Psychology in the News

Wrongly Convicted Man and His Accuser Tell Their Story

NEW YORK, NY, January 5, 2010. St. Martin's Press has announced the release of the paperback edition of *Picking Cotton,* a remarkable true story of what novelist John Grisham calls an "account of violence, rage, redemption, and, ultimately, forgiveness."

The story began in 1987, in Burlington, North Carolina, with the rape of a young white college student named Jennifer Thompson. During her ordeal, Thompson swore to herself that she would never forget the face of her rapist, a man who climbed through the window of her apartment and assaulted her brutally. During the attack, she made an effort to memorize every detail of his face, looking for scars, tattoos, or other identifying marks. When the police asked her if she could identify the assailant from a book of mug shots, she picked one that she was sure was correct, and later she identified the same man in a lineup.

Based on her convincing eyewitness testimony, a 22-year-old black man named Ronald Cotton was sentenced to prison for two life terms. Cotton's lawyer appealed the decision, and by the time of the appeals hearing, evidence had come to light suggesting that the real rapist might have been a man who looked very like Cotton, an imprisoned criminal named Bobby Poole. Another trial was held. Jennifer Thompson looked at both men face to face, and once again said that Ronald Cotton was the one who raped her.

Eleven years later, DNA evidence completely exonerated Cotton and just as unequivocally convicted Poole, who confessed to the crime. Thompson was shocked and devastated. "The man I was so sure I had never seen in my life was the man who was inches from my throat, who raped me, who hurt me, who took my spirit away, who robbed me of my soul," she wrote. "And the man I had identified so emphatically on so many occasions was absolutely innocent."

Jennifer Thompson decided to meet Cotton and apologize to him personally. Remarkably, both were able to put this tragedy behind them, overcome the racial barrier that divided them, and write a book, which they have subtitled "Our memoir of injustice and redemption."

Nevertheless, Thompson says, she still lives "with constant anguish that my profound mistake cost him so dearly. I cannot begin to imagine what would have happened had my mistaken identification occurred in a capital case."

Ronald Cotton (left) was convicted of rape solely on the basis of Jennifer Thompson's eyewitness testimony. The real rapist, Bobby Peale (right), was eventually identified by DNA tests.

CHAPTER

8

Memory

Many criminals are sent to prison on the basis of accurate testimony by eyewitnesses. But, in the absence of corroborating evidence, should a witness's confidence in his or her memory be sufficient for establishing guilt? Much is at stake in our efforts to answer this question: getting justice for crime victims and also avoiding the false conviction of defendants who are innocent.

Memory refers to the capacity to retain and retrieve information, and also to the structures that account for this capacity. Human beings are capable of astonishing feats of memory. Most of us can easily remember the tune of our national anthem, how to use an ATM, the most embarrassing experience we ever had, and hundreds of thousands of other bits of information. Memory confers competence; without it, we would be as helpless as newborns, unable to carry out even the most trivial daily tasks. Memory also endows us with a sense of identity; each of us is the sum of our recollections. Individuals and cultures alike rely on a remembered history for a sense of coherence and meaning; memory gives us our past and guides our future.

And yet our memories can be distorted, embellished, and even completely false. Have you ever had a conversation with a sibling, parent, or friend about a memory of a shared experience, only to realize you completely differ on what "really" happened? ("I was there and remember that evening perfectly!" one of you says. "You think you were *there*?" the other says in astonishment. "You weren't even in the same city! You didn't even *know* about that evening for three months!")

This chapter will raise some fascinating but troubling questions about memory: When should we trust our memories, and when should we be cautious about doing so? We all forget things that did happen; do we also "remember" things that never happened? Are memory malfunctions the exception to the rule or commonplace? And if memory is not always reliable, how can any of us hope to know the story of our own lives? How can we hope to understand the past?

YOU are about to learn...

- why memory does not work like a camera—and how it does work.
- why errors can creep into our memories of even surprising or shocking events.
- why having strong feelings about a memory does not mean that the memory is accurate.

Reconstructing the Past

Imagine what life would be like if you could never form any new memories. That tragedy occurs in older people who are suffering from dementia and sometimes in younger people who have brain injuries or diseases. The case of one man, Henry Molaison, whom researchers called H. M. until his death in 2008 at age 82, is probably the most intensely studied in the annals of medicine (Corkin, 1984; Corkin et al., 1997; Hilts, 1995; Milner, 1970; Ogden & Corkin, 1991). In 1953, when H. M. was 27, surgeons removed most of his hippocampus, along with part of the amygdala. The operation was a last-ditch effort to relieve H. M.'s severe and life-threatening epilepsy, which was causing unrelenting, uncontrollable seizures. The operation did achieve its goal: Afterward, the young man's seizures were milder and could be managed with medication. His memory, however, had been affected profoundly. Although he continued to recall most events that had occurred before the operation, he could no longer remember new experiences for much longer than 15 minutes. Facts, songs, stories, and faces all vanished like water down the drain. He would read the same magazine over and over without realizing it. He could not recall the day of the week, the year, or even his last meal.

If this little birthday boy, sitting somewhat overwhelmed in front of his cake among his happy relatives, remembers his birthday party later in life, his construction will include details picked up from this photograph, videos, and stories. He will probably be unable to distinguish an actual memory from information he got elsewhere.

H. M. loved to do crossword puzzles and play bingo, skills acquired before the operation. But although he remained cheerful, he knew he had memory problems. He would occasionally recall an unusually emotional event, such as the assassination of someone named Kennedy, and he sometimes remembered that both of his parents were dead. But according to Suzanne Corkin, who studied H. M. extensively, these "islands of remembering" were the exceptions in a vast sea of forgetfulness. This good-natured man could not recognize a photograph of his own face, and he never remembered the scientists who studied him for decades; he was stuck in a time warp from the past.

The Manufacture of Memory

In ancient times, philosophers compared memory to a soft wax tablet that would preserve anything that chanced to make an imprint on it. Then, with the advent of the printing press, they began to think of memory as a gigantic library, storing specific events and facts for later retrieval. Today, many people compare memory to a digital recorder or video camera, automatically recording every moment of their lives.

Popular and appealing though this belief about memory is, it is utterly wrong. Not everything that happens to us or impinges on our senses is tucked away for later use. Memory is selective. If it were not, our minds would be cluttered with mental junk: the temperature at noon on Thursday, the price of turnips two years ago, a phone number needed only once. Moreover, recovering a memory is not at all like replaying a video of an event. It is more like watching a few unconnected frames and then figuring out what the rest of the scene must have been like.

One of the first scientists to make this point was the British psychologist Sir Frederic Bartlett (1932). Bartlett asked people to read lengthy, unfamiliar stories from other cultures and then tell the stories back to him. As the volunteers tried to recall the stories, they made interesting errors: They often eliminated or changed details that did not make sense to them, and they added other details to make the story coherent, sometimes even adding a moral. Memory, Bartlett concluded, must therefore

be largely a *reconstructive* process. We may reproduce some kinds of simple information by rote, said Bartlett, but when we remember complex information, we typically alter it in ways that help us make sense of the material, based on what we already know or think we know. Since Bartlett's time, hundreds of studies have found this to be true for everything from stories to conversations to personal experiences.

In reconstructing their memories, people often draw on many sources. Suppose that someone asks you to describe one of your early birthday parties. You may have some direct recollection of the event, but you may also incorporate information from family stories, photographs, or home videos, and even from accounts of other people's birthdays and reenactments of birthdays on television. You take all these bits and pieces and build one integrated account. Later, you may not be able to distinguish your actual memory from information you got elsewhere. This phenomenon is known as **source misattribution**, or sometimes *source confusion* (Johnson, Hashtroudi, & Lindsay, 1993; Mitchell & Johnson, 2009).

Of course, some shocking or tragic events—such as earthquakes, accidents, a mass killing, an assassination—do hold a special place in memory, especially when we have experienced them personally. So do some unusual, exhilaratingly happy events, such as learning that you just won a lottery. Years ago, Roger Brown and James Kulik (1977) labeled these vivid recollections of emotional events *flashbulb memories* because that term captures the surprise, illumination, and seemingly photographic detail that characterize them.

Some flashbulb memories have lasted for years, even decades. In a Danish study, older people who had lived through the Nazi occupation of their country in World War II often had an accurate memory of verifiable wartime events, such as the time of day that the radio had announced liberation and what the weather had been like at the time (Berntsen & Thomsen, 2005). Yet even flashbulb memories are not always complete or accurate. People typically remember the *gist* of a startling, emotional event they experienced or witnessed, such as the destruction of the World Trade Centers in New York in 2001. But when researchers question them about their memories over time, errors creep into the details, and after a few years, some people even forget the gist (Neisser & Harsch, 1992; Talarico & Rubin, 2003).

Even with flashbulb memories, then, facts tend to get mixed with a little fiction. Remembering is an active process, one that involves not only dredging up stored information but also putting two and two together to reconstruct the past. Sometimes, unfortunately, we put two and two together and get five.

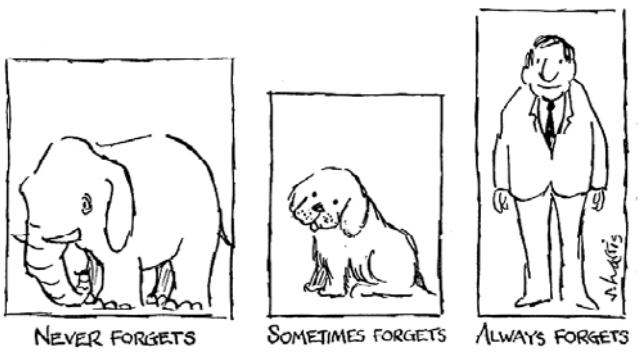
Do you remember where you were when you learned that Michael Jackson had died? Many of his fans probably have a "flashbulb" memory of hearing about his sudden death on June 25, 2009. But even flashbulb memories are not always complete or accurate, and distortions often creep in over time.

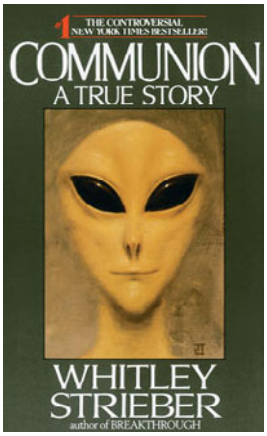
source misattribution The inability to distinguish an actual memory of an event from information you learned about the event elsewhere.

The Conditions of Confabulation

Because memory is reconstructive, it is subject to **confabulation**—confusing an event that happened to someone else with one that happened to you, or coming to believe that you remember something that never really happened. Such confabulations are especially likely under the following circumstances

confabulation Confusion of an event that happened to someone else with one that happened to you, or a belief that you remember something when it never actually happened.





In the 1980s, Whitley Strieber published the best seller *Communion*, in which he claimed to have had encounters with some sort of nonhuman beings, possibly aliens from outer space. An art director designed this striking cover. Ever since, many people have assumed that this is what an extraterrestrial must look like, and some have imported the image into their own confabulated memories of alien abduction.

(Garry et al., 1996; Hyman & Pentland, 1996; Mitchell & Johnson, 2009):

1 You have thought, heard, or told others about the imagined event many times. Suppose that at family gatherings you keep hearing about the time that Uncle Sam scared everyone at a New Year's party by pounding a hammer into the wall with such force that the wall collapsed. The story is so colorful that you can practically see Uncle Sam in your mind's eye. The more you think about this event, the more likely you are to believe that you were actually there, even if you were sound asleep in another house. This process has been called *imagination inflation*, because your own active imagination inflates your belief that the event really occurred (Garry & Polaschek, 2000). Even merely explaining how a hypothetical childhood experience *could* have happened inflates people's confidence that it really did. Explaining an event makes it seem more familiar and thus real (Sharman, Manning, & Garry, 2005).

2 The image of the event contains lots of details that make it feel real. Ordinarily, we can distinguish an imagined event from a real one by the amount of detail we recall; real events tend to produce more details. But the longer you think about an imagined event, the more details you are likely to add—what Sam was wearing, the fact that he'd had too much to drink, the crumbling plaster, people standing around in party hats—and these details may in turn persuade you that the event really happened and that you have a direct memory of it.

