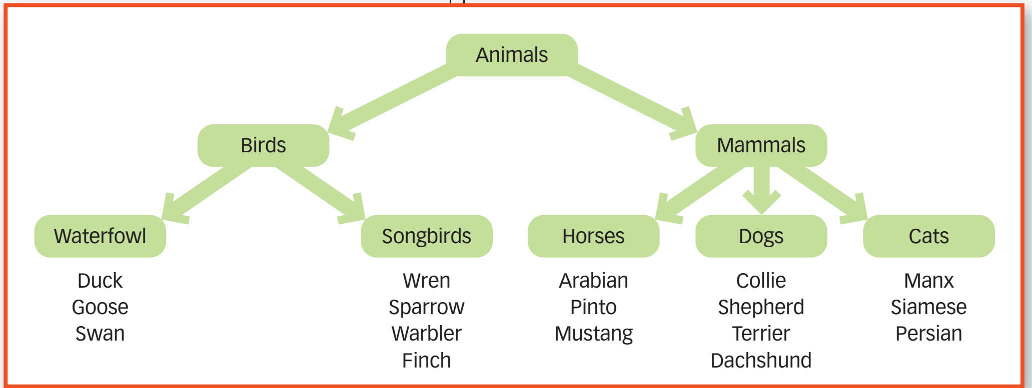



**FIGURE 5.4**
**Organizing Words into a Hierarchy**
*Organizing words into conceptual groups and relating them to one another—such as in this example of a hierarchy—makes it easier to reconstruct the items from memory later (Bower et al., 1969). Keeping track of the 17 items in this example can be facilitated by remembering the hierarchical groupings they fall under.*

For example, suppose you had to memorize the words *peach, cow, chair, apple, table, cherry, lion, couch, horse,* and *desk*. The task seems difficult, but if you organized the items into three categories—fruit (*peach, apple, cherry*), animals (*cow, lion, horse*), and furniture (*chair, couch, desk*)—the task becomes much easier. Studies have shown that instructing people to sort items into categories like this is an effective way to enhance their subsequent recall of those items (Mandler, 1967). Even more complex organizational schemes have been used, such as the hierarchy in **FIGURE 5.4** (Bower et al., 1969). People can improve their recall of individual items by organizing them into multiple-level categories, all the way from a general category such as *animals,* through intermediate categories such as *birds* and *songbirds,* down to specific examples such as *wren* and *sparrow*.

**Why might mentally organizing the material for an exam enhance your retrieval of that material?**

Just as elaborative and visual imagery encoding activate distinct regions of the brain, so too does organizational encoding. As you can see in Figure 5.3b, organizational encoding activates the upper surface of the left frontal lobe (Fletcher, Shallice, & Dolan, 1998; Savage et al., 2001). Different types of encoding strategies appear to rely on different areas of brain activation.

## summary quiz [5.1]

**1.** The process of transforming information into a lasting memory is called
- a. rehearsal.
- b. sensory storage.
- c. encoding.
- d. chunking.

**2.** The process of actively relating new information to knowledge that is already in memory is called
- a. elaborative encoding.
- b. visual imagery encoding.
- c. organizational encoding.
- d. iconic memory.

**3.** Research described in the textbook found that servers in restaurants remember their orders by relying on
- a. visual imagery encoding.
- b. organizational encoding.
- c. elaborative encoding.
- d. prospective memory.

**4.** Visual imagery encoding occurs in which part of the brain?
- a. frontal lobe
- b. parietal lobe
- c. temporal lobe
- d. occipital lobe

## Storage: Maintaining Memories over Time

Encoding is the process of turning perceptions into memories. But one of the hallmarks of a memory is that you can bring it to mind on Tuesday, not on Wednesday, and then bring it to mind again on Thursday. So where are our memories when we aren't using them? Clearly, those memories are *stored* somewhere in your brain. **Memory storage** is *the process of maintaining information in memory over time*. We can think of a memory store as a place in which memories are kept when we are not consciously experiencing them. The memory store has three major divisions: sensory, short-term, and long-term. As these names suggest, the three divisions are distinguished primarily by the amount of time in which a memory can be kept inside them.

### Sensory Storage

The **sensory memory store** is *the place in which sensory information is kept for a few seconds or less*. In a series of classic experiments, research participants were asked to remember rows of letters (Sperling, 1960). In one version of the procedure, participants viewed three rows of four letters each, as shown in FIGURE 5.5. The researcher flashed the letters on a screen for just 1/20th of a second. When asked to remember all 12 of the letters they had just seen, participants recalled fewer than half (Sperling, 1960). There were two possible explanations for this: Either people simply couldn't encode all the letters in such a brief period of time, or they had encoded the letters but forgotten them while trying to recall everything they had seen.

To test the two ideas, the researchers relied on a clever trick. Just after the letters disappeared from the screen, a tone sounded that cued the participants to report the letters in a particular row. A *high tone* cued participants to report the contents of the top row, a *medium* tone cued participants to report the contents of the middle row, and a *low* tone cued participants to report the contents of the bottom row. When asked to report only a single row, people recalled almost all of the letters in that row! Because the tone sounded *after* the letters disappeared from the screen, the researchers concluded that people could have recalled the same number of letters from *any* of the rows had they been asked to. Participants had no way of knowing which of the three rows would be cued, so the researchers inferred that virtually all the letters had been encoded. In fact, if the tone was substantially delayed, participants couldn't perform the task; the information had slipped away from their sensory memories. Like the afterimage of a flashlight, the 12 letters flashed on a screen are visual icons, a lingering trace stored in memory for a very short period.

● How long is information held in iconic and echoic memory before it decays?

Because we have more than one sense, we have more than one kind of sensory memory. **Iconic memory** is *a fast-decaying store of visual information*. A similar storage area serves as a temporary warehouse for sounds. **Echoic memory** is *a fast-decaying store of auditory information*. When you have difficulty understanding what someone has just said, you probably find yourself replaying the last few words—listening to them echo in your "mind's ear," so to speak. When you do that, you are accessing information that is being held in your echoic memory store. The hallmark of both the iconic and echoic memory stores is that they hold information for a very short time. Iconic memories usually decay in about a second or less, and echoic memories usually decay in about 5 seconds (Darwin, Turvey, & Crowder, 1972). These two sensory memory stores are a bit like doughnut shops: The products come in, they sit briefly on the shelf, and then they are discarded. If you want one, you have to grab it fast.

### Short-Term Storage and Working Memory

A second kind of memory store is the **short-term memory store**, which is *a place where nonsensory information is kept for more than a few seconds but less than a minute*. For example, if someone tells you a telephone number, you can usually repeat it back with ease—

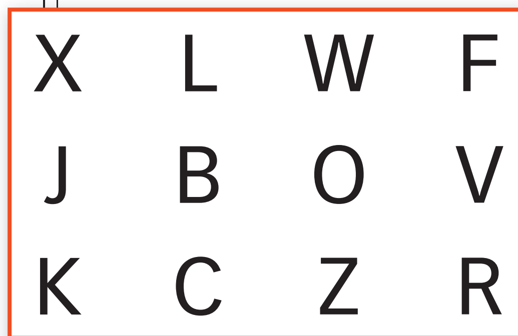



**FIGURE 5.5** **Iconic Memory Test** *When a grid of letters is flashed on-screen for only 1/20th of a second, it is difficult to recall individual letters. But if prompted to remember a particular row immediately after the grid is shown, research participants will do so with high accuracy. Sperling used this procedure to demonstrate that although iconic memory stores the whole grid, the information fades away too quickly for a person to recall everything (Sperling, 1960).*

**memory storage** The process of maintaining information in memory over time.

**sensory memory store** The place in which sensory information is kept for a few seconds or less.

**iconic memory** A fast-decaying store of visual information.

**echoic memory** A fast-decaying store of auditory information.

**short-term memory store** A place where nonsensory information is kept for more than a few seconds but less than a minute.

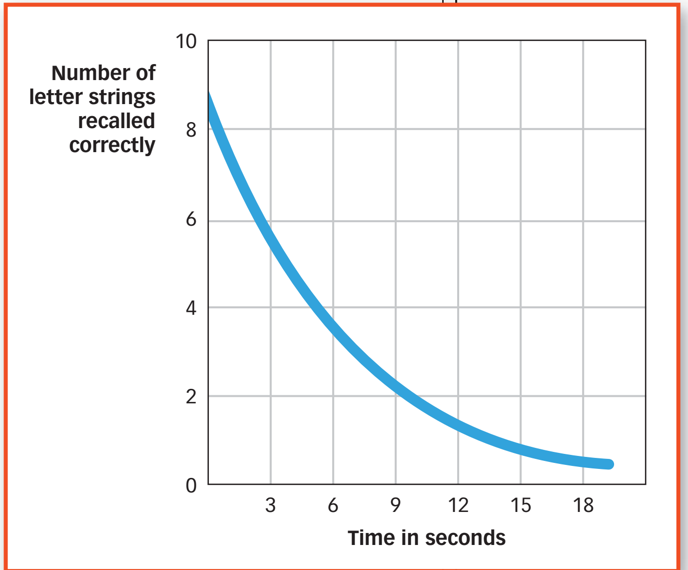



FIGURE 5.6
**The Decline of Short-Term Memory**
*A 1959 experiment showed how quickly short-term memory fades without rehearsal. On a test for memory of three-letter strings, research participants were highly accurate when tested a few seconds after exposure to each string, but if the test was delayed another 15 seconds, people barely recalled the strings at all (Peterson & Peterson, 1959).*

but only for a few seconds. In one study, research participants were given consonant strings to remember, such as DBX and HLM. After seeing each string, participants were asked to count backward from 100 by 3s for varying amounts of time and were then asked to recall the strings (Peterson & Peterson, 1959). As shown in FIGURE 5.6, memory for the consonant strings declined rapidly, from approximately 80% after a 3-second delay to less than 20% after a 20-second delay. These results suggest that information can be held in the short-term memory store for about 15 to 20 seconds.

What if we need the information for a while longer? We can use a trick that allows us to get around the natural limitations of our short-term memories. **Rehearsal** is *the process of keeping information in short-term memory by mentally repeating it*. If someone gives you a telephone number and you don't have a pencil, you say it over and over to yourself until you find one. Each time you repeat the number, you are "reentering" it into short-term memory, thus giving it another 15 to 20 seconds of shelf life.

Short-term memory is limited in how *long* it can hold information and also in how *much* information it can hold. Most people can keep approximately seven numbers in short-term memory, and if they put more new numbers in, then old numbers begin to fall out (Miller, 1956). Short-term memory isn't limited to numbers, of course: it can also hold about seven letters, or seven words—even though those seven words contain many more than seven letters. In fact, short-term memory can hold about seven *meaningful items* at once (Miller, 1956). Therefore, one way to increase storage is to group several letters into a single meaningful item. **Chunking** involves *combining small pieces of information into larger clusters or chunks*. Waitresses who organize customer orders into groups are essentially chunking the information, thus giving themselves less to remember.

● Why is it helpful that local phone numbers are only seven digits long?

Short-term memory was originally conceived of as a kind of "place" where information is kept for a limited amount of time. A more dynamic model of a limited-capacity memory system has been developed and refined over the past few decades. **Working memory** refers to *active maintenance of information in short-term storage* (Baddeley & Hitch, 1974). It differs from the traditional view that short-term memory is simply a place to hold information and instead includes the operations and processes we use to work with information in short-term memory.

Working memory includes subsystems that store and manipulate visual images or verbal information. If you wanted to keep the arrangement of pieces on a chessboard in mind as you contemplated your next move, you'd be relying on working memory. Working memory includes the visual representation of the positions of the pieces, your mental manipulation of the possible moves, and your awareness of the flow of information into and out of memory, all stored for a limited amount of time. In short, the working memory model acknowledges both the limited nature of this kind of memory storage and the activities that are commonly associated with it.

## Long-Term Storage

In contrast to the time-limited sensory memory store and short-term memory stores, **long-term memory store** is *a place in which information can be kept for hours, days, weeks, or years*. In contrast to both the sensory and short-term memory stores, the long-term store has no known capacity limits (see FIGURE 5.7). For example, most people can recall 10,000 to 15,000 words in their native language, tens of thousands of facts ("The capital of France is Paris" and "3 × 3 = 9"), and an untold number of personal experiences. Just think of all the song lyrics you can recite by heart, and you'll understand that you've got a lot of information tucked away in long-term memory!

**rehearsal** The process of keeping information in short-term memory by mentally repeating it.

**chunking** Combining small pieces of information into larger clusters or chunks that are more easily held in short-term memory.

**working memory** Active maintenance of information in short-term storage.

**long-term memory store** A place in which information can be kept for hours, days, weeks, or years.

**anterograde amnesia** The inability to transfer new information from the short-term store into the long-term store.

**retrograde amnesia** The inability to retrieve information that was acquired before a particular date, usually the date of an injury or operation.

Amazingly, people can recall items from the long-term memory store even if they haven't recalled them for years. For example, researchers have found that even 50 years after graduation, people can accurately recognize about 90% of their high school classmates from yearbook photographs (Bahrick, 2000). The feat is the more remarkable when you consider that most of this information had probably not been accessed for years before the experiment.