3 The event is easy to imagine. If imagining an event takes little effort (as does visualizing a man pounding a wall with a hammer), then we tend to think that our memory is real. In contrast, when we must make an effort to form an image of an experience—for example, of being in a place we have never seen or doing something that is utterly foreign to us—our cognitive efforts serve as a cue that the event did not really take place, or that we were not there when it did.

As a result of confabulation, you may end up with a memory that feels emotionally, vividly real to you and yet is completely false. Inaccuracies in memory can occur when you first form a memory (perhaps because your attention is divided or you are distracted) or when you later retrieve the memory (when you might confuse associated thoughts, wishes, and imagined ideas with what really happened) (Mitchell & Johnson, 2009). This means that your feelings about an event, no matter how strong they are, do not guarantee that the event really happened.

Consider again our Sam story, which happens to be true. A woman we know believed for years that she had been present as an 11-year-old child when her uncle destroyed the wall. Because the story was so vivid and upsetting to her, she felt angry at him for what she thought was his mean and violent behavior, and she assumed that she must have been angry at the time as well. Then, as an adult, she learned that she was not at the party at all but had merely heard about it repeatedly over the years. Moreover, Sam had not pounded the wall in anger, but as a joke, to inform the assembled guests that he and his wife were about to remodel their home. Nevertheless, our friend's family has had a hard time convincing her that her "memory" of this event is entirely wrong, and they are not sure she believes them yet.

As the Sam story illustrates, and as laboratory research verifies, false memories can be as stable over time as true ones (Roediger & McDermott, 1995). There's just no getting around it: Memory is reconstructive. Simulate

Simulate **Creating False Memories** on **mypsychlab.com**

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Quick Quiz

Can you reconstruct what you have read so far to answer these questions?

1. Memory is like (a) a wax tablet, (b) a giant file cabinet, (c) a video camera, (d) none of these.
2. *True or false:* Because they are so vivid, flashbulb memories remain perfectly accurate over time.
3. Which of the following confabulated "memories" might a person be most inclined to accept as having really happened to them, and why? (a) getting lost in a shopping center at the age of 5, (b) taking a class in astrophysics, (c) visiting a monastery in Tibet as a child, (d) being bullied by another kid in the fourth grade.

Answers:

1. d **2.** false **3.** a and d, because they are common events that are easy to imagine and that contain a lot of vivid details. It would be harder to induce someone to believe that he or she had studied astrophysics or visited Tibet because these are rare events that take an effort to imagine.

YOU are about to learn...

- how memories of an event can be affected by the way someone is questioned about it.
- why children's memories and testimony about sexual abuse cannot always be trusted.

Memory and the Power of Suggestion

The reconstructive nature of memory helps the mind work efficiently. Instead of cramming our brains with infinite details, we can store the essentials of an experience and then use our knowledge of the world to figure out the specifics when we need them. But precisely because memory is reconstructive, it is also vulnerable to suggestion—to ideas implanted in our minds after the event, which then become associated with it. This fact raises thorny problems in legal cases that involve eyewitness testimony or people's memories of what happened, when, and to whom.

The Eyewitness on Trial

Without the accounts of eyewitnesses, many guilty people would go free. But, as Jennifer Thompson learned to her sorrow, eyewitness testimony is not always reliable. Lineups and photo arrays don't necessarily help, because witnesses may simply identify the person who looks most like the perpetrator of the crime (Wells & Olson, 2003). As a result, some convictions based on eyewitness testimony, like that of Ronald Cotton, turn out to be tragic mistakes.

Eyewitnesses are especially likely to make mistaken identifications when the suspect's ethnicity differs from their own. Because of unfamiliarity with other ethnic groups, the eyewitness may focus solely on the ethnicity of the person they see committing a crime ("He's black"; "She's white"; "He's an Arab") and ignore the distinctive features that would later make identification more accurate (Levin, 2000; Meissner & Brigham, 2001).

In a program of research spanning nearly four decades, Elizabeth Loftus and her colleagues have shown that memories are also influenced by the way in which questions are put to the eyewitness and by suggestive comments made during an interrogation or interview. In one classic study, the researchers showed how even subtle changes in the wording of questions can lead a witness to give different answers. Participants first viewed short films depicting car collisions. Afterward, the researchers

On TV crime shows, witnesses often identify a criminal from a lineup or a group of photos. But these methods can mislead witnesses, who may wrongly identify a person because he or she resembles the actual culprit more closely than the other people do. Thanks to psychological research, many law enforcement agencies are now using better methods, such as having witnesses look at photos of suspects one at a time without being able to go back to an earlier one.

asked some of them, "About how fast were the cars going when they hit each other?" Other viewers were asked the same question, but with the verb changed to *smashed*, *collided*, *bumped*, or *contacted*. Estimates of how fast the cars were going varied, depending on which word was used. *Smashed* produced the highest average speed estimates (40.8 mph), followed by *collided* (39.3 mph), *bumped* (38.1 mph), *hit* (34.0 mph), and *contacted* (31.8 mph) (Loftus & Palmer, 1974).

In a similar study, the researchers asked some participants, "Did you see a broken headlight?" but asked others "Did you see the broken headlight?" (Loftus & Zanni, 1975). The question with *the* presupposes a broken headlight and merely asks whether the witness saw it, whereas the question with *a* makes no such presupposition. People who received questions with *the* were far more likely to report having seen something that had not really appeared in the film than were those who received questions with *a*. If a tiny word like *the* can lead people to "remember" what they never saw, you can imagine how the leading questions of police detectives and lawyers might influence a witness's recall.

Misleading information from sources other than the interviewer also can alter what witnesses report. Consider what happened when students were shown the face of a young man who had straight hair, then heard a description of the face supposedly written by another witness—a description that wrongly said the man had light, curly hair

A B

FIGURE 8.1
The Influence of Misleading Information
In a study described in the text, students saw the face of a young man with straight hair and then had to reconstruct it from memory. On the left is one student's reconstruction in the absence of misleading information about the man's hair. On the right is another person's reconstruction of the same face after exposure to misleading information that mentioned curly hair (Loftus & Greene, 1980).

(see Figure 8.1). When the students reconstructed the face using a kit of facial features, a third of their reconstructions contained the misleading detail, whereas only 5 percent contained it when curly hair was not mentioned (Loftus & Greene, 1980).

Leading questions, suggestive comments, and misleading information affect people's memories not only for events they have witnessed but also for their own experiences. Researchers have successfully used these techniques to induce people to believe they are recalling complicated events from early in life that never actually happened, such as getting lost in a shopping mall, being hospitalized for a high fever, being harassed by a bully, getting in trouble for playing a prank on a first grade teacher, or spilling punch all over the mother of the bride at a wedding (Hyman & Pentland, 1996; Lindsay et al., 2004; Loftus & Pickrell, 1995; Mazzoni et al., 1999). When people were shown a phony Disneyland ad featuring Bugs Bunny, about 16 percent later recalled having met a Bugs character at Disneyland (Braun, Ellis, & Loftus, 2002). In later studies, the percentages were even higher. Some people even claimed to remember shaking hands with the character, hugging him, or seeing him in a parade. But these memories were impossible, because Bugs Bunny is a Warner Brothers creation and would definitely be rabbit non grata at Disneyland!

Children's Testimony

The power of suggestion can affect anyone, but many people are especially concerned about its impact on children who are being questioned regarding possible sexual abuse. How can adults find out whether a young child has been sexually molested without influencing or tainting what the child says? The answer is crucial. Throughout the 1980s and 1990s, accusations of child abuse in daycare centers across the United States skyrocketed. After being interviewed by therapists and police investigators, children were claiming that their teachers had molested them in the most terrible ways: hanging them in trees, raping them, and even forcing them to eat feces. Although in no case had parents actually seen the daycare teachers treating the children badly, although none of the children had complained to their parents, and although none of the parents had noticed any symptoms or problems in their children, most of the accused teachers were sentenced to many years in prison.

Thinking Critically about Children's Testimony

Thanks largely to research by psychological scientists, the hysteria eventually subsided and people were able to assess more clearly what had gone wrong in the interviewing of the children in these cases. Today we know that although most children *do* recollect accurately much of what they have observed or experienced, many children will say that something happened when it did not. Like adults, they can be influenced by leading questions and suggestions from the person interviewing them (Ceci & Bruck, 1995). The question, therefore, is not "Can children's memories be trusted?" but "Under what conditions are children apt to be suggestible and to report that something happened to them when in fact it did not?"

The answer, from many experimental studies, is that a child is more likely to give a false report when the interviewer strongly believes that the child has been molested and then uses suggestive techniques to get the child to reveal molestation (Bruck, 2003). Interviewers who are biased in this way seek only confirming evidence and ignore discrepant evidence and other explanations for a child's behavior. They reject a child's denial of having been molested and assume the child is "in denial." They use techniques that encourage

imagination inflation ("Let's pretend it happened!") and that blur reality and fantasy in the child's mind. They pressure or encourage the child to describe terrible events, badger the child with repeated questions, tell the child that "everyone else" said the events happened, or use bribes and threats (Poole & Lamb, 1998).

A team of researchers analyzed the actual transcripts of interrogations of children in the first highly publicized sexual abuse case, the McMartin preschool case (which ended in a hung jury). Then they applied the same suggestive techniques in an experiment with preschool children (Garven et al., 1998). A young man visited children at their preschool, read them a story, and handed out treats. The man did nothing aggressive, inappropriate, or surprising. A week later, an experimenter questioned the children individually about the man's visit. She asked children in one group leading questions ("Did he bump the teacher? Did he throw a crayon at a kid who was talking?" "Did he tell you a secret and tell you not to tell?"). She asked a second group the same questions but also applied influence techniques used by interrogators in the McMartin and other daycare cases, such as telling the children what "other kids" had supposedly said, expressing disappointment if answers were negative, and praising the children for making allegations.

In the first group, children said "Yes, it happened" to about 17 percent of the false allegations about the man's visit. And in the second group, they said "yes" to the false allegations suggested to them a whopping 58 percent of the time. As you can see in Figure 8.2, the 3-year-olds in this group, on average, said "yes" to over 80 percent of the false allegations, and the 4- to 6-year-olds said "yes" to over half of the allegations. Note that the interviews in this study lasted only 5 to 10 minutes, whereas in actual investigations, interviewers often question children repeatedly over many weeks or months.

Many people believe that children cannot be induced to make up experiences that are truly traumatic, but psychologists have shown that this assumption, too, is wrong. When schoolchildren were asked for their recollections of an actual sniper incident at their school, many of those who had been absent from school that day reported memories of hearing shots, seeing someone lying on the ground, and other details they could not possibly have experienced directly. Apparently, they had been influenced by the accounts of the children who had been there (Pynoos & Nader, 1989).

Of course, some children, especially those who lack language skills and self-control, are more vulnerable to influence techniques than others. But all children can be misled under certain conditions. Rumor and hearsay play a big role in promoting false beliefs and memories in children, just as they do in adults (Principe et al., 2006).

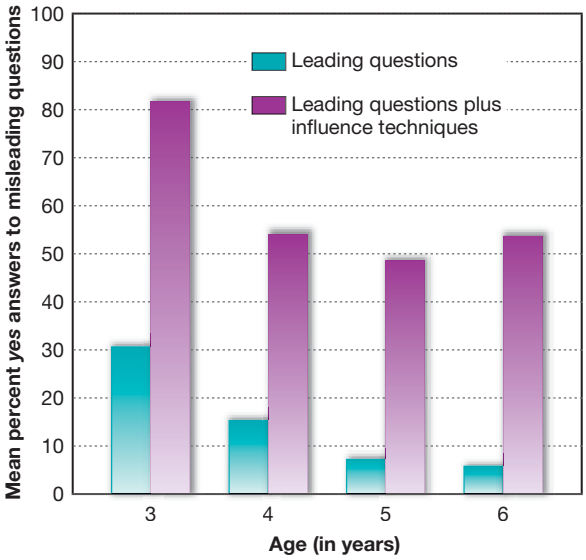


FIGURE 8.2
Social Pressure and Children's False Allegations
When researchers asked 3-year-olds leading questions about events that had not occurred—such as whether a previous visitor to their classroom had committed aggressive acts—nearly 30 percent said that yes, he had. This percentage declined among older children. But when the researchers used influence techniques taken from actual child-abuse investigations, most of the children of all ages agreed with the false allegation (Garven et al., 1998).

As a result of such findings, psychologists have been able to develop ways of interviewing children that reduce the chances of false reporting. If the interviewer says, "Tell me the reason you came to talk to me today," and nothing more, most actual victims will disclose what happened to them (Bruck, 2003). The interviewer must not assume that the child was molested, must avoid leading or suggestive questions, and must understand that children do not speak the way adults do. Young children often drift from topic to topic, and their words may not be the words adults use (Poole & Lamb, 1998). One little girl being interviewed thought her "private parts" were her elbows!

In sum, children, like adults, can be accurate in what they report and, also like adults, they can distort, forget, fantasize, and be misled. Their memory processes are only human.

Study and **Review** on **mypsychlab.com**

Quick Quiz

Now see how accurate your own memory processes are.

1. *True or false*: Mistaken identifications are more likely when a suspect's ethnicity differs from that of the eyewitness, even when the witness feels convinced that he or she is accurate.
2. Research suggests that the best way to encourage truthful testimony by children is to (a) reassure them that their friends have had the same experience, (b) reward them for saying that something happened, (c) scold them if you believe they are lying, (d) avoid leading questions.
3. Some time ago, hundreds of people in psychotherapy began claiming that they could recall long-buried memories of having taken part in satanic rituals involving animal and human torture and sacrifice. Yet local detectives and the FBI were unable to confirm any of these reports. Based on what you have learned so far, how might you explain such "memories"?

Answers:

1. true **2.** d **3.** Therapists who uncritically assumed that satanic cults were widespread may have asked leading questions and otherwise influenced their patients. Patients who were susceptible to their therapists' interpretations may then have confabulated and "remembered" experiences that did not happen, borrowing details from fictionalized accounts or from other troubling experiences in their lives. The result was source misattribution and the patients' mistaken conviction that their memories were real.

YOU are about to learn...

- **why multiple-choice test items are generally easier than short-answer or essay questions.**
- **whether you can know something without knowing that you know it.**
- **why the computer is often used as a metaphor for the mind.**

In Pursuit of Memory

Now that we have seen how memory *doesn't* work—namely, like an infallible recording of everything that happens to you—we turn to studies of how it *does* work.

Measuring Memory

explicit memory Conscious, intentional recollection of an event or of an item of information.

recall The ability to retrieve and reproduce from memory previously encountered material.

recognition The ability to identify previously encountered material.

implicit memory Unconscious retention in memory, as evidenced by the effect of a previous experience or previously encountered information on current thoughts or actions.

Conscious, intentional recollection of an event or an item of information is called **explicit memory**. It is usually measured using one of two methods. The first method tests for **recall**, the ability to retrieve and reproduce information encountered earlier. Essay and fill-in-the-blank exams require recall. The second method tests for **recognition**, the ability to identify information you have previously observed, read, or heard about. The information is given to you, and all you have to do is say whether it is old or new, or perhaps correct or incorrect, or pick it out of a set of alternatives. The task, in other words, is to compare the information you are given with the information stored in your memory. True–false and multiple-choice tests call for recognition.

Recognition tests can be tricky, especially when false items closely resemble correct ones. Under most circumstances, however, recognition is easier than recall. Recognition for visual images is particularly impressive. If you show people 2,500 slides of faces and places, and later you ask them to identify which ones they saw out of a larger set, they will be able to identify more than 90 percent of the original slides accurately (Haber, 1970).

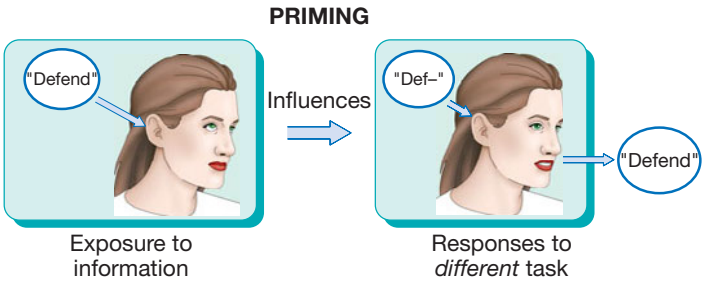
The superiority of recognition over recall was once demonstrated in a study of people's memories of their high school classmates (Bahrick, Bahrick, & Wittlinger, 1975). The participants, ages 17 to 74, first wrote down the names of as many classmates as they could remember. Recall was poor; even when prompted with yearbook pictures, the youngest people failed to name almost a third of their classmates, and the oldest failed to name most of them. Recognition, however, was far better. When asked to look at a series of cards, each of which contained a set of five photographs, and asked to say which picture in each set showed a former classmate, recent graduates were right 90 percent of the time—and so were people who had graduated 35 years earlier. The ability to recognize names was nearly as impressive.

Sometimes, information encountered in the past affects our thoughts and actions even though we do not consciously or intentionally remember it, a phenomenon known as **implicit memory**

(Schacter, Chiu, & Ochsner, 1993). To get at this subtle sort of memory, researchers must rely on indirect methods instead of the direct ones used to measure explicit memory. One common method, **priming**, which we introduced in Chapter 6 in our discussion of subliminal perception, asks you to read or listen to some information and then tests you later to see whether the information affects your performance on another type of task.

Suppose that you had to read a list of words, some of which began with the letters *def* (such as *define*, *defend*, or *deform*). Later you might be asked to complete word stems (such as *def-*) with the first word that came to mind. Even if you could not recognize or recall the original words very well, you would be more likely to complete the word fragments with words from the list than you would be if you had not seen the list. In this procedure, the original words "prime" responses on the word-completion task (that is, make them more available), showing that people can retain more knowledge about the past than they realize. They know more than they know that they know (Richardson-Klavehn & Bjork, 1988; Roediger, 1990). And they know it for a very long time. One study primed people with black-and-white picture fragments (rather than word fragments) for only 1 to 3 seconds, asking them to name the object the fragments were part of. When they were tested *17 years later*, they were again shown the same fragments and a set they had never seen. Their identification rate for the formerly primed objects was significantly higher, even when people couldn't remember having been in the original study (Mitchell, 2006).

Another way to measure implicit memory, the **relearning method**, or *savings method*, was devised by Hermann Ebbinghaus (1885/1913) in the nineteenth century. The relearning method requires you to relearn information or a task that you learned earlier. If you master it more quickly the second time around, you must be remembering something from the first experience.



Models of Memory

Although people usually refer to memory as a single faculty, as in "I must be losing my memory" or "He has a memory like an elephant's," the term *memory* actually covers a complex collection of abilities and processes. If a video camera is not an accurate metaphor for capturing these diverse components of memory, what metaphor would be better?

Many cognitive psychologists liken the mind to an information processor, along the lines of a computer, though more complex. They have constructed *information-processing models* of cognitive processes, liberally borrowing computer-programming terms such as *input*, *output*, *accessing*, and *information retrieval*. When you type something on your computer's keyboard, a software program encodes the information into an electronic language, stores it on a hard drive, and retrieves it when you need to use it. Similarly, in information-processing models of memory, we *encode* information (convert it to a form that the brain can process and use), *store* the information (retain it over time), and *retrieve* the information (recover it for use). In storage, the information may be represented as

priming A method for measuring implicit memory in which a person reads or listens to information and is later tested to see whether the information affects performance on another type of task.

relearning method A method for measuring retention that compares the time required to relearn material with the time used in the initial learning of the material.

Get Involved! Recalling Rudolph's Friends

You can try this test of recall if you are familiar with the poem that begins "'Twas the Night Before Christmas" or the song "Rudolph the Red-Nosed Reindeer." Rudolph had eight reindeer friends; name as many of them as you can. After you have done your best, turn to the Get Involved exercise on the next page for a recognition test on the same information.

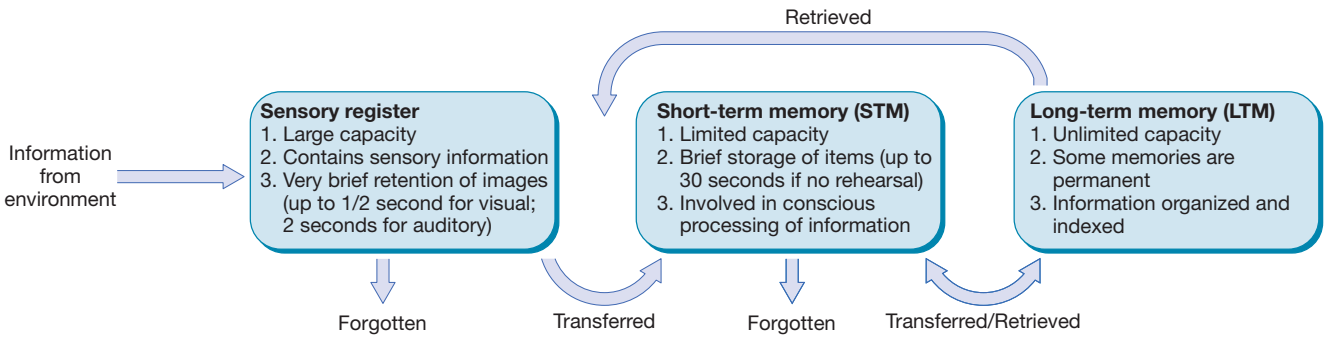


FIGURE 8.3
Three Memory Systems
In the three-box model, information that does not transfer out of the sensory register or short-term memory is assumed to be forgotten forever. Once in long-term memory, information can be retrieved for use in analyzing incoming sensory information or performing mental operations in short-term memory.

concepts, propositions, images, or *cognitive schemas*, mental networks of knowledge, beliefs, and expectations concerning particular topics or aspects of the world. (If you can't retrieve these terms, see Chapter 7.)

In most information-processing models, storage takes place in three interacting memory systems. A *sensory register* retains incoming sensory information for a second or two, until it can be processed further. *Short-term memory (STM)* holds a limited amount of information for a brief period of time, perhaps up to 30 seconds or so, unless a conscious effort is made to keep it there longer. *Long-term memory (LTM)* accounts for longer storage, from a few minutes to decades (Atkinson & Shiffrin, 1968, 1971). Information can pass from the sensory register to short-term memory and in either direction between short-term and long-term memory, as illustrated in Figure 8.3.

This model, which is known informally as the "three-box model," has dominated research on memory since the late 1960s. The problem is that the human brain does not operate like your average computer. Most computers process instructions and data sequentially, one item after another, and so the three-box model has emphasized sequential operations. In contrast, the brain performs many operations simultaneously, in parallel. It recognizes patterns all at once rather than as a sequence of information bits, and it perceives new information, produces speech, and searches memory all at the same time. It can do these things because millions of neurons are active at once, and each neuron communicates with thousands of others, which in turn communicate with millions more.

Because of these differences between human beings and machines, some cognitive scientists prefer a **parallel distributed processing (PDP)** or *connectionist* model. Instead of representing information as flowing from one system to another, a PDP model represents the contents of memory as connections among a huge number of interacting processing units, distributed in a vast network and all operating in parallel, just like the neurons of the brain (McClelland, 1994; Rumelhart, McClelland, & the PDP Research Group, 1986). As information enters the system, the ability of these units to excite or inhibit each other is constantly adjusted to reflect new knowledge.

In this chapter, we emphasize the three-box model, but keep in mind that the computer metaphor that inspired it could one day be as outdated as the metaphor of memory as a camera.

parallel distributed processing (PDP) model A model of memory in which knowledge is represented as connections among thousands of interacting processing units, distributed in a vast network, and all operating in parallel.

Get Involved! Recognizing Rudolph's Friends

If you took the recall test in the Get Involved exercise on the previous page, now try a recognition test. From the following list, see whether you can identify the correct names of Rudolph the Red-Nosed Reindeer's eight reindeer friends. The answers are at the end of this chapter, but no fair peeking!

Blitzen	Dander	Dancer	Masher
Cupid	Dasher	Prancer	Comet
Kumquat	Donner	Flasher	Pixie
Bouncer	Blintzes	Trixie	Vixen

Which was easier, recall or recognition? Can you speculate on the reason?

Quick Quiz

How well have you encoded and stored what you just learned?

1. Alberta solved a crossword puzzle a few days ago. She no longer recalls the words in the puzzle, but while playing a game of Scrabble, she unconsciously tends to form words that were in the puzzle, showing that she has _____ memories of some of the words.
2. The three basic memory processes are _____, storage, and _____.
3. Do the preceding two questions ask for recall, recognition, or relearning? (And what about *this* question?)
4. One objection to traditional information-processing theories of memory is that, unlike most computers, the brain performs many independent operations _____.