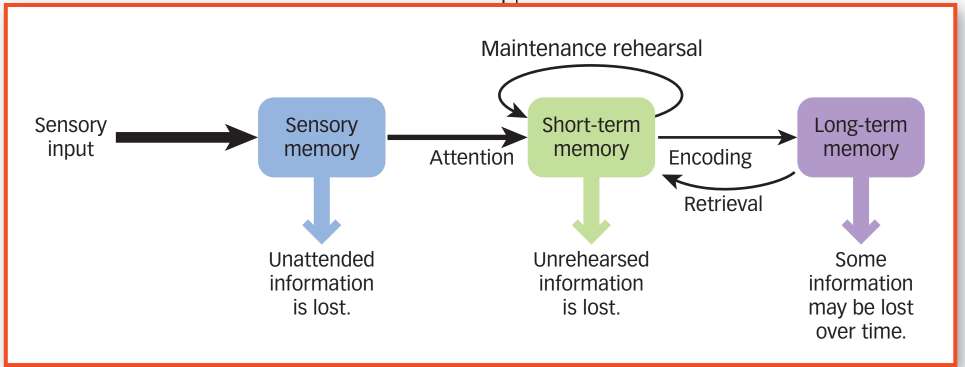



**FIGURE 5.7** **The Flow of Information through the Memory System** *Information moves through several stages of memory as it gets encoded, stored, and made available for later retrieval.*

Not everyone has the same ability to put information into the long-term memory store. In 1953, a 27-year-old man, known by the initials HM, suffered from intractable epilepsy (Scoville & Milner, 1957). In a desperate attempt to stop the seizures, HM's doctors removed parts of his temporal lobes, including the hippocampus and some surrounding regions (FIGURE 5.8). After the operation, HM could converse easily, use and understand language, and perform well on intelligence tests—but he could not remember anything that happened to him *after* the operation. HM could repeat a telephone number with no difficulty, suggesting that his short-term memory store was just fine (Corkin, 1984, 2002; Hilts, 1995). But after information left the short-term store, it was gone forever. For example, he would often forget that he had just eaten a meal or fail to recognize the hospital staff who helped him on a daily basis. Like Greg, HM now lacked the ability to hang on to the new memories he created. Studies of HM and others have shown that the hippocampal region of the brain is critical for putting new information into the long-term store. When this region is damaged, patients suffer from a condition known as **anterograde amnesia**, which is *the inability to transfer new information from the short-term store into the long-term store.*

Some amnesic patients also suffer from **retrograde amnesia**, which is *the inability to retrieve information that was acquired before a particular date, usually the date of an injury or operation.* The fact that HM had much worse anterograde than retrograde amnesia suggests that the hippocampal region is not the site of long-term memory; indeed, research has shown that different aspects of a single memory—its sights, sounds, smells, emotional content—are stored in different places in the cortex (Damasio, 1989; Schacter, 1996; Squire & Kandel, 1999). Psychologists now believe that the hippocampal region acts as a kind of "index" that links together all of these otherwise separate bits and pieces so that we remember them as one memory (Schacter, 1996; Squire, 1992; Teyler & DiScenna, 1986). Over time, this index may become less necessary. You can think of the hippocampal-region index like a printed recipe. The first time you make a pie, you need the recipe to help you retrieve all the ingredients and then mix them together in the right amounts. As you bake more and more pies, though, you don't need to rely on the printed recipe anymore. Similarly, although the hippocampal-region index is critical when a new memory is first formed, it may become less important as the memory ages. Scientists are still debating the extent to which the hippocampal region helps us to remember details of our old memories (Bayley et al., 2005; Moscovitch et al., 2006), but the notion of the hippocampus as an index explains why people like HM *cannot* make new memories and why they *can* remember old ones.

● How is using the hippocampal-region like learning a recipe?

**ONLY HUMAN**

**HELP! I'VE EATEN AND I CAN'T GET HOME!** In Oslo, Norway, Jermund Slogstad, 50, was moving into his new apartment when he took a break to get something to eat. He went to a nearby café but forgot to take his wallet, which contained his new address. He was unable to find his way home. "This is embarrassing," he told a newspaper a month later, hoping word of his plight would reach his new landlady, whom he had paid a month's rent in advance.

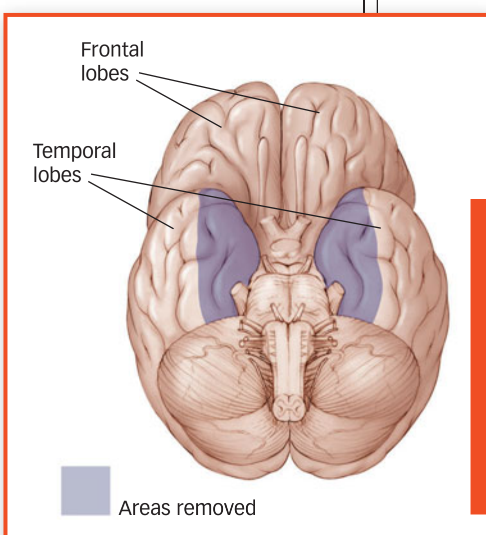



**FIGURE 5.8** **The Hippocampus Patient** *HM had his hippocampus and adjacent structures of the medial temporal lobe (indicated by the shaded area) surgically removed to stop his epileptic seizures. As a result, he could not remember things that happened after the surgery.*

## Memories in the Brain

If you could shrink yourself down to the size of a cell and go wandering around inside someone's brain, where exactly would you look for their memories? You'd probably be tempted to look at their neurons. But that isn't where you'd find them. Research suggests that the best place to look for memories is in the *spaces* between neurons. You'll recall from Chapter 3 that a *synapse* is the small space between the axon of one neuron and the dendrite of another, and neurons communicate by sending neurotransmitters across these synapses. As it turns out, sending a neurotransmitter across a synapse isn't like sending a toy boat across a pond because the act of sending actually *changes* the synapse. Specifically, it strengthens the connection between the two neurons, making it easier for them to transmit to each other the next time. This is why researchers sometimes say, "Cells that fire together wire together" (Hebb, 1949).

● Why are the spaces between neurons so important to memory?

The idea that the connections between neurons are strengthened by their communication, thus making communication easier the next time, provides the neurological basis for long-term memory, and much of what we know about this comes from the tiny sea slug *Aplysia*. Having an extremely simple nervous system consisting of only 20,000 neurons (compared to roughly 100 billion in the human brain), *Aplysia* has been attractive to researchers because it is relatively uncomplicated. By studying these little animals, researchers have been able to observe how learning experiences result in physical changes in neurons: both by enhancing neurotransmitter release to make the messages stronger, and also by causing the growth of new synapses, to increase the number of possible communication sites (Abel et al., 1995; Squire & Kandel, 1999).

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*The sea slug* Aplysia californica *is useful to researchers because it has an extremely simple nervous system that can be used to investigate the mechanisms of short- and long-term memory.*

The same processes happen in larger-brained organisms, including humans. In the early 1970s, researchers applied a brief electrical stimulus to a neural pathway in a rat's hippocampus (Bliss & Lømo, 1973). They found that the electrical current produced a stronger connection between synapses that lay along the pathway and that the strengthening lasted for hours or even weeks. They called this **long-term potentiation**, more commonly known as **LTP**, which is *enhanced neural processing that results from the strengthening of synaptic connections*. Long-term potentiation has a number of properties that indicate to researchers that it plays an important role in long-term memory storage: It occurs in several pathways within the hippocampus, it can be induced rapidly, and it can last for a long time. In fact, drugs that block LTP can turn rats into rodent versions of patient HM: The animals have great difficulty remembering where they've been recently and become easily lost in a maze (Bliss, 1999; Morris, Anderson, Lynch, & Baudry, 1986). More work remains to be done in this area to conclusively show how LTP leads to the formation of long-term memories, but this line of research is giving us our first chance to "see" memories in the brain.

**long-term potentiation (LTP)** Enhanced neural processing that results from the strengthening of synaptic connections.

### summary quiz [5.2]

**5.** A fast-decaying store of visual information is called
- a. echoic memory.
- b. iconic memory.
- c. episodic memory.
- d. prospective memory.

**6.** Short-term memory can hold about ___ meaningful items at once.
- a. 3
- b. 5
- c. 7
- d. 12

7. The region of the brain called the ________ plays an important role in long-term memory storage.
   a. hippocampus
   b. hypothalamus
   c. amygdala
   d. temporal lobe

8. Enhanced neural processing that results from the strengthening of synaptic connections is called
   a. elaborative encoding.
   b. short-term memory store.
   c. chunking.
   d. long-term potentiation.

**retrieval cue** External information that is associated with stored information and helps bring it to mind.

## Retrieval: Bringing Memories to Mind

There is something fiendishly frustrating about piggy banks. You can put money in them, you can shake them around to assure yourself that the money is there, but you can't easily get the money out, which is why no one carries a piggy bank instead of a wallet. If memory were like a piggy bank, it would be similarly useless. We could make memories, we could store them, and we could even shake our heads around and listen for the telltale jingle. But if we couldn't bring our memories out of storage and use them, then what would be the point of saving them in the first place? Retrieval is the process of bringing to mind information that has been previously encoded and stored, and it is perhaps the most important of all memorial processes (Roediger, 2000; Schacter, 2001a).

### Retrieval Cues: Reinstating the Past

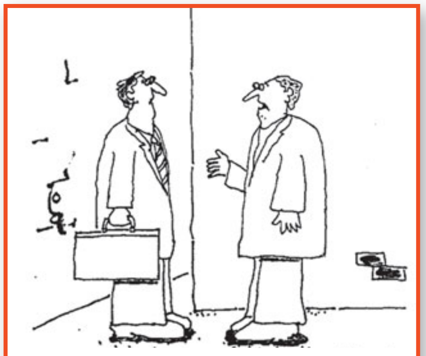
One of the best ways to retrieve information from *inside* your head is to encounter information *outside* your head that is somehow connected to it. The information outside your head is called a **retrieval cue**, which is *external information that is associated with stored information and helps bring it to mind*. Retrieval cues can be incredibly effective.

In one experiment, undergraduates studied lists of words, such as *table, peach, bed, apple, chair, grape,* and *desk* (Tulving & Pearlstone, 1966). Later, the students were asked to write down all the words from the list that they could remember. When they were absolutely sure that they had emptied their memory stores of every last word that was in them, the experimenters again asked the students to remember the words on the list, but this time, the experimenters provided with retrieval cues, such as "furniture" or "fruit." The students who were sure that they had done all the remembering they possibly could were suddenly able to remember more words (Tulving & Pearlstone, 1966). These results suggest that information is sometimes *available* in memory even when it is momentarily *inaccessible* and that retrieval cues help us bring inaccessible information to mind. Of course, this is something you already knew. How many times have you said something like, "I *know* who starred in *Charlie and the Chocolate Factory,* but I just can't remember it"? only to have a friend give you a hint ("Wasn't he in *Pirates of the Caribbean*?"), which instantly brings the answer to mind ("Johnny Depp!").

*A particular light, odor, or melody can make a memory reappear vividly, with all its force and its precision, as if a window opened on the past.*

DENISE KAPPA/DREAMSTIME.COM

Callahan



CALLAHAN. COURTESY OF LEVIN REPRESENTS

*"I wonder if you'd mind giving me directions. I've never been sober in this part of town before."*

Hints are one kind of retrieval cue, but they are not the only kind. The **encoding specificity principle** states that *a retrieval cue can serve as an effective reminder when it helps re-create the specific way in which information was initially encoded* (Tulving & Thomson, 1973). External contexts often make powerful retrieval cues. For example, in one study, divers learned some words on land and some other words underwater; they recalled the words best when they were tested in the same dry or wet environment in which they had initially learned them because the environment itself served as a retrieval cue (Godden & Baddely, 1975). Recovering alcoholics often experience a renewed urge to drink when visiting places in which they once drank because these places serve as retrieval cues. There may even be some wisdom to finding a seat in a classroom, sitting in it every day, and then sitting in it again when you take the test because the feel of the chair and the sights you see may help you remember the information you learned while you sat there.

● Why might it be a good idea to sit in the same seat for an exam that you sat in during lecture?

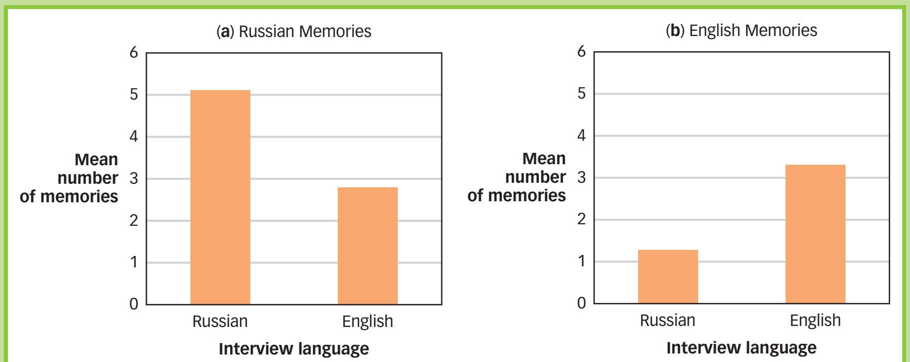
Retrieval cues need not be external contexts—they can also be inner states. **State-dependent retrieval** is *the tendency for information to be better recalled when the person is in the same state during encoding and retrieval*. For example, retrieving information when you are in a sad or happy mood increases the likelihood that you will retrieve sad or happy episodes (Eich, 1995), which is part of the reason it is so hard to "look on the bright side" when you're feeling low. Retrieval cues can even be thoughts themselves, as when one thought calls to mind another, related thought (Anderson et al., 1976).