Answers:

1. implicit 2. encoding, retrieval 3. The first two questions both measure recall; the third question measures recognition. 4. simultaneously, or in parallel

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YOU are about to learn...

- **how the three "boxes" in the three-box model of memory operate.**
- **why short-term memory is like a leaky bucket.**
- **why a word can feel like it's "on the tip of your tongue" and what errors you are likely to make when you finally recall it.**
- **the difference between "knowing how" and "knowing that."**

The Three-Box Model of Memory

The information model of three separate memory systems—sensory, short-term, and long-term—remains a leading approach because it offers a convenient way to organize the major findings on memory, does a good job of accounting for these findings, and is consistent with the biological facts about memory. Let us now peer into each of the "boxes."

The Sensory Register: Fleeting Impressions

In the three-box model, all incoming sensory information must make a brief stop in the **sensory register**, the entryway of memory. The sensory register includes a number of separate memory subsystems, as many as there are senses. Visual images remain in a visual subsystem for a maximum of a half second. Auditory images remain in an auditory subsystem for a slightly longer time, by most estimates up to two seconds or so.

The sensory register acts as a holding bin, retaining information in a highly accurate form until we can select items for attention from the stream of stimuli bombarding our senses. It gives us a brief time to decide whether information is extraneous or important; not everything detected by our senses warrants our attention. And the identification of a stimulus on the basis of information already contained in long-term memory occurs during the transfer of information from the sensory register to short-term memory.

Information that does not quickly go on to short-term memory vanishes forever, like a message written in disappearing ink. That is why people who see an array of twelve letters for just a fraction of a second can only report four or five of them; by the time they answer, their sensory memories are already fading (Sperling, 1960). The fleeting nature of incoming sensations is actually beneficial; it prevents multiple sensory images—"double exposures"—that might interfere with the accurate perception and encoding of information.

sensory register A memory system that momentarily preserves extremely accurate images of sensory information.

Short-Term Memory: Memory's Scratch Pad

Like the sensory register, **short-term memory (STM)** retains information only temporarily—for up to about 30 seconds by many estimates, although some researchers think that the maximum interval may extend to a few minutes for some tasks. In short-term memory, the material is no longer an exact sensory image but is an encoding of one, such as a word or a phrase. This material either transfers into long-term memory or decays and is lost forever.

short-term memory (STM) In the three-box model of memory, a limited-capacity memory system involved in the retention of information for brief periods; it is also used to hold information retrieved from long-term memory for temporary use.

Get Involved! Your Sensory Register at Work

In a dark room or closet, swing a flashlight rapidly in a circle. You will see an unbroken circle of light instead of a series of separate points. The reason: The successive images remain briefly in the sensory register.

Individuals with brain injury, such as H. M., demonstrate the importance of transferring new information from short-term memory into long-term memory. H. M. was able to store information on a short-term basis; he could hold a conversation and his behavior appeared normal when you first met him. Yet, for the most part, he could not retain explicit information about new facts and events for longer than a few minutes. His terrible memory deficits involved a problem in transferring explicit memories from short-term storage into long-term storage. With a great deal of repetition and drill, patients like H. M. can learn some new visual information, retain it in long-term memory, and recall it normally (McKee & Squire, 1992). But usually information does not get into long-term memory in the first place.

The Leaky Bucket

People such as H. M. fall at the extreme end on a continuum of forgetfulness, but even those of us with normal memories know from personal experience how frustratingly brief short-term retention can be. We look up a telephone number, are distracted for a moment, and find that the number has vanished from our minds. We meet someone at a meeting and two minutes later find ourselves groping unsuccessfully for the person's name. Is it any wonder that short-term memory has been called a "leaky bucket"?

According to most memory models, if the bucket did not leak it would quickly overflow, because at any given moment, short-term memory can hold only so many items. Years ago, George Miller (1956) estimated its capacity to be "the magical number 7 plus or minus 2." Five-digit zip codes and 7-digit telephone numbers fall conveniently in this range; 16-digit credit card numbers do not. Some researchers have questioned whether Miller's magical number is so magical after all; estimates of STM's capacity have ranged from 2 items to 20, with one estimate putting the "magical number" at 4 (Cowan, 2010; Cowan et al., 2008). Everyone agrees, however, that the number of items that short-term memory can handle at any one time is small.

If this is so, then how do we remember the beginning of a spoken sentence until the speaker reaches the end? After all, most sentences are longer than just a few words. According to most information-processing models of memory, we overcome this problem by grouping small bits of information into larger units, or **chunks**. The real capacity of STM, it turns out, is not a few bits of information but a few chunks (Cowan & Chen, 2009). A chunk may be a word, a phrase, a sentence, or even a visual image, and it depends on previous experience. For most Americans, the acronym *FBI* is one chunk, not three, and the date *1492* is one chunk, not four. In contrast, the number *9214* is four chunks and *IBF* is three, unless your address is

If you do not play chess, you probably will not be able to recall the positions of these chess pieces after looking away from the board for a while. But experienced chess players can remember the position of every piece after glancing only briefly at the board. They are able to "chunk" the pieces into a few standard configurations instead of trying to memorize where each piece is located.

chunk A meaningful unit of information; it may be composed of smaller units.

9214 or your initials are IBF. To take a visual example: If you are unfamiliar with football and look at a field full of players, you probably won't be able to remember their positions when you look away. But if you are a fan of the game, you may see a single chunk of information—say, a wishbone formation—and be able to retain it. Simulate

But even chunking cannot keep short-term memory from eventually filling up. Information that is needed for longer periods must therefore be transferred to long-term memory. Items that are particularly meaningful or that have an emotional impact may transfer quickly. Items that require more processing will be displaced with new information, and will thus be lost, unless we do something to keep it in STM for a while, as we will discuss shortly.

Working Memory In the original three-box model, short-term memory functioned basically as a buffer for holding and rehearsing information until it could be transferred to long-term memory. Since then, many psychologists have concluded that a more complex model is needed, one in which STM also functions more actively as a **working memory** that is intimately involved in thought and intelligence (Baddeley, 1992, 2007; Engle, 2002). In this view, besides retaining new information for brief periods while we are learning it, working memory holds and operates on information that has been retrieved from long-term memory for temporary use, including verbal and visual information. It provides the mental equivalent of a scratch pad while we solve particular problems and carry out particular tasks. And it includes active "executive" processes that control the manipulation of information and interpret it appropriately depending on the task at hand. When you do an arithmetic problem, your working memory contains the numbers and the instructions for doing the necessary operations, and it also carries out those operations and retains the intermediate results from each step.

To accomplish a complex cognitive task, working memory also draws on processes that control attention and enable us to avoid distraction so that information will remain accessible and easily retrieved (Unsworth & Engle, 2007). People who do well on tests of working memory tend to do well in reading comprehension, following directions, taking notes, playing bridge, learning new words, and many other real-life tasks. When they are engrossed in challenging activities that require their concentration and effort, they stay on task longer, and their minds are less likely to wander (Kane et al., 2007).

Long-Term Memory: Final Destination

The third box in the three-box model of memory is **long-term memory (LTM)**. The capacity of long-term memory seems to have no practical limits. The vast amount of information stored there enables us to learn, get around in the environment, and build a sense of identity and a personal history.

Simulate **Digit Span** on **mypsychlab.com**

Organization in Long-Term Memory Because long-term memory contains so much information, it must be organized in some way, so that we can find the particular items we are looking for. One way to organize words is by the *semantic categories* to which they belong. *Chair*, for example, belongs to the category *furniture*. In a study done many years ago, people had to memorize 60 words that came from four semantic categories: animals, vegetables, names, and professions. The words were presented in random order, but when people were allowed to recall the items in any order they wished, they tended to recall them in clusters corresponding to the four categories (Bousfield, 1953). This finding has been replicated many times.

Evidence on the storage of information by semantic category also comes from cases of people with brain damage. In one such case, a patient called M. D. appeared to have made a complete recovery after suffering several strokes, with one odd exception: He had trouble remembering the names of fruits and vegetables. M. D. could easily name a picture of an abacus or a sphinx, but he drew a blank when he saw a picture of an orange or a carrot. He could sort pictures of animals, vehicles, and other objects into their appropriate categories, but he did poorly with pictures of fruits and vegetables. On the other hand, when M. D. was *given* the names of fruits and vegetables, he immediately pointed to the corresponding pictures (Hart, Berndt, & Caramazza, 1985). Apparently, M. D. still had information about fruits and vegetables, but his brain lesion prevented him from using their names to get to the information when he needed it, unless someone else provided the names. This evidence suggests that information in memory about a particular concept (such as *orange*) is linked in some way to information about the concept's semantic category (such as *fruit*).

Indeed, many models of long-term memory represent its contents as a vast network of interrelated concepts and propositions (Anderson, 1990; Collins & Loftus, 1975). In these models, a small part of a conceptual network for *animals* might look something like the one in Figure 8.4 on the next page. The way people use these networks, however,

working memory In many models of memory, a cognitively complex form of short-term memory that involves the active mental processes that control retrieval of information from long-term memory and interpret that information appropriately for a given task.

long-term memory (LTM) In the three-box model of memory, the memory system involved in the long-term storage of information.

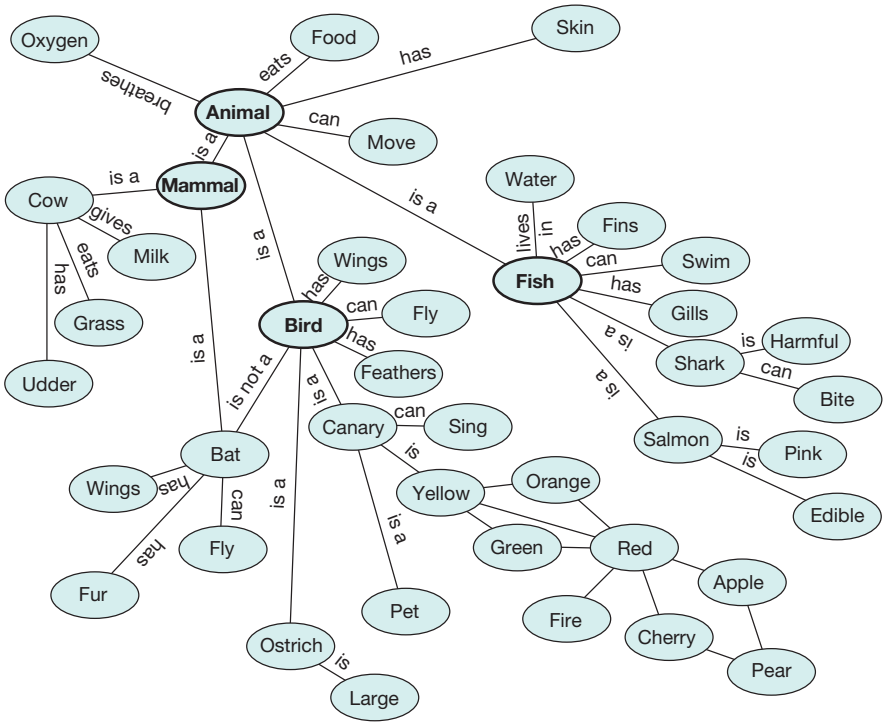

FIGURE 8.4
Part of a Conceptual Grid in Long-Term Memory
Many models of memory represent the contents of long-term semantic memory as an immense network or grid of concepts and the relationships among them. This illustration shows part of a hypothetical grid for *animals*.

procedural memories
Memories for the performance of actions or skills ("knowing how").

declarative memories
Memories of facts, rules, concepts, and events ("knowing that"); they include semantic and episodic memories.

semantic memories
Memories of general knowledge, including facts, rules, concepts, and propositions.

depends on experience and education. In rural Liberia, the more schooling children have, the more likely they are to use semantic categories in recalling lists of objects (Cole & Scribner, 1974). This makes sense, because in school, children must memorize a lot of information in a short time, and semantic grouping can help. Unschooled children, having less need to memorize lists, do not cluster items and do not remember them as well. But this does not mean that unschooled children have poor memories. When the task is one that is meaningful to them, such as recalling objects that were in a story or a village scene, they remember extremely well (Mistry & Rogoff, 1994).

We organize information in long-term memory not only by semantic groupings but also in terms of the way words sound or look. Have you ever tried to recall some word that was on the "tip of your tongue"? Nearly everyone experiences such *tip-of-the-tongue (TOT) states*, especially when trying to recall the names of acquaintances or famous people, the names of objects and places, or the titles of movies or books (Burke et al., 1991). TOT states are even reported by users of sign language, who call them tip-of-the-finger states (Thompson, Emmorey, & Gollan, 2005). When a word is on the tip of the tongue, people tend to come up with words that are similar in meaning to the right one—or similar in the starting letter, the prefix or suffix, or number of syllables—before they finally recall it (R. Brown & McNeill, 1966). For the name *Kevin* they might say, "Wait . . . it starts with a K and has two syllables . . . Kenny? Kerran? . . ."

Information in long-term memory may also be organized by its familiarity, relevance, or association with other information. The method used in any given instance probably depends on the nature of the memory; you would no doubt store information about the major cities of Europe differently from information about your first romantic kiss. To understand the organization of long-term memory, then, we must know what kinds of information can be stored there.

The Contents of Long-Term Memory

Most theories of memory distinguish skills or habits ("knowing how") from abstract or representational knowledge ("knowing that"). **Procedural memories** are memories of knowing how to do something—comb your hair, use a pencil, solve a jigsaw puzzle, knit a sweater, or swim. Many researchers consider procedural memories to be implicit, because once skills and habits are learned well, they do not require much conscious processing. **Declarative memories** involve knowing that something is true, as in knowing that Ottawa is the capital of Canada; they are usually assumed to be explicit.

Declarative memories come in two varieties: semantic memories and episodic memories (Tulving, 1985). **Semantic memories** are internal representations of the world, independent of any

Culture affects the encoding, storage, and retrieval of information in long-term memory. Navajo healers, who use stylized, symbolic sand paintings in their rituals, must commit to memory dozens of intricate visual designs because no exact copies are made and the painting is destroyed after each ceremony.

particular context. They include facts, rules, concepts, and other items of general knowledge. On the basis of your semantic memory of the concept *cat*, you can describe a cat as a small, furry mammal that typically spends its time eating, sleeping, prowling, and staring into space, even though a cat may not be present when you give this description, and you probably won't know how or when you first learned it. **Episodic memories** are internal representations of personally experienced events. When you remember how your cat once surprised you in the middle of the night by pouncing on you as you slept, you are retrieving an episodic memory. Figure 8.5 summarizes these kinds of memories.

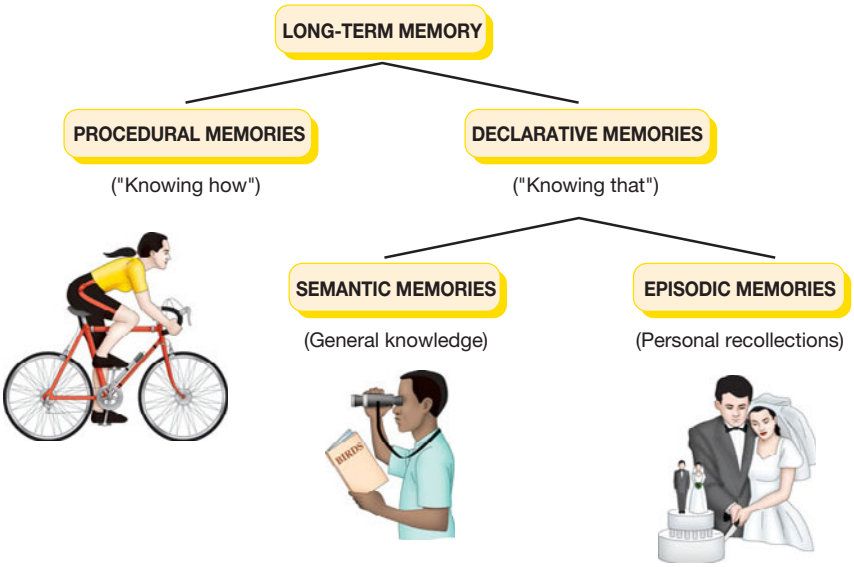

FIGURE 8.5
Types of Long-Term Memories
This diagram summarizes the distinctions among long-term memories. Can you come up with other examples of each memory type?

From Short-Term to Long-Term Memory: A Puzzle The three-box model of memory is often invoked to explain an interesting phenomenon called the **serial-position effect**. If you are shown a list of items and are then asked immediately to recall them, your retention of any particular item will depend on its position in the list (Bhatarah, Ward, & Tan, 2008; Johnson & Miles, 2009). Recall will be best for items at the beginning of the list (the *primacy effect*) and at the end of the list (the *recency effect*). A serial-position effect occurs when you are introduced to a lot of people at a party and find you can recall the names of the first few people you met and the last few, but almost no one in between.

According to the three-box model, the first few items on a list are remembered well because short-term memory is relatively empty when they enter, so these items do not have to compete with others to make it into long-term memory. They get thoroughly processed, so they remain memorable. The last few items are remembered for a different reason: At the time of recall, they are still sitting in short-term memory. The items in the middle of a list are not so well retained because by the time they get into short-term memory, it is already crowded. As a result, many of these items drop out of short-term memory before they can be stored in long-term memory. The problem with this explanation is that the recency effect sometimes occurs even after a considerable delay, when the items at the end of a list can no longer be in short-term memory (Davelaar et al., 2004). The serial-position curve, therefore, remains something of a puzzle.

Quick Quiz

Find out whether the findings just discussed have transferred from your short-term memory to your long-term memory.

1. The _____ holds images for a fraction of a second.
2. For most people, the abbreviation *USA* consists of _____ informational chunk(s).
3. Suppose you must memorize a long list of words that includes *desk*, *pig*, *gold*, *dog*, *chair*, *silver*, *table*, *rooster*, *bed*, *copper*, and *horse*. If you can recall the words in any order you wish, how are you likely to group these items in recall? Why?
4. When you go ice skating (assuming you know how), are you relying on procedural, semantic, or episodic memory? How about when you recall the months of the year? Or when you remember falling while learning to ice skate on an icy January day?
5. If a child is trying to memorize the alphabet, which sequence should present the greatest difficulty: *abcdefg*, *klmnopq*, or *tuvwxyz*? Why?

Answers:

1. sensory register **2.** one **3.** *Desk*, *chair*, *table*, and *bed* will probably form one cluster; *pig*, *dog*, *rooster*, and *horse* a second; and *gold*, *silver*, and *copper* a third. Concepts tend to be organized in long-term memory in terms of semantic categories, such as *furniture*, *animals*, and *metals*. **4.** procedural; semantic; episodic **5.** *klmnopq*, because of the serial-position effect.

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episodic memories
Memories of personally experienced events and the contexts in which they occurred.

serial-position effect
The tendency for recall of the first and last items on a list to surpass recall of items in the middle of the list.

YOU are about to learn...

- changes that occur in the brain when you store a short-term versus a long-term memory.
- where in the brain memories for facts and events are stored.
- which hormones can improve memory.

The Biology of Memory

We have been discussing memory solely in terms of information processing, but what is happening in the brain while all of that processing is going on?

long-term potentiation A long-lasting increase in the strength of synaptic responsiveness, thought to be a biological mechanism of long-term memory.

consolidation The process by which a long-term memory becomes durable and stable.

Changes in Neurons and Synapses

Forming a memory involves chemical and structural changes at the level of synapses, and these changes differ for short-term memory and long-term memory.

In short-term memory, changes within neurons *temporarily* alter their ability to release neurotransmitters, the chemicals that carry messages from one cell to another (Kandel, 2001). In contrast, long-term memory involves *lasting* structural changes in the brain. To mimic what they think may happen during the formation of a long-term memory, researchers apply brief, high-frequency electrical stimulation to groups of neurons in the brains of animals or to brain cells in a laboratory culture. In various areas, especially the hippocampus, this stimulation causes neurons at some synapses to become more responsive to transmitting neurons, making certain synaptic pathways more excitable (Bliss & Collingridge, 1993; Whitlock et al., 2006). The result of these changes, known as **long-term potentiation**, is like increasing the diameter of a funnel's neck to permit more flow through the funnel. During long-term potentiation, dendrites also grow and branch out, and some types of synapses increase in number (Greenough, 1984). At the same time, some neurons become less responsive than they were previously (Bolshakov & Siegelbaum, 1994).

Unfortunately, the most likely reason for midterm memory loss is not studying enough—or in the right way.

Most of these changes take time, which probably explains why long-term memories remain vulnerable to disruption for a while after they are stored, and why a blow to the head may disrupt new memories even though old ones are unaffected. Just as concrete takes time to set, the neural and synaptic changes in the brain that underlie long-term memory take a while to develop fully. Memories therefore undergo a period of **consolidation**, or stabilization, before they solidify. Consolidation can continue for weeks in animals and for several years in human beings. The process is usually gradual, because rapid changes would constantly disrupt the brain's existing schemas, which have been built up on the basis of past knowledge and experience (Squire, 2007).

Locating Memories

Scientists have used microelectrodes, brain-scan technology, and other techniques to identify the brain structures responsible for the formation and storage of specific types of memories. The amygdala is involved in the formation, consolidation, and retrieval of memories of fearful and other emotional events (Buchanan, 2007; see Chapter 13). Areas in the frontal lobes of the brain are especially active during short-term and working memory tasks (Goldman-Rakic, 1996; Mitchell & Johnson, 2009). The prefrontal cortex and areas adjacent to the hippocampus in the temporal lobe are also important for the efficient encoding of pictures and words.

But it is the hippocampus that has the starring role in many aspects of memory. It is critical to the formation of long-term declarative memories ("knowing that"); as we have seen in the case of H. M., damage to this structure can cause amnesia for new facts and events. And studies of rats and human beings suggest that the hippocampus is also critical in recalling past experiences (Pastalkova et al., 2008).

A team of researchers has identified how neurons in the hippocampus may become involved in specific memories. They implanted electrodes into the brains of 13 people about to undergo surgery for severe epilepsy. (This is standard procedure because it enables doctors to pinpoint the location of the brain activity causing the seizures.) As the patients were being prepped, they watched a series of 5- to 10-second film clips of popular shows such as *Seinfeld* or *The Simpsons*, or of animals and landmarks. The researchers recorded which neurons in the hippocampus were firing as the patients watched; for each patient, particular neurons might become highly active during particular videos and respond only weakly to others. After a few minutes, the patients were asked to recall what they had seen. They remembered almost all of the clips, and as they recalled each one, the very neurons that had been active when they first saw it were reignited (Gelbard-Sagiv et al., 2008). Other evidence also supports the idea that the brain regions involved in *encoding* an episode are partially reactivated when the person later *remembers* it (Danker & Anderson, 2010).

The formation and retention of procedural memories (memory for skills and habits) seem to involve other brain structures and pathways. In work with rabbits, Richard Thompson (1983, 1986) showed that one kind of procedural memory—a simple, classically conditioned response to a stimulus, such as an eye blink in response to a tone—depends on activity in the cerebellum. Human patients with damage in the cerebellum are incapable of this type of conditioning (Daum & Schugens, 1996).

The formation of declarative and procedural memories in different brain areas could explain a curious finding about patients like H. M. Despite their inability to form new declarative memories, with sufficient practice such patients can acquire new procedural memories that enable them to solve a puzzle, read mirror-reversed words, or play tennis—even though they do not recall the training sessions in which they learned these skills. Apparently, the parts of the brain involved in acquiring new procedural memories have remained intact. Patients such as H. M. also retain some implicit memory for verbal material, as measured by priming tasks. Some psychologists conclude that there must therefore be separate systems in the brain for implicit and explicit tasks. As Figure 8.6 shows, this view has been bolstered by brain scans, which reveal differences in the location of brain activity when ordinary people perform explicit versus implicit memory tasks (Reber, Stark, & Squire, 1998; Squire et al., 1992).