The encoding specificity principle makes some unusual predictions. For example, you learned earlier that making semantic judgments about a word (e.g., "What does *orange* mean?") usually produces more durable memory for the word than does making rhyme judgments (e.g., "What rhymes with *orange*?"). So if you were asked to think of a word that rhymes with *brain* and your friend were asked to think about what *brain* means, we would expect your friend to remember the word better the next day if we simply asked you both, "Hey, what was that word you saw yesterday?" However, if instead of asking that question, we asked you both, "What was that word that rhymed with *train*?" we would expect you to remember it better than your friend did (Fisher & Craik, 1977). This is a fairly astounding finding. Semantic judgments almost always yield better memory than rhyme judgments. But in this case, the typical finding is turned upside down because the retrieval cue matched your encoding context better than it matched your friend's. The principle of **transfer-appropriate processing** states that *memory is likely to transfer from one situation to another when we process information in a way that is*

## Culture & Community

### Is Language a Factor in Memory Retrieval? A Study from Cornell University Indicates That It Is

In a memory retrieval experiment, bilingual Russian American college students were asked to relate memories that came to mind after hearing prompt words (Marian & Neisser, 2000). They were queried about four different stages of their lives. One part of the interview was conducted in English, and the other part was conducted in Russian. Participants were able to recall more events that took place in Russia when interviewed in Russian than in English, whereas they were able to recall more events that took place in the United States when interviewed in English than in Russian. Like other forms of context discussed in this section that are known to influence remembering, such as our moods or the external environment, this study shows that language can serve as a contextual cue that plays a significant role in determining what will be remembered.



*appropriate to the retrieval cues that will be available later* (Morris, Bransford, & Franks, 1977; Roediger, Weldon, & Challis, 1989).

## Separating the Components of Retrieval

Before leaving the topic of retrieval, let's look at how the process actually works. There is reason to believe that *trying* to recall an incident and *successfully* recalling one are fundamentally different processes that occur in different parts of the brain (Moscovitch, 1994; Schacter, 1996). For example, regions in the left frontal lobe show heightened activity when people *try* to retrieve information that was presented to them earlier (Shallice et al., 1994; Squire et al., 1992; Tulving et al., 1994). Many psychologists believe that this activity reflects the mental effort that people put forth when they struggle to dredge up the past event (Lepage et al., 2000). However, *successfully* remembering a past experience tends to be accompanied by activity in the hippocampal region (see **FIGURE 5.9**) and also in parts of the brain that play a role in processing the sensory features of an experience (Eldridge et al., 2000; Nyberg et al., 1996; Schacter et al., 1996a). For instance, recall of previously heard sounds is accompanied by activity in the auditory cortex (the upper part of the temporal lobe), whereas recall of previously seen pictures is accompanied by activity in the visual cortex (in the occipital lobe) (Wheeler, Petersen, & Buckner, 2000). Although retrieval may seem like a single process, brain studies suggest that separately identifiable processes are at work.

● **How is brain activity different when trying to recall versus successfully recalling?**

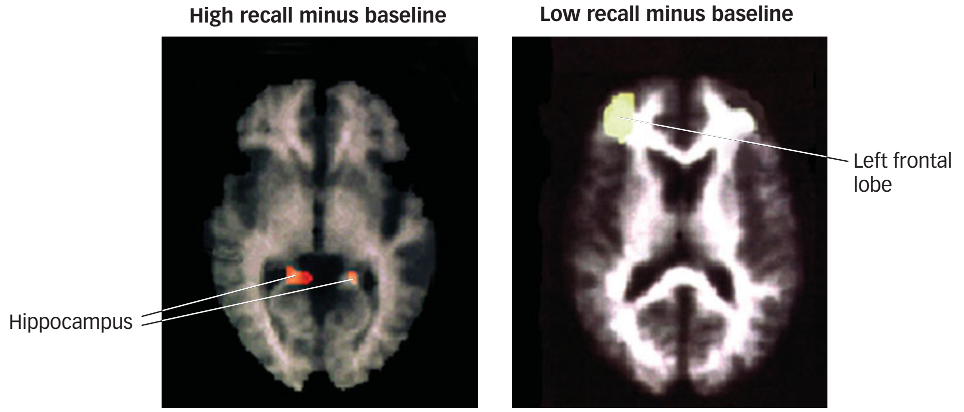



**FIGURE 5.9** **PET Scans of Successful and Unsuccessful Recall** *When people successfully remembered words they saw earlier in an experiment, achieving high levels of recall on a test, the hippocampus showed increased activity. When people tried but failed to recall words they had seen earlier, achieving low levels of recall on a test, the left frontal lobe showed increased activity (Schacter et al., 1996a).*

### summary quiz [5.3]

**9.** You are more likely to recall a happy event in your life when you are in a happy mood. This illustrates
a. state-dependent retrieval.
b. transfer-appropriate processing.
c. the encoding specificity principle.
d. elaborative encoding.

**10.** Your textbook suggests that sitting in the same seat in a classroom every day, including exam day, may help you retrieve information learned in class when taking your exam. This illustrates
a. state-dependent retrieval.
b. transfer-appropriate processing.
c. the encoding specificity principle.
d. organizational encoding.

**11.** *Trying* to recall a melody involves the ________, whereas *successfully* recalling the melody involves the ________.
a. left frontal lobe; hypothalamus and parietal lobe
b. right frontal lobe; hippocampus and temporal lobe
c. left frontal lobe; hypothalamus and temporal lobe
d. right frontal lobe; amygdala and occipital lobe

**encoding specificity principle** The idea that a retrieval cue can serve as an effective reminder when it helps re-create the specific way in which information was initially encoded.

**state-dependent retrieval** The tendency for information to be better recalled when the person is in the same state during encoding and retrieval.

**transfer-appropriate processing** The idea that memory is likely to transfer from one situation to another when we process information in a way that is appropriate to the retrieval cues that will be available later.

**explicit memory** The act of consciously or intentionally retrieving past experiences.

**implicit memory** The influence of past experiences on later behavior and performance, even though people are not trying to recollect them and are not aware that they are remembering them.

**procedural memory** The gradual acquisition of skills as a result of practice, or "knowing how," to do things.

**priming** An enhanced ability to think of a stimulus, such as a word or object, as a result of a recent exposure to the stimulus.

# Multiple Forms of Memory: How the Past Returns

Although Greg was unable to make new memories, some of the new things that happened to him seemed to leave a mark. For example, Greg did not recall learning that his father had died, but he did seem sad and withdrawn for years after hearing the news. Similarly, HM could not make new memories after his surgery, but if he played a game in which he had to track a moving target, his performance gradually improved with each round (Milner, 1962). Greg could not consciously remember hearing about his father's death, and HM could not consciously remember playing the tracking game, but both showed clear signs of having been permanently changed by experiences that they so rapidly forgot. In other words, these patients *behaved* as though they were remembering things while claiming to remember nothing at all. This suggests that there must be several kinds of memory, some of which are accessible to conscious recall and some that we cannot consciously access (Eichenbaum & Cohen, 2001; Schacter & Tulving, 1994; Schacter, Wagner, & Buckner, 2000; Squire & Kandel, 1999).

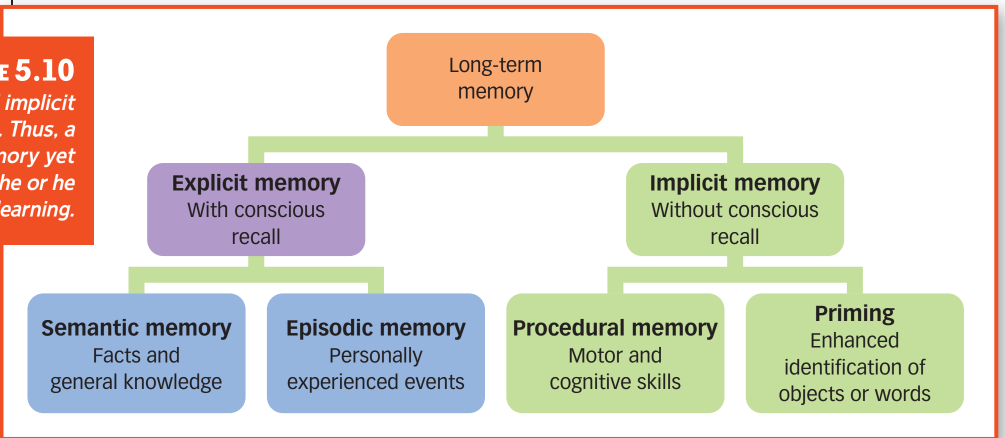
## Explicit and Implicit Memory

The fact that people can be changed by past experiences without having any awareness of those experiences suggests that there must be at least two different classes of memory (FIGURE 5.10). **Explicit memory** occurs *when people consciously or intentionally retrieve past experiences*. Recalling last summer's vacation, incidents from a novel you just read, or facts you studied for a test all involve explicit memory. Indeed, anytime you start a sentence with "I remember . . . ," you are talking about an explicit memory. **Implicit memory** occurs when *past experiences influence later behavior and performance, even though people are not trying to recollect them and are not aware that they are remembering them* (Graf & Schacter, 1985; Schacter, 1987). Implicit memories are not consciously recalled, but their presence is "implied" by our actions. Greg's persistent sadness after his father's death, even though he had no conscious knowledge of the event, is an example of implicit memory. So is HM's improved performance on a tracking task that he didn't consciously remember doing. So is the ability to ride a bike or tie your shoelaces or play guitar: you may know how to do these things, but you probably can't describe how to do them. Such knowledge reflects a particular kind of implicit memory called **procedural memory**, which refers to *the gradual acquisition of skills as a result of practice, or "knowing how," to do things*.

● What type of memory is it when you just "know how" to do something?

One of the hallmarks of procedural memory is that the things you remember are automatically translated into actions. Sometimes you can explain how it is done ("Put one

**FIGURE 5.10**
**Multiple Forms of Memory** *Explicit and implicit memories are distinct from each other. Thus, a person with amnesia may lose explicit memory yet display implicit memory for material that she or he cannot consciously recall learning.*



finger on the third fret of the E string, one finger . . ."), and sometimes you can't ("Get on the bike and . . . well, uh . . . just balance"). The fact that people who have amnesia can acquire new procedural memories suggests that the hippocampal structures that are usually damaged in these patients may be necessary for explicit memory, but they aren't needed for implicit procedural memory. In fact, it appears that brain regions outside the hippocampal area (including areas in the motor cortex) are involved in procedural memory. Chapter 6 discusses this evidence further, where you will also see that procedural memory is crucial for learning various kinds of motor, perceptual, and cognitive skills.

Not all implicit memories are procedural or "how to" memories. For example, in one experiment, college students were asked to study a long list of words, including items such as *avocado, mystery, climate, octopus,* and *assassin* (Tulving, Schacter, & Stark, 1982). Later, explicit memory was tested by showing participants some of these words along with new ones they hadn't seen and asking them which words were on the list. To test implicit memory, participants received word fragments and were asked them to come up with a word that fit the fragment.

Try the test yourself:

ch——nk

o–t–p—

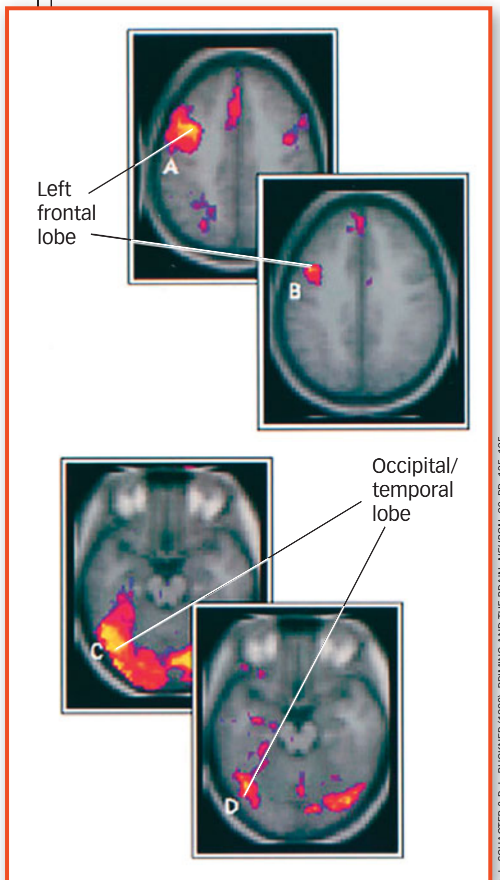
–og–y—–

–l–m–te

You probably had difficulty coming up with the answers for the first and third fragments (*chipmunk, bogeyman*) but had little problem coming up with answers for the second and fourth (*octopus, climate*). Seeing *octopus* and *climate* on the original list made those words more accessible later, during the fill-in-the-blanks test. This is an example of **priming**, which refers to *an enhanced ability to think of a stimulus, such as a word or object, as a result of a recent exposure to the stimulus* (Tulving & Schacter, 1990). Just as priming a pump makes water flow more easily, priming the memory system makes some information more accessible. In the fill-in-the-blanks experiment, people showed priming for studied words even when they failed to consciously remember that they had seen them earlier. This suggests that priming is an example of implicit, not explicit memory. As such, you'd expect amnesic patients such as HM and Greg to show priming. In fact, many experiments have shown that amnesic patients can show substantial priming effects—often as large as healthy, nonamnesic people—even though they have no explicit memory for the items they studied. These and other similar results suggest that priming, like procedural memory, does not require the hippocampal structures that are damaged in cases of amnesia (Schacter & Curran, 2000).