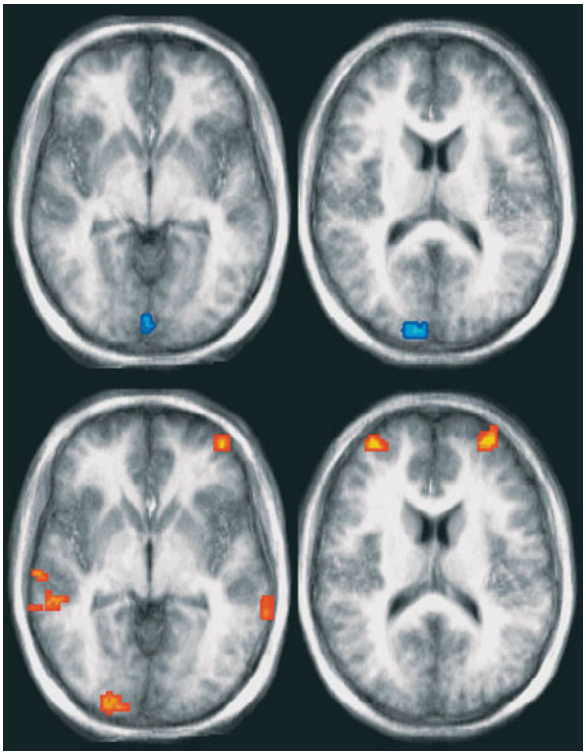

FIGURE 8.6
Brain Activity in Explicit and Implicit Memory
As these composite functional MRI scans show, patterns of brain activity differ depending on the type of memory task involved. When people had an explicit memory for dot patterns they had seen earlier, areas in the visual cortex, temporal lobes, and frontal lobes (indicated by orange in the lower photos) were more active. When people's implicit memories were activated, areas in the visual cortex (blue in the upper photos) were relatively inactive (Reber, Stark, & Squire, 1998).

The brain circuits that take part in the *formation* and *retrieval* of long-term memories, however, are not the same as those involved in long-term *storage* of those memories. Although the hippocampus is vital for formation and retrieval, the ultimate destinations of declarative memories seem to lie in parts of the cerebral cortex (Maviel et al., 2004). In fact, memories may be stored in the same cortical areas that were involved in the original perception of the information: When people remember pictures, visual parts of the brain become active. And when people remember sounds, auditory areas become active, just as they did when the information was first perceived (Nyberg et al., 2000; Thompson & Kosslyn, 2000).

The typical "memory" is a complex cluster of information. When you recall meeting a man yesterday, you remember his greeting, his tone of voice, how he looked, and where he was. These different pieces of information are probably processed separately and stored at different locations that are distributed across wide areas of the brain, with all the sites participating in the representation of the event or concept as a whole. The hippocampus may somehow bind together the diverse aspects of a memory at the time it is formed, so that even though these aspects are stored in different cortical sites, the memory can later be retrieved as one coherent entity (Squire & Zola-Morgan, 1991).

Hormones, Emotion, and Memory

Have you ever smelled fresh cookies and recalled a tender scene from your childhood? Do you have a vivid memory of seeing a particularly horrifying horror movie? Emotional memories such as these are often especially intense, and the explanation resides partly in our hormones.

Hormones released by the adrenal glands during stress and emotional arousal, including epinephrine (adrenaline) and norepinephrine, can enhance memory, probably by influencing the effects of neurotransmitters in the brain. If you give people a drug that prevents their adrenal glands from producing these hormones, they will remember less about emotional stories they heard than a control group will (Cahill et al., 1994). Conversely, if you give animals norepinephrine right after learning, their memories will improve. The link between emotional arousal and memory makes evolutionary sense: Arousal tells the brain that an event or piece of information is important enough to encode and store for future use.

However, extreme arousal is not necessarily a good thing. When animals or people are given very high doses of stress hormones, their memories for learned tasks sometimes suffer instead of improving; a moderate dose may be optimal (Andreano & Cahill, 2006). Two psychologists demonstrated the perils of high stress and anxiety in a real-life setting: the Horror Labyrinth of the London Dungeon (Valentine & Mesout, 2009). The labyrinth is a maze of disorienting mirrored walls set in Gothic vaults. As visitors walk through it, they hear strange noises and screams, and alarming things suddenly appear, including a "scary person"—an actor dressed in a dark robe, wearing makeup to appear scarred and bleeding. Volunteers wore a wireless heart-rate monitor as they walked through the labyrinth so that their stress and anxiety levels could be recorded. The higher their stress and anxiety, the less able they were to accurately describe the "scary person" later, and the fewer correct identifications they made of him in a lineup. Such effects on memory do not matter much at an amusement attraction. But they can have serious consequences when crime victims, police officers, and soldiers must recall details of a highly stressful experience, such as a shoot-out or the identity of an enemy interrogator (Morgan et al., 2007).

We have given you just a few small nibbles from the smorgasbord of findings now available about the biology of memory. Neuroscientists hope that someday they will be able to describe the entire stream of events in the brain that occur from the moment you say to yourself "I must remember this" to the moment you actually do remember . . . or find that you can't.

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Quick Quiz

We hope your memory circuits will link up to help you answer this quiz.

1. Is long-term potentiation associated with (a) increased responsiveness of certain receiving neurons to transmitting neurons, (b) a decrease in receptors on certain receiving neurons, or (c) reaching your true potential?
2. The cerebellum has been associated with _____ memories; the hippocampus has been associated with _____ memories.
3. *True or false:* Hormone research suggests that if you want to remember well, you should be as relaxed as possible while learning.

Answers:

1. a 2. procedural, declarative 3. false

YOU are about to learn...

- **how memory can be improved, and why rote methods are not the best strategy.**
- **why memory tricks, although fun, are not always useful.**

How We Remember

Once we understand the basics of how memory works, we can use that knowledge to encode and store information so that it sticks in our minds and

will be there when we need it. What are the best strategies to use?

Effective Encoding

Our memories, as we have seen, are not exact replicas of experience. When you hear a lecture you may hang on every word (we hope you do), but you do not memorize those words verbatim. You extract the main points and encode them.

To remember information well, you have to encode it accurately in the first place. With some kinds of information, accurate encoding takes place automatically, without effort. Think about where you usually sit in your psychology class. When were you last there? You can probably provide this information easily, even though you never made a deliberate effort to encode it. But many kinds of information require *effortful encoding:* the plot of a novel, the procedures for assembling a cabinet, the arguments for and against a proposed law. To retain such information, you might have to select the main points, label concepts, or associate the information with personal experiences or with material you already know. Experienced students know that most of the information in a college course requires effortful encoding, otherwise known as studying. The mind does not gobble up information automatically; you must make the material digestible.

Rehearsal

An important technique for keeping information in short-term memory and increasing the chances of long-term retention is *rehearsal*, the review or practice of material while you are learning it. When people are prevented from rehearsing, the contents of their short-term memories quickly fade (Peterson & Peterson, 1959). You are taking advantage of rehearsal when you look up a phone number and then repeat it over and over to keep it in short-term memory until you no longer need it. And when you can't remember a phone number because you have always used speed dial to call it, you are learning what happens when you *don't* rehearse!

Short-term memory holds many kinds of information, including visual information and abstract meanings. But most people, or at least most hearing people, seem to favor speech for encoding and rehearsing the contents of short-term memory. The speech may be spoken aloud or to oneself. When people make errors on short-term memory tests that use letters or words, they often confuse items that sound the same or similar, such as *d* and *t*, or *bear* and *bare*. These errors suggest that they have been rehearsing verbally.

Encoding classroom material for later recall usually requires deliberate effort. Which of these students do you think will remember best?

Some strategies for rehearsing are more effective than others. **Maintenance rehearsal** involves merely the rote repetition of the material. This kind of rehearsal is fine for keeping information in STM, but it will not always lead to long-term retention. A better strategy if you want to remember for the long haul is **elaborative rehearsal**, also called *elaboration of encoding* (Cermak & Craik, 1979; Craik & Tulving, 1975). Elaboration involves associating new items of information with material that has already been stored or with other new facts. It can also involve analyzing the physical, sensory, or semantic features of an item.

maintenance rehearsal
Rote repetition of material in order to maintain its availability in memory.

elaborative rehearsal
Association of new information with already stored knowledge and analysis of the new information to make it memorable.

When actors learn a script, they do not rely on maintenance rehearsal alone. They also use elaborative rehearsal and deep processing, analyzing the meaning of their lines and associating their lines with imagined information about the character they are playing.

deep processing In the encoding of information, the processing of meaning rather than simply the physical or sensory features of a stimulus.

Suppose that you are studying the hypothalamus, first discussed in Chapter 4. Simply memorizing the definition of the hypothalamus is unlikely to help much. But if you can elaborate the concept of the hypothalamus, you are more likely to remember it. Knowing that *hypo* means "under" tells you its location, under the thalamus. Knowing that it is part of the limbic system should clue you that it is involved in survival drives and emotion. Many students try to pare down what they are learning to the bare essentials, but in fact, knowing more details about something makes it more memorable; that is what elaboration means.

A related strategy for prolonging retention is **deep processing**, or the processing of meaning (Craik & Lockhart, 1972). If you process only the physical or sensory features of a stimulus, such as how the word *hypothalamus* is spelled and how it sounds, your processing will be shallow even if it is elaborated. If you recognize patterns and assign labels to objects or events ("The *hypo*thalamus is *below* the thalamus"), your processing will be somewhat deeper. If you fully analyze the meaning of what you are trying to remember (perhaps by encoding the functions and importance of the hypothalamus), your processing will be deeper yet. *Shallow processing* is sometimes useful; when you memorize a poem, you will want to pay attention to (and elaborately encode) the sounds of the words and the patterns of rhythm in the poem and not just the poem's meaning. Usually, though, deep processing is more effective. That is why, if you try to memorize information that has little or no meaning for you, the information may not stick. Explore

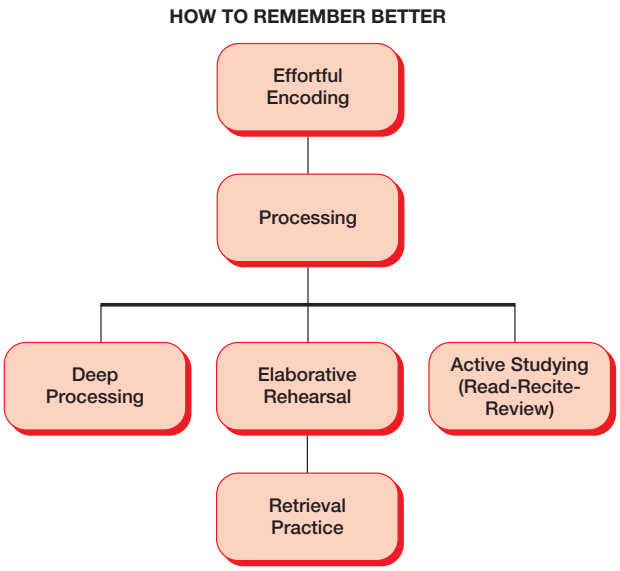
Explore **Maintaining Long-Term Memory** on **mypsychlab.com**

Read, Recite, Review

One of the reasons elaborate encoding and deep processing are so useful is that they force you to be an active rather than a passive learner. Many students believe that the best way to study for an exam is to read and reread a textbook passage until they think that they've "got it." This passive strategy feels intuitively right, but it is actually much less effective than actively rehearsing and recalling the material. In the *read-recite-review* strategy, you read the passage, close the book, hide your notes, write down (or say out loud) everything you can recall, and then review what you've read to see if you understood and remember the information. In a series of experiments, researchers compared this strategy with simply rereading and taking notes. Participants took free recall tests on the material, answered multiple-choice questions, and took short-answer tests right after studying and again a week later. The active read-recite-review strategy was the hands-down winner (McDaniel, Howard, & Einstein, 2009).