● How does priming make memory more efficient?

If the hippocampal region isn't required for procedural memory and priming, what parts of the brain are involved? Experiments have revealed that priming is associated with *reduced* activity in various regions of the cortex that are activated when people perform an unprimed task. For instance, when research participants are shown the word stem *mot*___ or *tab*___ and are asked to provide the first word that comes to mind, parts of the occipital lobe involved in visual processing and parts of the frontal lobe involved in word retrieval become active. But if people perform the same task after being primed by seeing *motel* and *table,* there's less activity in these same regions (Buckner et al., 1995; Schacter, Dobbins, & Schnyer, 2004; Wiggs & Martin, 1998). Something similar happens when people see pictures of everyday objects on two different occasions. On the second exposure to a picture, there's less activity in parts of the visual cortex that were activated by seeing the picture initially. Priming seems to make it easier for parts of the cortex that are involved in perceiving a word or object to identify the item after a recent exposure to it. This suggests that the brain "saves" a bit of processing time after priming (**FIGURE 5.11**).




D. L. SCHACTER & R. L. BUCKNER (1998). PRIMING AND THE BRAIN, *NEURON*, 20, PP. 185–195.

**FIGURE 5.11** **Primed and Unprimed Processing of Stimuli** *Priming is associated with reduced levels of activation in the cortex on a number of different tasks. In each pair of fMRIs, the images on the upper left (A, C) show brain regions in the frontal lobe (A) and occipital/temporal lobe (C) that are active during an unprimed task (in this case, providing a word response to a visual word cue). The images on the lower right within each pair (B, D) show reduced activity in the same regions during the primed version of the same task.*

**semantic memory** A network of associated facts and concepts that make up our general knowledge of the world.

**episodic memory** The collection of past personal experiences that occurred at a particular time and place.

## Semantic and Episodic Memory

Consider these two questions: (a) Why do we celebrate on July 4? and (b) What is the most spectacular Fourth of July celebration you've ever seen? Every American knows the answer to the first question (we celebrate the signing of the Declaration of Independence on July 4, 1776), but we all have our own answers to the second. Although both of these questions required you to search your long-term memory and explicitly retrieve information that was stored there, one required you to dredge up a fact that every American schoolchild knows and that is not part of your personal autobiography and one required you to revisit a particular time and place—or episode—from your personal past. These memories are called *semantic* and *episodic* memories, respectively (Tulving, 1972, 1983, 1998). **Semantic memory** is *a network of associated facts and concepts that make up our general knowledge of the world,* whereas **episodic memory** is *the collection of past personal experiences that occurred at a particular time and place*.

● What form of memory uses "mental time travel"?

Episodic memory is special because it is the only form of memory that allows us to engage in "mental time travel," projecting ourselves into the past and revisiting events that have happened to us. This ability allows us to connect our pasts and our presents and construct a cohesive story of our lives. People who have amnesia can usually travel back in time and revisit episodes that occurred before they became amnesiac, but they are unable to revisit episodes that happened later. For example, Greg couldn't travel back to any time after 1969 because that's when he stopped being able to create new episodic memories. But can people with amnesia create new semantic memories?

Researchers have studied three young adults who suffered damage to the hippocampus during birth as a result of difficult deliveries that interrupted the oxygen supply to their brains (Vargha-Khadem et al., 1997). Their parents noticed that the children could not recall what happened during a typical day, had to be constantly reminded of appointments, and often became lost and disoriented. In view of their hippocampal damage, you might also expect that each of the three would perform poorly in school and might even be classified as learning disabled. Remarkably, however, all three children learned to read, write, and spell; developed normal vocabularies; and acquired other kinds of semantic knowledge that allowed them to perform well at school. Based on this evidence, researchers have concluded that the hippocampus is not necessary for acquiring new *semantic* memories.


THE PHOTO WORKS

*This contestant on the game show* Who Wants to Be a Millionaire? *is consulting her semantic memory to answer the question. The answer is B: Bulgaria.*

## summary quiz [5.4]

**12.** Remembering how to ride a bike or tie your shoelaces illustrates
  a. iconic memory.
  b. procedural memory.
  c. explicit memory.
  d. priming.

**13.** An enhanced ability to think of a stimulus, such as a word or object, as a result of recent exposure to the stimulus, is called
  a. elaborative encoding.
  b. chunking.
  c. priming.
  d. state-dependent retrieval.

**14.** Almost all American schoolchildren know that July 4 celebrates the signing of the Declaration of Independence. This illustrates
  a. semantic memory.
  b. episodic memory.
  c. implicit memory.
  d. explicit memory.

**transience** Forgetting what occurs with the passage of time.

# Memory Failures: The Seven Sins of Memory

You probably haven't given much thought to breathing today, and the reason is that from the moment you woke up, you've been doing it effortlessly and well. But the moment breathing fails, you are reminded of just how important it is. Memory is like that. Every time we see, think, notice, imagine, or wonder, we are drawing on our ability to use information stored in our brains, but it isn't until this ability fails that we become acutely aware of just how much we should treasure it. Like a lot of human behavior, we can better understand how a process works correctly by examining what happens when it works incorrectly. We've seen in other contexts how an understanding of mind bugs—those foibles and errors of human thought and action—reveals the normal operation of various behaviors. Such memory mind bugs—the "seven sins" of memory—cast similar illumination on how memory normally operates and how often it operates well (Schacter, 1999, 2001b). We'll discuss each of the seven sins in detail.

APTV/AP PHOTO

*President Clinton hugs Monica Lewinsky as he greets the crowd at a public appearance. Clinton's claims to have forgotten several incidents related to their affair may be an example of transience.*

## 1. Transience

The investigation and eventual impeachment of U.S. president Bill Clinton held the nation spellbound in the late 1990s. Aside from tabloid revelations about Clinton's relationship with White House intern Monica Lewinsky, the investigation also produced a lot of discussion about Clinton's claims to have forgotten a variety of things. For example, 3 weeks after a meeting with his good friend Vernon Jordan to discuss a sexual harassment lawsuit, the president claimed not to remember any of the important details of that discussion (Schacter, 2001b). Was that claim reasonable? Could a person simply forget such important information so quickly? Or, as Clinton's prosecutor argued, were these apparent memory lapses self-serving conveniences designed to avoid embarrassing admissions?

We may never know for sure. But certainly, memories can and do degrade with time. The culprit here is **transience:** *forgetting what occurs with the passage of time*. Transience

**retroactive interference** Situations in which later learning impairs memory for information acquired earlier.

**proactive interference** Situations in which earlier learning impairs memory for information acquired later.

**absentmindedness** A lapse in attention that results in memory failure.

**prospective memory** Remembering to do things in the future.

occurs during the storage phase of memory, after an experience has been encoded and before it is retrieved. You've already seen the workings of transience—rapid forgetting—in sensory storage and short-term storage. Transience also occurs in long-term storage, as was first illustrated in the late 1870s by Hermann Ebbinghaus, a German philosopher who measured his own memory for lists of nonsense syllables at different delays after studying them (Ebbinghaus, 1885/1964). Ebbinghaus charted his recall of nonsense syllables over time, creating the forgetting curve shown in **FIGURE 5.12**. Ebbinghaus noted a rapid drop-off in retention during the first few tests, followed by a slower rate of forgetting on later tests—a general pattern confirmed by many subsequent memory researchers (Wixted & Ebbesen, 1991). So, for example, when English speakers were tested for memory of Spanish vocabulary acquired during high school or college courses 1 to 50 years previously, there was a rapid drop-off in memory during the first 3 years after the students' last class, followed by tiny losses in later years (Bahrick, 1984, 2000). In all these studies, memories don't fade at a constant rate as time passes; most forgetting happens soon after an event occurs, with increasingly less forgetting as more time passes.

With the passage of time, the quality of our memories also changes. At early time points on the forgetting curve—minutes, hours, and days—memory preserves a relatively detailed record, allowing us to reproduce the past with reasonable if not perfect accuracy. But with the passing of time, we increasingly rely on our general memories for what usually happens and attempt to reconstruct the details by inference and even sheer guesswork. Transience involves a gradual switch from specific to more general memories (Brewer, 1996; Eldridge, Barnard, & Bekerian, 1994; Thompson et al., 1996). In one early study, British research participants read a brief Native American folktale that had odd imagery and unfamiliar plots in it, and then recounted it as best they could after a delay (Bartlett, 1932). The readers made interesting but understandable errors, often eliminating details that didn't make sense to them or adding elements to make the story more coherent. As the specifics of the story slipped away, the general meaning of the events stayed in memory but usually with elaborations and embellishments that were consistent with the readers' worldview. Because the story was unfamiliar to the readers, they raided their stores of general information and patched together a reasonable recollection of what *probably* happened.

**How might general memories come to distort specific memories?**

Yet another way that memories can be distorted is by interference from other memories. For example, if you carry out the same activities at work each day, by the time Friday rolls around, it may be difficult to remember what you did on Monday because later activities blend in with earlier ones. This is an example of **retroactive**

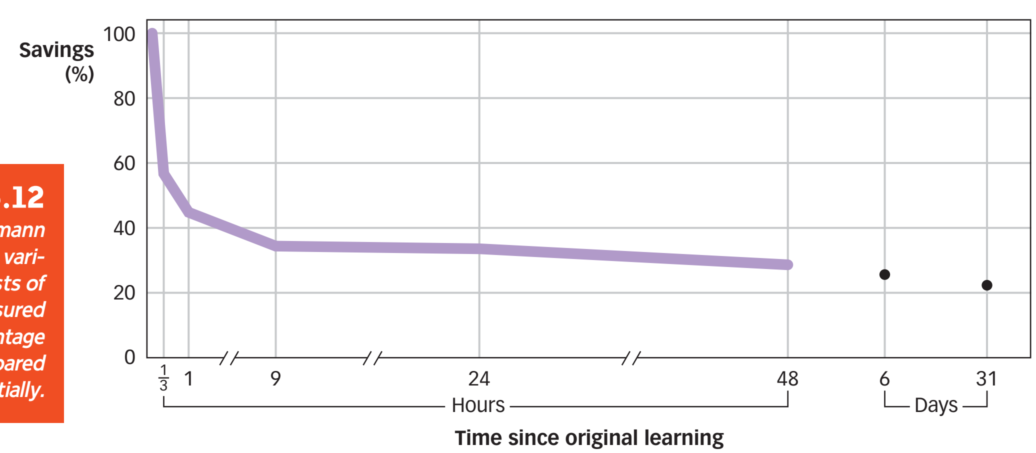



**FIGURE 5.12** **The Curve of Forgetting** *Hermann Ebbinghaus measured his retention at various delay intervals after he studied lists of nonsense syllables. Retention was measured in percent savings—that is, the percentage of time needed to relearn the list compared to the time needed to learn it initially.*

**interference**, which occurs when *later learning impairs memory for information acquired earlier* (Postman & Underwood, 1973). **Proactive interference**, in contrast, refers to situations in which *earlier learning impairs memory for information acquired later*. If you use the same parking lot each day at work or school, you've probably gone out to find your car and then stood there confused by the memories of having parked it on previous days.

## 2. Absentmindedness

The great cellist Yo-Yo Ma put his treasured $2.5 million instrument in the trunk of a taxicab in Manhattan and then rode to his destination. After a 10-minute trip, he paid the driver and left the cab, forgetting his cello. Minutes later, Ma realized what he had done and called the police. Fortunately, they tracked down the taxi and recovered the instrument within hours (Finkelstein, 1999). But how had the celebrated cellist forgotten about something so important that had occurred only 10 minutes earlier? Transience is not a likely culprit. As soon as Mr. Ma realized what he'd done with his instrument, he recalled where he had put it. This information had not disappeared from his memory (which is why he was able to tell the police where the cello was). Instead, Yo-Yo Ma was a victim of **absentmindedness**, which is *a lapse in attention that results in memory failure.*

TED THAI/GETTY IMAGES

*Yo-Yo Ma with his $2.5 million cello. The famous cellist lost it when he absentmindedly forgot that he'd placed the instrument in a taxi's trunk minutes earlier.*

What makes people absentminded? One common cause is lack of attention. Attention plays a vital role in encoding information into long-term memory. Without proper attention, material is much less likely to be stored properly, and recalled later. In studies of "divided attention," research participants are given materials to remember, such as a list of words, a story, or a series of pictures. At the same time, they are required to perform an additional task that draws their attention away from the material. For example, in one study, participants listened to lists of 15 words for a later memory test (Craik et al., 1996). They were allowed to pay full attention to some of the lists, but while they heard other lists, they simultaneously viewed a visual display containing four boxes and pressed different keys to indicate where an asterisk was appearing and disappearing. On a later test, participants recalled far fewer words from the list they had heard while their attention was divided.

What happens in the brain when attention is divided? In one study, volunteers tried to learn a list of word pairs while researchers scanned their brains with positron emission tomography (PET) (Shallice et al., 1994). Some people simultaneously performed a task that took little attention (they moved a bar the same way over and over), whereas other people simultaneously performed a task that took a great deal of attention (they moved a bar over and over but in a novel, unpredictable way each time). The researchers observed less activity in the participants' lower left frontal lobe when their attention was divided. As you saw earlier, greater activity in the lower left frontal region during encoding is associated with better memory. Dividing attention, then, prevents the lower left frontal lobe from playing its normal role in elaborative encoding, and the result is absentminded forgetting.

**How is memory affected for someone whose attention is divided?**

Another common cause of absentmindedness is forgetting to carry out actions that we planned to do in the future. On any given day, you need to remember the times and places that your classes meet, you need to remember with whom and where you are having lunch, you need to remember which grocery items to pick up for dinner, and you need to remember which page of this book you were on when you fell asleep. In other words, you have to remember to remember, and this is called **prospective memory**, or *remembering to do things in the future* (Einstein & McDaniel, 1990).

LEE LORENZ/CARTOONBANK.COM

*"It says, 'Please disregard this reminder if your check is in the mail.'"*




*Many people rely on memory aids such as calendars—and, more recently, personal digital assistants (PDAs) such as the iPhone—to help them remember to perform a particular activity in the future.*

Failures of prospective memory are a major source of absentmindedness. Avoiding these mind bugs often requires having a cue available at the moment you need to remember to carry out an action. For example, air traffic controllers must sometimes postpone an action, such as granting a pilot's request to change altitude, but remember to carry out that action a few minutes later when conditions change. In a simulated air traffic control experiment, researchers provided controllers with electronic signals to remind them to carry out a deferred request 1 minute later. The reminders were made available either during the 1-minute waiting period or at the time the controller needed to act on the deferred request. The controllers' memory for the deferred action improved only when the reminder was available at the time needed for retrieval. Providing the reminder during the waiting period did not help (Vortac, Edwards, & Manning, 1995). An early reminder, then, is no reminder at all.

## 3. Blocking

Have you ever tried to recall the name of a famous movie actor or a book you've read—and felt that the answer was "on the tip of your tongue," rolling around in your head *somewhere* but just out of reach at the moment? This tip-of-the-tongue experience is a classic example of **blocking**, which is *a failure to retrieve information that is available in memory even though you are trying to produce it*. The sought-after information has been encoded and stored, and a cue is available that would ordinarily trigger recall of it. The information has not faded from memory, and you aren't forgetting to retrieve it. Rather, you are experiencing a full-blown retrieval failure, which makes this memory mind bug especially frustrating. It seems absolutely clear that you should be able to produce the information you seek, but the fact is that you can't. Researchers have described the tip-of-the-tongue state, in particular, as "a mild torment, something like [being] on the brink of a sneeze" (Brown & McNeill, 1966, p. 326).

Blocking occurs especially often for the names of people and places (Cohen, 1990; Valentine, Brennen, & Brédart, 1996). Why? Because their links to related concepts and knowledge are weaker than for common names. That somebody's last name is Baker doesn't tell us much about the person, but saying that he *is* a baker does. To illustrate this point, researchers showed people pictures of cartoon and comic strip characters, some with descriptive names that highlight key features of the character (e.g., Grumpy, Snow White, Scrooge) and others with arbitrary names (e.g., Aladdin, Mary Poppins, Pinocchio) (Brédart & Valentine, 1998). Even though the two types of names were equally familiar to participants in the experiment, they blocked less often on the descriptive names than on the arbitrary names.

● **Why is Snow White's name easier to remember than Mary Poppins's?**

Although it's frustrating when it occurs, blocking is a relatively infrequent event for most of us. However, it occurs more often as we grow older, and it is a very common complaint among people in their 60s and 70s (Burke et al., 1991). Even more striking, some brain-damaged patients live in a nearly perpetual tip-of-the-tongue state. One patient could recall the names of only 2 of 40 famous people when she saw their photographs, compared to 25 of 40 for healthy volunteers in the control group (Semenza & Zettin, 1989). Yet she could still recall correctly the occupations of 32 of these people—the same number as healthy people could recall. This case and similar ones have given researchers important clues about what parts of the brain are involved in retrieving proper names. Name blocking usually results from damage to parts of the left temporal lobe on the surface of the cortex, most often as a result of a stroke. In fact, studies that show strong activation of regions within the temporal lobe when people recall proper names support this idea (Damasio et al., 1996; Tempini et al., 1998).

## 4. Memory Misattribution

Shortly after the devastating 1995 bombing of the federal building in Oklahoma City, police set about searching for two suspects they called John Doe 1 and John Doe 2. John Doe 1 turned out to be Timothy McVeigh, who was quickly apprehended

**ONLY HUMAN**

**MONEY TO BURN** Chef Albert Grabham of the New House Hotel in Wales hid the restaurant's New Year's Eve earnings in the oven. He failed to remember that when he lit the same oven to prepare New Year's Day lunch.

**blocking** A failure to retrieve information that is available in memory even though you are trying to produce it.

and later convicted of the crime and sentenced to death. John Doe 2, who had supposedly accompanied McVeigh when he rented a van from Elliott's Body Shop, 2 days before the bombing, was never found. In fact, John Doe 2 had never existed; he was a product of the memory of Tom Kessinger, a mechanic at Elliott's Body Shop who was present when McVeigh rented the van. The day after, two other men had also rented a van in Kessinger's presence. The first man, like McVeigh, was tall and fair. The second man was shorter and stockier, was dark haired, wore a blue-and-white cap, and had a tattoo beneath his left sleeve—a match to the description of John Doe 2. Kessinger had confused his recollections of men he had seen on separate days in the same place. He was a victim of **memory misattribution:** *assigning a recollection or an idea to the wrong source* (**FIGURE 5.13**).

**memory misattribution** Assigning a recollection or an idea to the wrong source.

**source memory** Recall of when, where, and how information was acquired.

DAVID GLASS/AP PHOTO

FBI/THE OKLAHOMAN/AP PHOTO

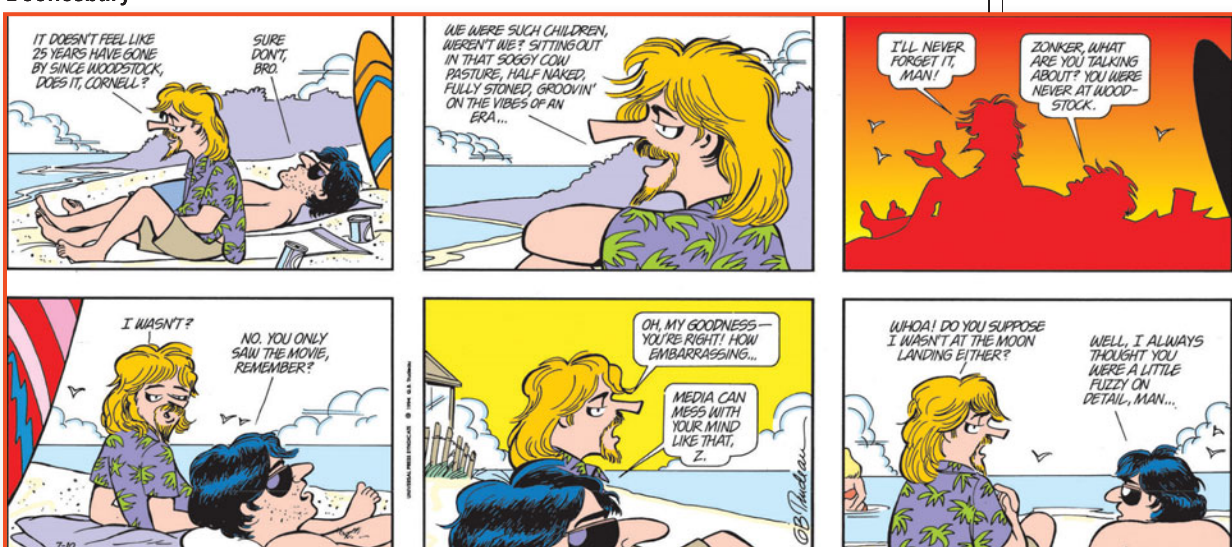
**FIGURE 5.13 Memory Misattribution** *In 1995, the Murrah Federal Building in Oklahoma City was bombed in an act of terrorism. The police sketch shows "John Doe 2," who was originally thought to have been culprit Timothy McVeigh's partner in the bombing. It was later determined that the witness had confused his memories of different men whom he had encountered at Elliott's Body Shop on different days.*

Memory misattribution errors are some of the primary causes of eyewitness misidentifications. The memory researcher Donald Thomson was accused of rape based on the victim's detailed recollection of his face, but he was eventually cleared when it turned out he had an airtight alibi. At the time of the rape, Thompson was giving a live television interview on the subject of distorted memories! The victim had been watching the show just before she was assaulted and misattributed her memory of Thomson's face to the rapist (Schacter, 1996; Thomson, 1988).

Part of memory is knowing where our memories came from. This is known as **source memory:** *recall of when, where, and how information was acquired* (Johnson, Hashtroudi, & Lindsay, 1993; Schacter, Harbluk, & McLachlan, 1984). People sometimes correctly recall a fact they learned earlier or accurately recognize a person or object they have seen before but misattribute the source of this knowledge—just as happened to Tom Kessinger and the rape victim in the Donald Thomson incident (Davies, 1988). Such misattribution could be the cause of déjà vu experiences, where you suddenly feel that you have been in a situation before even

● What can explain a déjà vu experience?

**Doonesbury**



though you can't recall any details. A present situation that is similar to a past experience may trigger a general sense of familiarity that is mistakenly attributed to having been in the exact situation previously (Reed, 1988).

Patients with damage to the frontal lobes are especially prone to memory misattribution errors (Schacter et al., 1984; Shimamura & Squire, 1987). This is probably because the frontal lobes play a significant role in effortful retrieval processes, which are required to dredge up the correct source of a memory. These patients sometimes produce bizarre misattributions. In 1991, a British photographer in his mid-40s known as MR was overcome with feelings of familiarity about people he didn't know. He kept asking his wife whether each new passing stranger was "somebody"—a screen actor, television newsperson, or local celebrity. MR's feelings were so intense that he often could not resist approaching strangers and asking whether they were indeed famous celebrities. When given formal tests, MR recognized the faces of actual celebrities as accurately as did healthy volunteers in the control group. But MR also "recognized" more than 75% of unfamiliar faces, whereas healthy controls hardly ever did. Neurological exams revealed that MR suffered from multiple sclerosis, which had caused damage to his frontal lobes (Ward et al., 1999).

**TABLE 5.1**

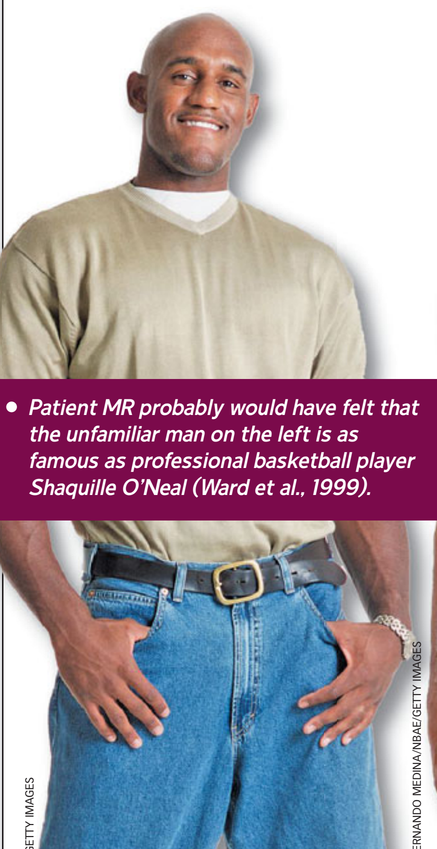
**False Recognition**

| | | | |
|---|---|---|---|
| Sour | Honey | Thread | Haystack |
| Candy | Soda | Pin | Pain |
| Sugar | Chocolate | Eye | Hurt |
| Bitter | Heart | Sewing | Injection |
| Good | Cake | Point | Syringe |
| Tooth | Tart | Prick | Cloth |
| Nice | Pie | Thimble | Knitting |

But we are all vulnerable to memory misattribution. Take the following test and there is a good chance that you will experience false recognition for yourself. First study the two lists of words presented in **TABLE 5.1** by reading each word for about 1 second. When you are done, return to the paragraph you were reading for more instructions, but don't look back at the table!