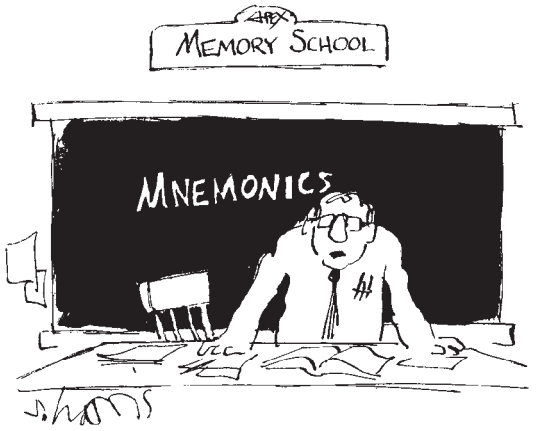
Retrieval Practice

Most students define "learning" as the ability to retrieve the correct answer to a question from memory. But then what? Once retrieved, say for an exam, does it stay put or vanish quickly like steam on a bathroom mirror? Cognitive psychologists have found that *retrieval practice* is necessary if a memory is going to undergo consolidation and therefore remain available for a long time—even after your course is over. In a series of experiments in which students learned words in foreign languages, once a student had learned the word, it was (a) repeatedly studied but dropped from further testing, (b) repeatedly tested but dropped from further studying, or (c) dropped from studying and testing. To the surprise of the students themselves, who were completely unable to predict how they would do on the tests, studying after learning had no effect on their subsequent ability to recall the foreign words. But repeated testing (that is, practice in repeatedly retrieving the words from memory) had a large, significant benefit (Karpicke & Roediger, 2008). So when your professors and your textbook authors want to keep quizzing you, why, it's only for your own good . . .



Mnemonics

In addition to using elaborative rehearsal, deep processing, strategies such as read-recite-review, and retrieval practice, people who want to give their powers



of memory a boost sometimes use **mnemonics** [neh-MON-iks], formal strategies and tricks for encoding, storing, and retaining information. (Mnemosyne, pronounced neh-MOZ-eh-nee, was the ancient Greek goddess of memory. Can you remember her?) Some mnemonics take the form of easily memorized rhymes (e.g., "Thirty days hath September/April, June, and November . . ."). Others use formulas (e.g., "**E**very **g**ood **b**oy **d**oes **f**ine" for remembering which notes are on the lines of the treble clef in musical notation). Still others use visual images or word associations. The best mnemonics force you to encode material actively and thoroughly. They may also reduce the amount of information by chunking it, which is why many companies use words for their phone numbers instead of unmemorable numbers.

mnemonics Strategies and tricks for improving memory, such as the use of a verse or a formula.

Some stage performers with amazing recall rely on far more complicated mnemonics. But for ordinary memory tasks, such as remembering a grocery list, why use a fancy mnemonic when you can write down what you need to buy? The fastest route to a good memory is to follow the principles suggested by the findings in this section and in "Taking Psychology with You."

Quick Quiz

Perhaps Mnemosyne will help you answer this question.

Camille is furious with her history professor. "I read the chapter three times, but I still failed the exam," she fumes. "The test must have been unfair." What's wrong with Camille's reasoning, and what are some other possible explanations for her poor performance, based on principles of critical thinking and what you have learned so far about memory?

Answer:

Camille is reasoning emotionally and is not examining the assumptions underlying her explanation. Perhaps she relied on automatic rather than effortful encoding, used maintenance instead of elaborative rehearsal, and used shallow instead of deep processing when she studied. Perhaps she didn't try to actively retrieve and recall the material while studying. She may also have tried to encode everything instead of being selective.

Study and **Review** on **mypsychlab.com**

YOU are about to learn...

- **the problem with remembering everything.**
- **the major reasons we forget even when we'd rather not.**
- **why most researchers are skeptical about claims of repressed and recovered memories.**

Why We Forget

Have you ever, in the heat of some deliriously happy moment, said to yourself, "I'll never forget this, never, *never*, NEVER"? Do you find that you can more clearly remember saying those words than the deliriously happy moment itself? Sometimes you encode an event, you rehearse it, you analyze its meaning, you tuck it away in long-term storage, and still you forget it. Is it any wonder that most of us have wished, at one time or another, for a "photographic memory"?

Actually, having a perfect memory is not the blessing that you might suppose. The Russian psychologist Alexander Luria (1968) once told of a journalist, S., who could reproduce giant grids of numbers both forward and backward, even after the passage of 15 years. But you should not envy him, for he had a serious problem: He could not forget even when he wanted to. Along with the diamonds of experience, he kept dredging up the pebbles. Images he had formed to aid his memory kept

creeping into consciousness, distracting him and interfering with his ability to concentrate. At times he even had trouble holding a conversation because the other person's words would set off a jumble of associations. Eventually, S. took to supporting himself by traveling from place to place, demonstrating his abilities for audiences.

Two modern people with extraordinary memories, Brad Williams and Jill Price, have offered to have their abilities studied by scientists. When given any date going back for decades, they are able to say instantly what they were doing, what day of the week it was, and whether anything of great importance happened on that date. Mention November 7, 1991, to Williams, and he says (correctly), "Let's see; that would be around when Magic Johnson announced he had HIV. Yes, a Thursday. There was a big snowstorm here the week before." Neither Williams nor Price uses mnemonics or can say where their accurate memories come from. Although Williams and his family regard his abilities as a source of amusement, Price describes her nonstop recollections as a mixed blessing (Parker, Cahill, & McGaugh, 2006). The phenomenon of constant, uncontrollable recall, she has written, is "totally exhausting. Some have called it a gift, but I call it a burden. I run my entire life through my head every day and it drives me crazy!!!"

Paradoxically, then, forgetting is adaptive: We need to forget some things if we wish to remember efficiently. Piling up facts without distinguishing the important from the trivial is just confusing. Nonetheless, most of us forget more than we want to and would like to know why.

In the early days of psychology, in an effort to measure pure memory loss independent of personal experience, Hermann Ebbinghaus (1885/1913) memorized long lists of nonsense syllables, such as *bok*, *waf*, or *ged*, and then tested his retention over a period of several weeks. Most of his forgetting occurred soon after the initial learning and then leveled off (see Figure 8.7a). Ebbinghaus's method of studying memory was adopted by

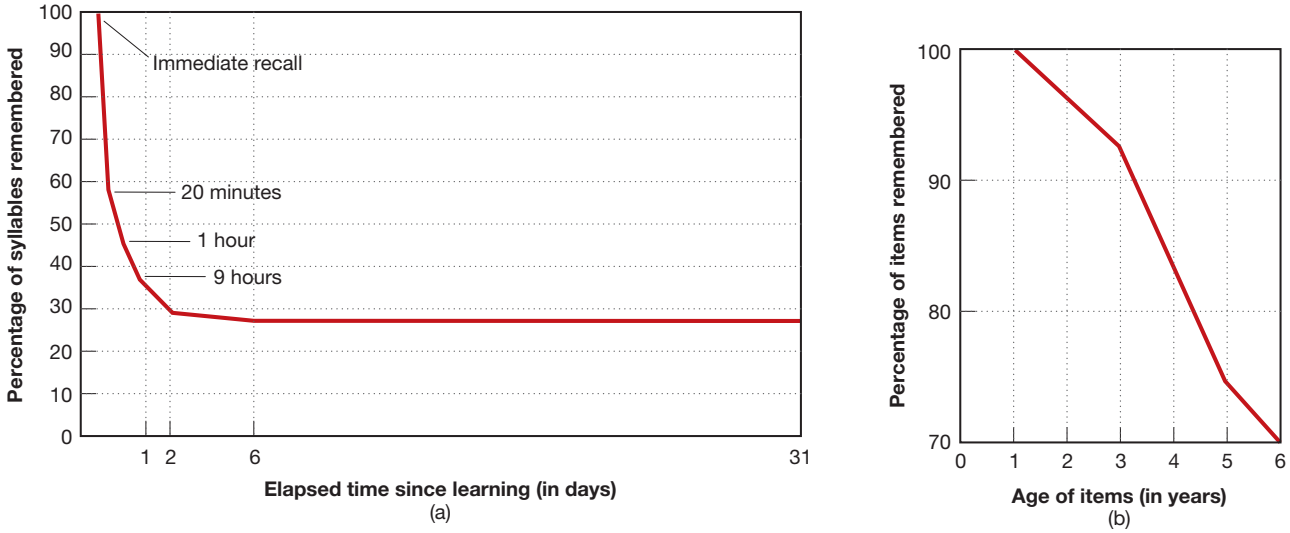


FIGURE 8.7 Two Kinds of Forgetting Curves
Hermann Ebbinghaus, who tested his own memory for nonsense syllables, found that his forgetting was rapid at first and then tapered off (a). In contrast, when Marigold Linton tested her own memory for personal events over a period of several years, her retention was excellent at first, but then it fell off at a gradual but steady rate (b).

generations of psychologists, but it did not tell them much about the kinds of memories that people care about most.

A century later, Marigold Linton decided to find out how people forget real events rather than nonsense syllables. Like Ebbinghaus, she used herself as a subject, but she charted the curve of forgetting over years rather than days. Every day for 12 years, she recorded on a 4- × 6-inch card two or more things that had happened to her that day. Eventually, she accumulated a catalogue of thousands of discrete events, both trivial ("I have dinner at the Canton Kitchen: delicious lobster dish") and significant ("I land at Orly Airport in Paris"). Once a month, she took a random sampling of all the cards accumulated to that point, noted whether she could remember the events on them, and tried to date the events. Linton (1978) expected the kind of rapid forgetting that Ebbinghaus reported. Instead, as you can see in Figure 8.7b, she found that long-term forgetting was slower and proceeded at a more constant pace, as details gradually dropped out of her memories.

Of course, some memories, especially those that mark important transitions, are more memorable than others. But why did Marigold Linton, like the rest of us, forget so many details? Psychologists have proposed five mechanisms to account for forgetting: decay, replacement of old memories by new ones, interference, cue-dependent forgetting, and repression.

Decay

One commonsense view, the **decay theory**, holds that memories simply fade with time if they are not accessed now and then. We have already seen that decay occurs in sensory memory and that it occurs in short-term memory as well unless we keep rehearsing the material. However, the mere passage of time does not account so well for forgetting in long-term memory. People commonly forget things that happened only yesterday while remembering events from many years ago. Indeed, some memories, both procedural and declarative, can last a lifetime. If you learned to swim as a child, you will still know how to swim at age 30, even if you have not been in a pool or lake for 22 years. We are also happy to report that some school lessons have great staying power. In one study, people did well on a Spanish test some 50 years after taking Spanish in high school, even though most had hardly used Spanish at all in the intervening years (Bahrick, 1984). Decay alone cannot entirely explain lapses in long-term memory.

Motor skills, which are stored as procedural memories, can last a lifetime; they never decay.

Replacement

Another theory holds that new information entering memory can wipe out old information, just as rerecording on an audiotape or videotape will obliterate the original material. In a study supporting this view, researchers showed people slides of a traffic accident and used leading questions to get them to think that they had seen a stop sign when they had really seen a yield sign, or vice versa (see Figure 8.8). People in a control group who were not misled in this way were able to identify the sign they had actually seen. Later, all the participants were told the purpose of the study and were asked to guess whether they had been misled. Almost all of those who had been misled continued to insist that they had *really*, *truly* seen the sign whose existence had been planted in their minds (Loftus, Miller, & Burns, 1978). The researchers interpreted this finding to mean that the subjects had not just been trying to please them and that people's original perceptions had in fact been erased by the misleading information.

Interference

A third theory holds that forgetting occurs because similar items of information interfere with one another in either storage or retrieval; the

decay theory The theory that information in memory eventually disappears if it is not accessed; it applies better to short-term than to long-term memory.

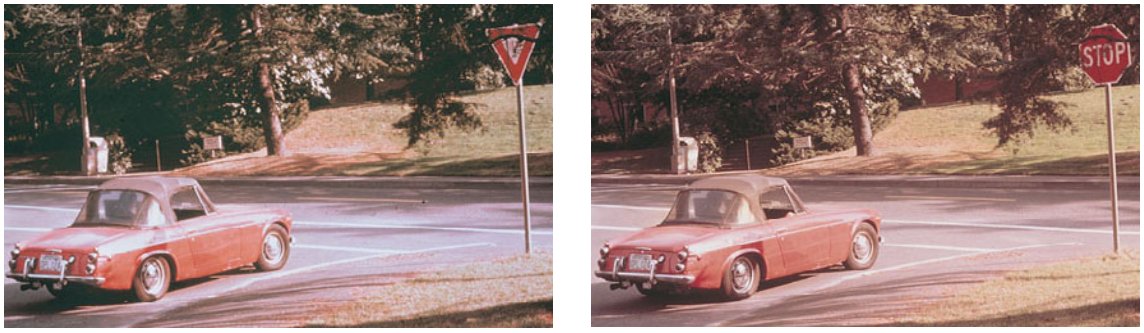
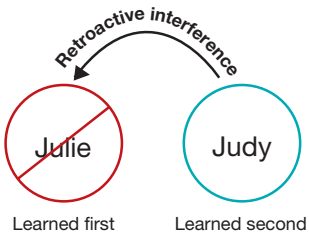


FIGURE 8.8
The Stop Sign Study
When people who saw a car with a yield sign (left) were later asked if they had seen "the stop sign" (a misleading question), many said they had. Similarly, when those shown a stop sign were asked if they had seen "the yield sign," many said yes. These false memories persisted even after the participants were told about the misleading questions, suggesting that misleading information had erased their original mental representations of the signs (Loftus, Miller, & Burns, 1978).

information may get into memory and stay there, but it becomes confused with other information. Such interference, which occurs in both short- and long-term memory, is especially common when you have to recall isolated facts such as names, addresses, passwords, and area codes.