Now, try to recognize which of the following words appeared on the list you just studied: *taste, bread, needle, king, sweet,* and *thread*. If you think that *taste* and *thread* were on the lists you studied, you're right. And if you think that *bread* and *king* weren't on those lists, you're also right. But if you think that *needle* or *sweet* appeared on the lists, you're dead wrong.

Most people make exactly the same mistake, claiming with confidence that they saw *needle* and *sweet* on the list. This occurs because all the words in the lists are associated with *needle* or *sweet*. Seeing each word in the study list activates related words. Because *needle* and *sweet* are related to all of the associates, they become more activated than other words—so highly activated that only minutes later, people swear that they actually studied the words (Deese, 1959; Roediger & McDermott, 1995, 2000). In fact, brain scanning studies using PET and fMRI show that many of the same brain regions are active during false recognition and true recognition, including the hippocampus (Cabeza et al., 2001; Schacter et al., 1996b; Slotnick & Schacter, 2004) (**FIGURE 5.14**). It is possible, however, to reduce or avoid false recognition by presenting distinctive information, such as a picture of *thread,* and encouraging participants to require specific recollections of seeing the picture before they say "yes" on a recognition test (Schacter, Israel, & Racine, 1999). Unfortunately, we do not always demand specific recollections before we say that we encountered a word in an experiment or—more importantly—make a positive identification of a suspect. When people experience a strong sense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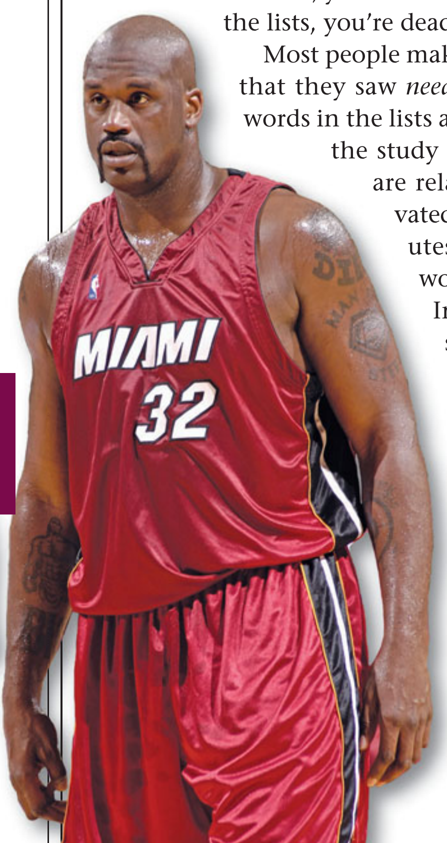
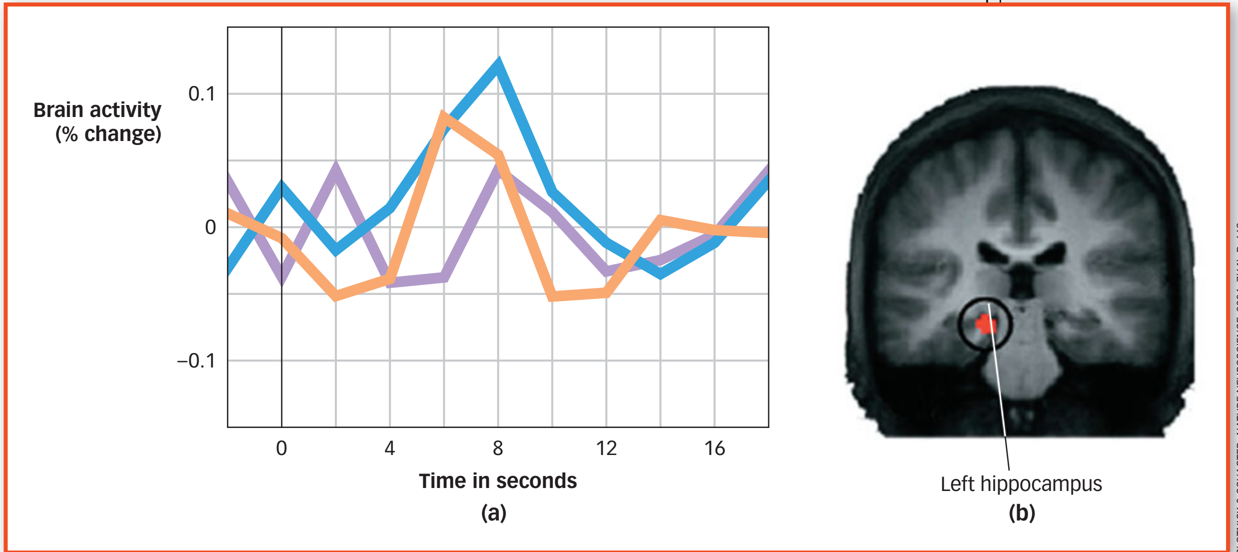


FERNANDO MEDINA/NBAE/GETTY IMAGES

*Patient MR probably would have felt that the unfamiliar man on the left is as famous as professional basketball player Shaquille O'Neal (Ward et al., 1999).*




SLOTNICK & SCHACTER, *NATURE NEUROSCIENCE*, 2004, 7(61), P. 669.

**FIGURE 5.14** **Hippocampal Activity during True and False Recognition** *Many brain regions show similar activation during true and false recognition, including the hippocampus. The figure shows results from an fMRI study of true and false recognition of visual shapes (Slotnick & Schacter, 2004). (a) A plot showing the activity level in the strength of the fMRI signal from the hippocampus over time. This shows that after a few seconds, there is comparable activation for true recognition of previously studied shapes (red line) and false recognition of similar shapes that were not presented (yellow line). Both true and false recognition show increased hippocampal activity compared with correctly classifying unrelated shapes as new (purple line). (b) A region of the left hippocampus.*

of familiarity about a person, object, or event but lack specific recollections, a potentially dangerous recipe for memory misattribution is in place. Understanding this point may be a key to reducing the dangerous consequences of misattribution in eyewitness testimony (see the Real World box on the next page).

## 5. Suggestibility

On October 4, 1992, an El Al cargo plane crashed into an apartment building in a southern suburb of Amsterdam, killing 39 residents and all 4 members of the airline crew. The disaster dominated news in the Netherlands for days as people viewed footage of the crash scene and read about the catastrophe. Ten months later, Dutch psychologists asked a simple question of university students: "Did you see the television film of the moment the plane hit the apartment building?" Fifty-five percent answered "yes." (Crombag et al., 1996). All of

ALBERT OVERBEEK/AP PHOTO

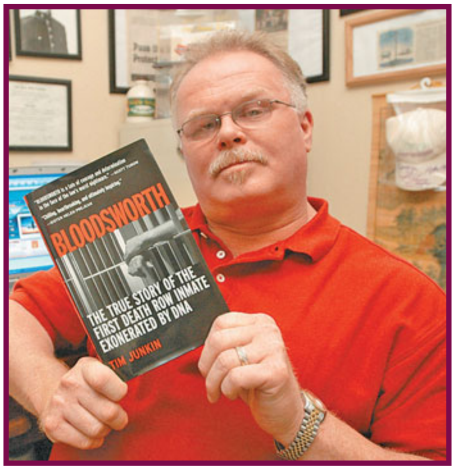
*In 1992, an El Al cargo plane crashed into an apartment building in a suburb of Amsterdam. When Dutch psychologists asked students if they'd seen the television film of the plane crashing, most said they had. In fact, no such footage exists (Crombag, Wagenaar, & Koppen, 1996).*

[THE REAL WORLD]

## Deadly Misattributions

On July 25, 1984, a 9-year-old girl was found dead in the woods near Baltimore after being brutally beaten and sexually assaulted. A witness identified 23-year-old Kirk Bloodsworth as the killer, based on a sketch police generated from five other witness accounts. Although Bloodsworth passionately maintained his innocence, a jury convicted him of first-degree murder, and the judge sentenced him to death. After Bloodsworth spent 2 years on death row, the sentence was reduced to life in prison on an appeal. In 1993, DNA testing revealed that Bloodsworth was not the source of incriminating semen stains in the victim's underwear. He was released from prison after serving 9 years, later received a full pardon, and returned to his quiet life as a crab fisherman (Chebium, 2000; Connors, Lundregan, Miller, & McEwen, 1997; Wells et al., 1998). The witness's memory misattribution cost Bloodsworth a decade of his life, and his mother did not live to see him freed: She died of a heart attack several months before his release.

Bloodsworth is not alone. The first 40 cases in which DNA evidence led to the release of wrongfully imprisoned individuals revealed that 36 of the convictions—90%—were based partly or entirely on mistaken eyewitness identification (Wells et al., 1998). Fifty separate eyewitnesses were involved in these cases; they were all confident in their memories but seriously mistaken. These statistics are especially troubling because eyewitness testimony is frequently relied on in




TODD DUDEK/AP PHOTO

*Kirk Bloodsworth spent 9 years behind bars for a crime he didn't commit. He was released after DNA evidence led to the reversal of his conviction based on mistaken eyewitness testimony. Here he holds up the book that tells his story, by author and attorney Tim Junkin.*

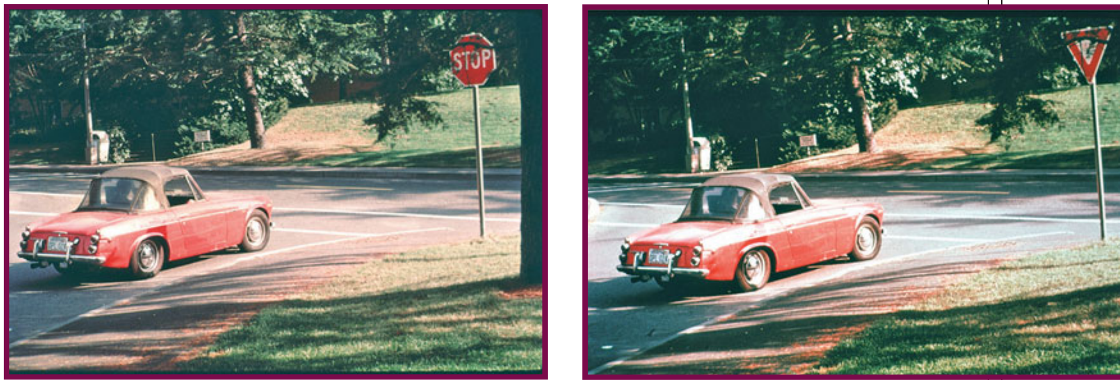
the courtroom: Each year more than 75,000 criminal trials are decided on the basis of eyewitness testimony (Ross et al., 1994, p. 918). Common lineup identification practices may often promote misattribution because people are encouraged to rely on general familiarity (Wells et al., 1998, 2000). In standard lineup procedures, witnesses are shown several suspects; after seeing all of them, they attempt to identify the culprit. Under these conditions, witnesses tend to rely on "relative judgments": They choose the person who, relative to the others in the lineup, looks most like the suspect. The problem is that even when the suspect is *not* in the lineup, witnesses still tend to choose the person who looks most like the suspect. Witnesses rely on general similarities between a face in a lineup and the actual culprit, even when they lack specific recollections of the culprit. There are ways to minimize reliance on relative judgments. For example, witnesses can be asked to make a "thumbs-up or thumbs-down" decision about each suspect immediately after seeing each face instead of waiting until all suspects' faces have been displayed (Wells et al., 1998, 2000). This procedure encourages people to examine their memories more carefully and evaluate whether the pictured suspect matches the details of their recollections.

One encouraging development is that law enforcement officials are listening to what psychologists have to say about the construction of lineups and other identification procedures that could promote inaccurate identification. In early 1998, then attorney general Janet Reno formed a working group of psychologists, police, and attorneys to develop guidelines for collecting eyewitness evidence. This group eventually published a set of guidelines based on rigorous psychological studies that provide law enforcement officials with specific steps to take when questioning witnesses or constructing lineups in order to reduce the likelihood of eyewitness errors (Wells et al., 2000).

this might seem perfectly normal except for one key fact: There was no television film of the moment when the plane actually crashed. The researchers had asked a suggestive question that implied that television film of the crash had been shown. Respondents may have viewed television film of the postcrash scene, and they may have read, imagined, or talked about what might have happened when the plane hit the building, but they most definitely did not see it. The suggestive question led participants to misattribute information from these or other sources to a film that did not exist. **Suggestibility** is the *tendency to incorporate misleading information from external sources into personal recollections*.

Research evidence of suggestibility abounds. For example, in one study, Elizabeth Loftus and her colleagues showed participants a videotape of an automobile accident involving a white sports car (Loftus, 1975; Loftus et al., 1978). Some participants were then asked how fast the car was going when it passed the barn. Nearly 20% of these

**suggestibility** The tendency to incorporate misleading information from external sources into personal recollections.




COURTESY OF ELIZABETH LOFTUS

*In a classic experiment by Elizabeth Loftus, people were shown a videotape of a car at a stop sign. Those who later received a misleading suggestion that the car had stopped at a yield sign often claimed they had seen the car at a yield sign (Loftus et al., 1978).*

individuals later recalled seeing a barn in the videotape—even though there was no barn (participants who weren't asked about a barn almost never recalled seeing one). In later experiments, Loftus showed that people who received a misleading suggestion that they had earlier seen a car stop at a yield sign (they had actually seen the car at a stop sign) often claimed later to remember seeing a yield sign. Misleading suggestions do not eliminate the original memory (Berkerian & Bowers, 1983; McCloskey & Zaragoza, 1985). Instead, they cause participants to make source memory errors: They have difficulty recollecting whether they actually saw a yield sign or only learned about it later.

Other researchers have also successfully implanted false memories of childhood experiences in a significant minority of participants (Hyman & Billings, 1998; Hyman & Pentland, 1996). In one study, college students were asked about several childhood events that, according to their parents, actually happened. But they were also asked about an event that never happened. For instance, the students were asked if they remembered a wedding reception they attended when they were 5, running around with some other kids and bumping into a table and spilling the punch bowl on the parents of the bride. Students remembered nearly all of the true events and initially reported no memory for the false events. However, with repeated probing, approximately 20% to 40% of the participants in different experimental conditions eventually came to describe some memory of the false event.

People develop false memories in response to suggestions for some of the same reasons memory misattribution occurs. We do not store all the details of our experiences in memory, making us vulnerable to accepting suggestions about what might have happened or should have happened. In addition, visual imagery plays an important role in constructing false memories (Goff & Roediger, 1998). Asking people to imagine an event like spilling punch all over the bride's parents at a wedding increases the likelihood that they will develop a false memory of it (Hyman & Pentland, 1996).

**Why can childhood memories be influenced by suggestion?**

Suggestibility played an important role in a controversy that arose during the 1980s and 1990s concerning the accuracy of childhood memories that people recall during psychotherapy. One highly publicized example involved a woman named Diana Halbrooks. After a few months in psychotherapy, she began recalling disturbing incidents from her childhood—for example, that her mother had tried to kill her and that her father had abused her sexually. Although her parents denied that these events had ever occurred, her therapist encouraged her to believe in the reality of her memories. Had Halbrooks retrieved terrible memories of events that had actually occurred, or were the memories inaccurate, perhaps the result of suggestive probing during psychotherapy?

Several kinds of evidence suggest that many recovered memories are inaccurate. First, some people have recovered highly implausible memories of being abused repeatedly during bizarre practices in satanic cults, and yet there is no proof of these practices or even that the cults exist (Pendergrast, 1995; Wright, 1994). Second, a number of the techniques used by psychotherapists to try to pull up forgotten childhood memories are clearly suggestive. A survey of 145 therapists in the United States revealed that approximately 1 in 3 tried to help patients remember childhood sexual abuse by using hypnosis or by encouraging them to imagine incidents that might or might not have actually happened (Poole et al., 1995). Yet research has shown that imagining past events and hypnosis can help create false memories (Garry, Manning, Loftus, & Sherman, 1996; Hyman & Pentland, 1996; McConkey, Barnier, & Sheehan, 1998). Although some recovered memories (especially those that patients remember on their own) are probably accurate, those recovered using techniques such as visualization that are known to create false memories in the lab are probably suspect.

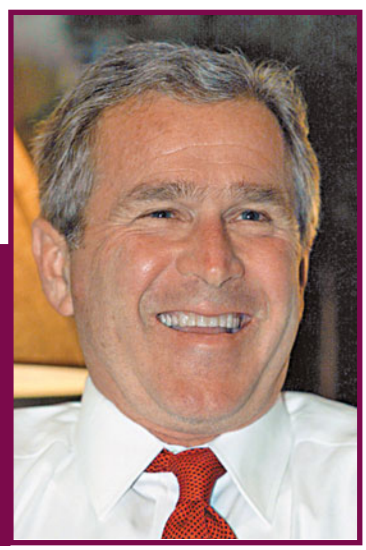
A growing number of patients eventually retracted their recovered memories after leaving therapy or returning to their families (McHugh, Lief, Freyd, & Fetkewicz, 2004). This is just what happened to Diana Halbrooks: She stopped therapy and eventually came to realize that the "memories" she had recovered were inaccurate. By the end of the 1990s, the number of new cases of disputed recovered memories of childhood sexual abuse had slowed to a trickle (McHugh et al., 2004). This probably occurred, at least in part, because some of the therapists who had been using suggestive procedures stopped doing so (McNally, 2003).

## 6. Bias

In 2000, the outcome of a very close presidential race between George W. Bush and Al Gore was decided by the Supreme Court 5 weeks after the election had taken place.

The day after the election (when the result was still in doubt), supporters of Bush and Gore were asked to predict how happy they would be after the outcome of the election was determined (Wilson, Meyers, & Gilbert, 2003). These same respondents reported how happy they felt with the outcome on the day after Al Gore conceded. And 4 months later, the participants recalled how happy they had been right after the election was decided.

Bush supporters, who eventually enjoyed a positive result (their candidate took office), were understandably happy on the day after the Supreme Court's decision. However, their retrospective accounts *over*estimated how happy they were at the time. Conversely, Gore supporters were not pleased with the outcome. But when polled 4 months after the election was decided, Gore supporters *under*estimated how happy they actually were at the time of the result. In both groups, recollections of happiness were at odds with existing reports of their actual happiness at the time (Wilson et al., 2003).


PAUL J. RICHARDS/AFP/GETTY IMAGES


DOUG MILLS/AP PHOTO

*How happy do you think you'd be if the candidate you supported won an election? Do you think you'd accurately remember your level of happiness if you recalled it several months later? Chances are good that bias in the memory process would alter your recollection of your previous happiness. Indeed, 4 months after they heard the outcome of the 2000 presidential election, Bush supporters overestimated how happy they were, while Gore supporters underestimated how happy they were.*

These results illustrate the problem of **bias,** which is *the distorting influences of present knowledge, beliefs, and feelings on recollection of previous experiences*. Sometimes what people remember from their pasts says less about what actually happened than about what they think, feel, or believe now.

Researchers have also found that our current moods can bias our recall of past experiences (Bower, 1981; Eich, 1995). So, in addition to helping you recall actual sad memories (as you saw earlier in this chapter), a sad mood can also bias your recollections of experiences that may not have been so sad. *Consistency bias* is the bias to reconstruct the past to fit the present. One researcher asked people in 1973 to rate their attitudes toward a variety of controversial social issues, including legalization of marijuana, women's rights, and aid to minorities (Marcus, 1986). They were asked to make the same rating again in 1982 and also to indicate what their attitudes had been in 1973. Researchers found that participants' recollections of their 1973 attitudes in 1982 were more closely related to what they believed in 1982 than to what they had actually said in 1973.

● How does your current outlook color your memory of a past event?

*The way each member of this happy couple recalls earlier feelings toward the other depends on how each currently views their relationship.*

ANDERSEN ROSS/PHOTOLIBRARY

Whereas consistency bias exaggerates the similarity between past and present, *change bias* is the tendency to exaggerate differences between what we feel or believe now and what we felt or believed in the past. In other words, change biases also occur. For example, most of us would like to believe that our romantic attachments grow stronger over time. In one study, dating couples were asked, once a year for 4 years, to assess the present quality of their relationships and to recall how they felt in past years (Sprecher, 1999). Couples who stayed together for the 4 years recalled that the strength of their love had increased since they last reported on it. Yet their actual ratings at the time did not show any increases in love and attachment. Objectively, the couples did not love each other more today than yesterday. But they did from the subjective perspective of memory.

A special case of change bias is *egocentric bias,* the tendency to exaggerate the change between present and past in order to make ourselves look good in retrospect. For example, students sometimes remember feeling more anxious before taking an exam than they actually reported at the time (Keuler & Safer, 1998), and blood donors sometimes recall being more nervous about giving blood than they actually were (Breckler, 1994). In both cases, change biases color memory and make people feel that they behaved more bravely or courageously than they actually did. Similarly, when college students tried to remember high school grades and their memories were checked against actual transcripts, they were highly accurate for grades of A (89% correct) and extremely inaccurate for grades of D (29% correct) (Bahrick, Hall, & Berger, 1996). The students were remembering the past as they wanted it to be rather than the way it was.

## 7. Persistence

The artist Melinda Stickney-Gibson awoke in her apartment to the smell of smoke. She jumped out of bed and saw black plumes rising through cracks in the floor. Raging flames had engulfed the entire building, and there was no chance to escape except by jumping from her third-floor window. Shortly after she crashed to the ground, the

**bias** The distorting influences of present knowledge, beliefs, and feelings on recollection of previous experiences.

BETTMANN/CORBIS

KATHY WILLENS/AP PHOTO

*Some events are so emotionally charged, such as the Kennedy assassination and the terrorist attack on the World Trade Center, that we form unusually detailed memories of when and where we heard about them. These flashbulb memories generally persist much longer than memories for more ordinary events.*

building exploded into a brilliant fireball. Although she survived the fire and the fall, Melinda became overwhelmed by memories of the fire. When she sat down in front of a blank canvas to start a new painting, her memories of that awful night intruded. Her paintings, which were previously bright, colorful abstractions, became dark meditations that included only black, orange, and ochre—the colors of the fire (Schacter, 1996).

Melinda Stickney-Gibson's experiences illustrate memory's seventh and most deadly sin: **persistence**, or *the intrusive recollection of events that we wish we could forget*. Melinda's experience is far from unique: Persistence frequently occurs after disturbing or traumatic incidents, such as the fire that destroyed her home. Although being able to quickly call up memories is usually considered a good thing, in the case of persistence, that ability mutates into a bedeviling mind bug.

## How does emotional trauma affect memory?

Intrusive memories are undesirable consequences of the fact that emotional experiences generally lead to more vivid and enduring recollections than nonemotional experiences do. One line of evidence comes from the study of **flashbulb memories**, which are *detailed recollections of when and where we heard about shocking events*. For example, most Americans can recall exactly where they were and how they heard about the September 11, 2001, terrorist attacks on the World Trade Center and the Pentagon—almost as if a mental flashbulb had gone off and recorded the event in long-lasting and vivid detail. Enhanced retention of flashbulb memories is partly attributable to the emotional arousal elicited by events such as the September 11 terrorist attacks. A key player in the brain's response to emotional events is a small almond-shaped structure called the amygdala, shown in **FIGURE 5.15.** The amygdala influences hormonal systems that kick into high gear when we experience an arousing event; these stress-related hormones, such as adrenaline and cortisol, mobilize the body in the face of threat—and they also enhance memory for the experience. Damage to the amygdala does not result in a general memory deficit. Patients with amygdala damage, however, do not remember emotional events any better than nonemotional events (Cahill & McGaugh, 1998).

For example, consider what happened when people viewed a series of photographic slides that began with a mother walking her child to school and later included an emotionally arousing event: the child being hit by a car. When tested later, the research participants remembered the arousing event better than the mundane ones. But patients

**persistence** The intrusive recollection of events that we wish we could forget.

**flashbulb memories** Detailed recollections of when and where we heard about shocking events.

with amygdala damage remembered the mundane and emotionally arousing events equally well (Cahill & McGaugh, 1998). PET and fMRI scans show that when healthy people view a slide sequence that includes an emotionally arousing event, the level of activity in their amygdalas at the time they see it is a good predictor of their subsequent memory for the slide. When there is heightened activity in the amygdala as people watch emotional events, there's a better chance that they will recall those events on a later test (Cahill et al., 1996; Kensinger & Schacter, 2005). And when people are given a drug that interferes with the amygdala-mediated release of stress hormones, their memory for the emotional sections is no better than their memory for the mundane sections.

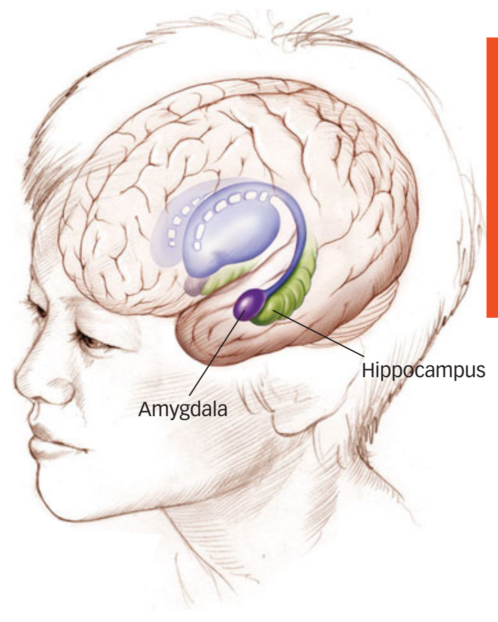



**FIGURE 5.15** **The Amygdala's Influence on Memory** *The amygdala, located next to the hippocampus, responds strongly to emotional events. Patients with amygdala damage are unable to remember emotional events any better than nonemotional ones (Cahill & McGaugh, 1998).*

In many cases, there are clear benefits to forming strong memories for highly emotional events—particularly those that are life-threatening. In the case of persistence, though, such memories may be too strong—strong enough to interfere with other aspects of daily life.

## Are the Seven Sins Vices or Virtues?

You may have concluded that evolution burdened us with an extremely inefficient memory system that is so prone to error that it often jeopardizes our well-being. Not so. The seven sins are the price we pay for the many benefits that memory provides (Schacter, 2001b). These mind bugs are the occasional result of the normally efficient operation of the human memory system.

● **How are we better off with imperfect memories?**

Consider the seemingly buggy nature of transience, for example. Wouldn't it be great to remember all the details of every incident in your life, no matter how much time had passed? Not necessarily. It is helpful and sometimes important to forget information that isn't current, like an old phone number. If we didn't gradually forget information over time, our minds would be cluttered with details that we no longer need (Bjork & Bjork, 1988). Information that is used infrequently is less likely to be needed in the future than information that is used more frequently over the same period (Anderson & Schooler, 1991, 2000). Memory, in essence, makes a bet that when we haven't used information recently, we probably won't need it in the future. We win this bet more often than we lose it, making transience an adaptive property of memory. But we are acutely aware of the losses—the frustrations of forgetting—and are never aware of the wins. This is why people are often quick to complain about their memories: The drawbacks of forgetting are painfully evident, but the benefits of forgetting are hidden.

Similarly, absentmindedness and blocking can be frustrating, but they are side effects of our memory's (usually successful) attempt to sort through incoming information, preserving details that are worthy of attention and recall, and discard those that are less worthy.

Memory misattribution and suggestibility both occur because we often fail to recall the details of exactly when and where we saw a face or learned a fact. This is because memory is adapted to retain information that is most likely to be needed in the environment in which it operates. We seldom need to remember all the precise contextual details of every experience. Our memories carefully record such details only when we think they may be needed later, and most of the time we are better off for it. Bias skews our memories so that we depict ourselves in an overly favorable light—but it can produce the benefit of contributing to our overall sense of contentment. Holding positive illusions about ourselves can lead to greater psychological well-being (Taylor, 1989). Although persistence can cause us to be haunted by traumas that we'd be better off forgetting, overall, it is probably adaptive to remember threatening or traumatic events that could pose a threat to survival.

Although each of the seven sins can cause trouble in our lives, they have an adaptive side as well. You can think of the seven sins as costs we pay for benefits that allow memory to work as well as it does most of the time.

## summary quiz [5.5]

**15.** If you carry out the same activities at work each day, by the time Friday comes, it may be difficult to recall what you did on Monday, because late-week activities blend in with early-week ones. This illustrates
a. retroactive interference.
b. proactive interference.
c. blocking.
d. memory misattribution.

**16.** When trying to recall the name of a book you read last summer, you feel that the answer is "right on the tip of your tongue." This is a classic example of
a. retroactive interference.
b. proactive interference.
c. blocking.
d. memory misattribution.

**17.** In 1992, a cargo plane crashed into an apartment building near Amsterdam. When Dutch psychologists asked students if they'd seen the television film of the plane crashing, most said they did. In fact, no such film exists. This illustrates a memory failure called
a. memory misattribution.
b. suggestibility.
c. bias.
d. persistence.

**18.** Students sometimes remember feeling more anxious before taking an exam than they actually reported at the time. This illustrates the memory failure called
a. consistency bias.
b. persistence.
c. memory misattribution.
d. egocentric bias.

**WhereDoYouStand?**

# The Mystery of Childhood Amnesia

As you have seen, transience is a pervasive characteristic of memory. Nonetheless, you can easily recall many experiences from different times in your life, such as last summer's job or vacation, the sights and sounds of a favorite concert, or the most exciting sporting event you've ever attended. But there is one period of time from which you likely have few or no memories: the first few years of your life. This lack of memory for our early years is called *childhood amnesia or infantile amnesia.*

In the 1930s and 1940s, psychologists carried out systematic studies in which they asked large samples of individuals to report their earliest memories with the dates when they occurred. These studies revealed that, on average, an individual's earliest memory dates to about 3½ years of age (Dudycha & Dudycha, 1933; Waldfogel, 1948). Later studies suggested that women report slightly earlier first memories (3.07 years of age) than men (3.4 years) (Howes, Siegel, & Brown, 1993). In one study, researchers asked individuals between 4 and 20 years old to recall as much as they could about a specific event: the birth of a younger sibling (Sheingold & Tenney, 1982). Participants who were at least 3 years old at the time of the birth remembered it in considerable detail, whereas participants who were younger than 3 years old at the time of the birth remembered little or nothing. A more recent study found that individuals can recall events surrounding the birth of a sibling that occurred when they were about 2.4 years old; some people even showed evidence of recall from ages 2.0 to 2.4 years, although these memories were very sketchy (Eacott & Crawley, 1998).

But such studies must be interpreted with caution. Memories of early events may be based on family conversations that took place long after the events occurred. An adult or a child who remembers having ice cream in the hospital as a 3-year-old when his baby sister was born may be recalling what his parents told him after the event. Consistent with this idea, cross-cultural studies have turned up an interesting finding. Individuals from cultures that emphasize talking about the past, such as North American culture, tend to report earlier first memories than individuals from cultures that place less emphasis on talking about the past, such as Korean and other Asian cultures (MacDonald, Uesilana, & Hayne, 2000; Mullen, 1994).

Recent research has examined whether the events that people say they remember from early childhood really are *personal recollections,* which involve conscious re-experiencing of some aspect of the event, or whether people *just know* about these events (perhaps from family photos and discussions), even though they don't truly possess personal recollections (Multhaup, Johnson, & Tetirick, 2005). Several experiments revealed that personal recollections tend to emerge later than memories based on "just knowing," with the transition from mostly "know" memories to mostly "recollect" memories occurring at 4.7 years.

Some events in your personal history are personal recollections. In other words, you actually remember the occurrence of the event.

Other events from your past are ones that you know happened but are not personal recollections. Instead, your knowledge of the event is based on an external source of information, perhaps your parents and/or other family members, friends, pictures, photo albums, diaries, or family stories. To find out about your own "recollected" versus "known" memories, complete the items listed here from the 2005 study by Multhaup et al.

## Instructions

Please label each of the events listed as a personal "recollection" or as an event that you "know" happened but that is not a personal memory. If you neither "recollect" nor "know" the event (perhaps because you never experienced it), please label it as "don't know." For each event you "recollect" or "know," indicate your age at the time the event occurred, as best you can determine, with the year followed by month (e.g., 4.0 is 4 years old exactly, 4.6 is 4½ years old, 4.9 is 4¾, and so forth).

| Event | Recollect | Know | Age | Don't Know |
|---|---|---|---|---|
| You read your first book with chapters. | ❒ | ❒ | ❒ | ❒ |
| You went to your first sleepover. | ❒ | ❒ | ❒ | ❒ |
| You saw your first movie in a movie theater. | ❒ | ❒ | ❒ | ❒ |
| You took your first swimming lesson. | ❒ | ❒ | ❒ | ❒ |
| You joined your first organized sports team. | ❒ | ❒ | ❒ | ❒ |
| You learned to write in cursive. | ❒ | ❒ | ❒ | ❒ |
| You stopped taking naps. | ❒ | ❒ | ❒ | ❒ |
| You learned to spell your name. | ❒ | ❒ | ❒ | ❒ |
| You went to an amusement park for the first time. | ❒ | ❒ | ❒ | ❒ |
| You were toilet trained. | ❒ | ❒ | ❒ | ❒ |
| Your first permanent tooth came in. | ❒ | ❒ | ❒ | ❒ |
| You learned to ride a bicycle (two wheels, no training wheels). | ❒ | ❒ | ❒ | ❒ |
| You slept in a bed instead of a crib. | ❒ | ❒ | ❒ | ❒ |

(Items are sampled from experiments 1 and 2 of Multhaup et al., 2005, p. 172.)

# CHAPTER REVIEW

## Summary

### Encoding: Transforming Perceptions into Memories

- Encoding is the process of transforming information into a lasting memory.
- Most instances of spectacular memory performance reflect skillful use of encoding strategies, rather than so-called photographic memory.
- Elaborative encoding, visual imagery encoding, and organizational encoding are all strategies that increase memory and use different parts of the brain.

### Storage: Maintaining Memories over Time

- There are several types of memory storage: sensory memory, which holds information for a second or two; short-term or working memory, which holds information for about 15 to 20 seconds; and long-term memory, which stores information from minutes to years or decades.
- The hippocampus and nearby structures play an important role in long-term memory storage, as shown by patients such as HM.
- Memory storage depends on changes in synapses, and long-term potentiation (LTP) increases synaptic connections.

### Retrieval: Bringing Memories to Mind

- Retrieval cues, which help reinstate how information was encoded, can help trigger successful recall of that information.
- External contexts, as well as moods and inner states, can serve as retrieval cues.
- Retrieval can be separated into the effort we make while trying to remember (which may involve the right frontal lobe of the brain) and the successful recovery of stored information (which may involve the hippocampus and also cortical areas related to sensory aspects of the material being recalled).

### Multiple Forms of Memory: How the Past Returns

- Long-term memory includes explicit memory (which can be consciously recalled) and implicit memory (the unconscious influences of past experiences on later behavior).
- Two examples of implicit memory are procedural memory, the acquisition of skills as a result of practice, and priming, a change in the ability to recognize information as the result of past exposure to that information.
- Patients with amnesia retain implicit memory, including procedural memory and priming, but lack explicit memory.
- Two subclasses of explicit memory are episodic memory, the collection of personal experiences from a particular time and place, and semantic memory, a network of general, impersonal knowledge of facts and concepts.

### Memory Failures: The Seven Sins of Memory

- Memory's mind bugs can be classified into "seven sins."
- Some of these "sins" reflect failure to retrieve information we want: Transience refers to decay of memory over time; absentmindedness can reflect failures of attention and is often associated with forgetting to do things in the future; blocking occurs when stored information is temporarily inaccessible (such as tip-of-the-tongue experiences). In contrast, persistence is the intrusive recollection of events we wish we could forget.
- Other "sins" reflect errors in memory content. Memory misattribution involves mistaken recollection of the specifics of where and when an event occurred; suggestibility is the tendency to incorporate misleading information from external sources into personal recollection; bias reflects the influence of current knowledge, beliefs, and feelings on memory.

## Key Terms

memory (p. 128)
encoding (p. 128)
storage (p. 128)
retrieval (p. 128)
elaborative encoding (p. 129)
visual imagery encoding (p. 131)
organizational encoding (p. 131)
memory storage (p. 133)
sensory memory store (p. 133)
iconic memory (p. 133)
echoic memory (p. 133)
short-term memory store (p. 133)
rehearsal (p. 134)
chunking (p. 134)
working memory (p. 134)
long-term memory store (p. 134)
anterograde amnesia (p. 135)
retrograde amnesia (p. 135)
long-term potentiation (LTP) (p. 136)
retrieval cue (p. 137)
encoding specificity principle (p. 138)
state-dependent retrieval (p. 138)
transfer-appropriate processing (p. 138)
explicit memory (p. 140)
implicit memory (p. 140)
procedural memory (p. 140)
priming (p. 141)
semantic memory (p. 142)
episodic memory (p. 142)
transience (p. 143)
retroactive interference (p. 144)
proactive interference (p. 145)
absentmindedness (p. 145)
prospective memory (p. 145)
blocking (p. 146)
memory misattribution (p. 147)
source memory (p. 147)
suggestibility (p. 150)
bias (p. 153)
persistence (p. 154)
flashbulb memories (p. 154)

## Critical Thinking Questions

1. Elaborative encoding involves actively relating new information to facts you already know; visual imagery encoding involves storing new information by converting it into mental pictures.

   How might you use both kinds of encoding to help store a new fact, such as the date of a friend's birthday that falls on, say, November 1?

2. Retrieval cues are "hints" that help bring stored information to mind. How does this explain the fact that most students prefer multiple-choice exams to fill-in-the-blank exams?

3. Transience, absentmindedness, and blocking are three of the seven "sins" of memory, and they deal with ways that memories can be temporarily or permanently lost.

   Suppose that, mentally consumed by planning for a psychology test the next day, you place your keys in an unusual spot and later forget where you put them. Is this more likely to reflect the memory "sin" of transience, absentmindedness, or blocking?

4. Misattribution, suggestibility, and bias are three memory "sins" that involve memories that are not forgotten but distorted.

   When researchers ask romantically involved couples to rate their relationships and then ask again 2 months later, those couples whose relationships have since soured tend to recall their initial ratings as more negative than they really were. Is this more likely to reflect the memory "sin" of misattribution, suggestibility, or bias?

## Answers to Summary Quizzes

**Summary Quiz 5.1**
1. c; 2. a; 3. b; 4. d

**Summary Quiz 5.2**
5. b; 6. c; 7. a; 8. d

**Summary Quiz 5.3**
9. a; 10. c; 11. b

**Summary Quiz 5.4**
12. b; 13. c; 14. a

**Summary Quiz 5.5**
15. a; 16. c; 17. b; 18. d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