Suppose you are at a party and you meet someone named Julie. A little later you meet someone named Judy. You go on to talk to other people, and after an hour, you again bump into Julie, but you call her Judy by mistake. The second name has interfered with the first. This type of interference, in which new information interferes with the ability to remember old information, is called **retroactive interference**:



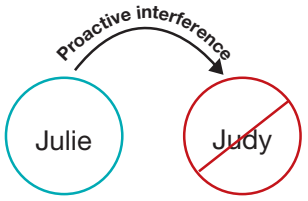
Retroactive interference is illustrated by the story of the professor of ichthyology (the study of fish) who complained that whenever he learned the name of a new student, he forgot the name of a fish. With replacement, the new memory erases the old and makes it irretrievable; but in retroactive interference, the loss of the old memory is sometimes temporary. With a little concentration, that professor could probably recall his new students and his old fish.

retroactive interference Forgetting that occurs when recently learned material interferes with the ability to remember similar material stored previously.

proactive interference Forgetting that occurs when previously stored material interferes with the ability to remember similar, more recently learned material.

Because new information is constantly entering memory, we are all vulnerable to the effects of retroactive interference, or at least most of us are. H. M. was an exception; his memories of childhood and adolescence were unusually detailed, clear, and unchanging. H. M. could remember actors who were famous when he was a child, the films they were in, and who their costars had been. He also knew the names of friends from the second grade. Presumably, these early declarative memories were not subject to interference from memories acquired after the operation, for the simple reason that H. M. had not acquired any new memories.

Interference also works in the opposite direction. Old information (such as the foreign language you learned in high school) may interfere with the ability to remember current information (such as the new language you are trying to learn now). This type of interference is called **proactive interference**:



Over a period of weeks, months, and years, proactive interference may cause more forgetting than retroactive interference does, because we have stored up so much information that can potentially interfere with anything new.

Cue-Dependent Forgetting

Often, when we need to remember, we rely on *retrieval cues*, items of information that can help us find the specific information we're looking for. If you are trying to remember the last name of an actor you saw in an old film, it might help to know the person's first name or a movie the actor starred in.

When we lack retrieval cues, we may feel as if we are lost in the mind's library. In long-term memory,

this type of memory failure, called **cue-dependent forgetting**, may be the most common type of all. Willem Wagenaar (1986), who, like Marigold Linton, recorded critical details about events in his life, found that he had forgotten 20 percent of those details within a year; after five years, he had forgotten 60 percent. Yet when he gathered cues from witnesses about 10 events that he thought he had forgotten, he was able to recall something about all 10, which suggests that some of his forgetting was cue dependent.

Cues that were present when you learned a new fact or had an experience are apt to be especially useful later as retrieval aids. That may explain why remembering is often easier when you are in the same physical environment as you were when an event occurred: Cues in the present context match those from the past. Ordinarily, this overlap helps us remember the past more accurately. But it may also help account for the eerie phenomenon of *déjà vu*, the fleeting sense of having been in *exactly* the same situation that you are in now (*déjà vu* means "already seen" in French). Some element in the present situation, familiar from some other context that you cannot identify—even a dream, a novel, or a movie—may make the entire situation seem so familiar that it feels like it happened before (Brown, 2004). In other words, déjà vu may be a kind of mistaken recognition memory. Similar feelings of familiarity can actually be produced in the laboratory. When something about newly presented words, shapes, or photographs resembles elements of stimuli seen previously, people report that the new words, shapes, or photographs are familiar even though they can't recall the original ones (Cleary, 2008).

In everyday forgetting, your mental or physical state may act as a retrieval cue, evoking a **state-dependent memory**. If you were afraid or angry at the time of an event, you may remember that event best when you are once again in the same emotional state (Lang et al., 2001). Your memories can also be biased by whether or not your current mood is consistent with the emotional nature of the material you are trying to remember, a phenomenon known as **mood-congruent memory** (Bower & Forgas, 2000; Buchanan, 2007; Fiedler et al., 2001). You are more likely to remember happy events, and forget or ignore unhappy ones, when you are feeling happy than when you are feeling sad. Likewise, you are apt to remember unhappy events better and remember more of them when you are feeling unhappy, which in turn creates a vicious cycle. The more unhappy memories you recall, the more depressed you feel, and the more depressed you feel, the more unhappy memories you recall . . . so you stay stuck in your depression and make it even worse (Joormann & Gotlib, 2007; Wenzel, 2005).

The Repression Controversy

A final theory of forgetting is concerned with **amnesia**, the loss of memory for important personal information. Amnesia most commonly results from organic conditions such as brain disease or head injury, and is usually temporary. In *psychogenic amnesia*, however, the causes of forgetting are psychological, such as a need to escape feelings of embarrassment, guilt, shame, disappointment, or emotional shock. Psychogenic amnesia begins immediately after the precipitating event, involves massive memory loss including loss of personal identity, and usually ends suddenly, after just a few weeks. Despite its frequent portrayal in films and novels, it is quite rare in real life (McNally, 2003).

Psychologists generally accept the notion of psychogenic amnesia. *Traumatic amnesia*, however, is far more controversial. Traumatic amnesia allegedly involves the burying of specific traumatic events for a long period of time, often for many years. When the memory returns, it is supposedly immune to the usual processes of distortion and confabulation, and is recalled with perfect accuracy. The notion of traumatic amnesia originated with the psychoanalytic theory of Sigmund Freud, who argued that the mind defends itself from unwelcome and upsetting memories through the mechanism of **repression**, the involuntary pushing of threatening or upsetting information into the unconscious (see Chapter 2).

cue-dependent forgetting The inability to retrieve information stored in memory because of insufficient cues for recall.

state-dependent memory The tendency to remember something when the rememberer is in the same physical or mental state as during the original learning or experience.

mood-congruent memory The tendency to remember experiences that are consistent with one's current mood and overlook or forget experiences that are not.

amnesia The partial or complete loss of memory for important personal information.

repression In psychoanalytic theory, the selective, involuntary pushing of threatening or upsetting information into the unconscious.

Most memory researchers reject the argument that a special unconscious mechanism called "repression" is necessary to explain either psychogenic or traumatic amnesia (Rofé, 2008). Richard McNally (2003) reviewed the experimental and clinical evidence and concluded, "The notion that the mind protects itself by repressing or dissociating memories of trauma, rendering them inaccessible to awareness, is a piece of psychiatric folklore devoid of convincing empirical support." The problem for most people who have suffered disturbing experiences is not that they cannot remember, but rather that they cannot forget: The memories keep intruding. There is no case on record of anyone who has repressed the memory of being in a concentration camp, being in combat, or being the victim of an earthquake or a terrorist attack, although details of even these horrible experiences are subject to distortion and fading over time, as are all memories.

Thinking Critically about Repression and Trauma

Further, repression is hard to distinguish from normal forgetting. People who seem to forget disturbing experiences could be intentionally keeping themselves from retrieving their painful memories by distracting themselves whenever a memory is reactivated. Or they may be focusing consciously on positive memories instead. Perhaps, understandably, they are not rehearsing unhappy memories, so those memories fade with time. Perhaps they are simply avoiding the retrieval cues that would evoke the memories. But a reluctance to think about an upsetting experience is not the same as an *inability* to remember it (McNally, 2003).

The debate over traumatic amnesia and repression erupted into the public arena in the 1990s, when claims of recovered memories of sexual abuse began to appear. Many women and some men came to believe, during psychotherapy, that they could recall long-buried memories of having been sexually victimized in bizarre ways for many years, usually by their fathers. For therapists who accepted the notion of repression, such claims were entirely believable (Brown, Scheflin, & Whitfield, 1999; Herman, 1992). However, most researchers today believe that almost all of these memories were false, having been evoked by therapists who were unaware of the research we described earlier on the power of suggestion and the dangers of confabulation (Lindsay & Read, 1994; McHugh, 2008; McNally, 2003; Schacter, 2001). By asking leading questions, and by encouraging clients to construct vivid images of abuse, revisit those images frequently, and focus on emotional aspects of the images, such therapists unwittingly set up the very conditions that encourage confabulation and false memories.

Since the 1990s, accusations have steadily declined, yet the concept of repression lingers on. Many of its original proponents have turned to the term "dissociation" to account for memory failures in traumatized individuals (see Chapter 11), the idea being that upsetting memories are split off (dissociated) from everyday consciousness. But a review of the research has found no good evidence that early trauma causes such dissociation (Giesbrecht et al., 2008).

Of course, it is obviously possible for someone to forget a single unhappy or deeply unpleasant experience and not recall it for years, just as going back to your elementary school might trigger a memory of the time that you did something embarrassing in front of your whole class. How then should we respond to an individual's claim to have recovered memories of years of traumatic experiences that were previously repressed? How can we distinguish true memories from false ones?

Clearly, a person's recollections are likely to be trustworthy if there is corroborating evidence available, such as medical records, police or school reports, or the accounts of other people who had been present at the time. In the absence of supporting evidence, we may have to tolerate uncertainty, because a person might have a detailed, emotionally rich "memory" that feels completely real but that has been unintentionally confabulated (Bernstein & Loftus, 2009). In such cases, it is important to consider the content of the recovered memory and how it was recovered.

Thus, given what we know about memory, we should be skeptical if people say that they have memories from the first year or two of life; as we will see in the next section, this is not possible, physiologically or cognitively. We should be skeptical if, over time, those memories become more and more implausible; for instance, a person says that sexual abuse continued day and night for 15 years without ever being remembered and without anyone else in the household ever noticing anything amiss. We should also be skeptical if a person suddenly recovers a traumatic memory as a result of therapy or after hearing about supposed cases of recovered memory in the news or reading about one in a best-selling autobiography. And we should hear alarm bells go off if a therapist used suggestive techniques, such as hypnosis, dream analysis, "age regression," guided imagery, and leading questions, to "recover" the memories (see Chapter 12). These techniques are all known to increase confabulation.

Quick Quiz

If you have not repressed what you just read, try these questions.

1. Wilma has loved the novels of Tom Robbins for years. Recently, she developed a crush on the actor Tim Robbins, but every time she tries to recall his name, she calls him "Tom." Why?
2. When a man at his 20th high school reunion sees his old friends, he recalls incidents he thought were long forgotten. Why?
3. What mechanisms other than repression could account for a person's psychogenic amnesia?

Answers:

1. proactive interference 2. The sight of his friends provides retrieval cues for the incidents. 3. The person could be intentionally avoiding the memory by using distraction or focusing on positive experiences; failure to rehearse the memory may be causing it to fade; or the person may be avoiding retrieval cues that would evoke the memory.

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YOU are about to learn...

- why the first few years of life are a mental blank.
- why human beings have been called the storytelling animal.

Autobiographical Memories

For most of us, our memories about our own experiences are by far the most fascinating. We analyze them to learn more about who we are. We modify and embellish them to impress others. And we use them to entertain ("Did I ever tell you about the time . . . ?").

Childhood Amnesia: The Missing Years

A curious aspect of autobiographical memory is that most adults cannot recall any events from earlier than the third or fourth year of life. A few people apparently can vaguely recall momentous experiences that occurred when they were as young as 2 years old, such as the birth of a sibling, but not earlier ones (Fivush & Nelson, 2004; Usher & Neisser, 1993). As adults, we cannot remember being fed in infancy, taking our first steps, or uttering our first halting sentences. We are victims of **childhood amnesia** (sometimes called *infantile amnesia*).

There is something disturbing about childhood amnesia—so disturbing that some people adamantly deny it, claiming to remember events from the second or even the first year of life. But like other false memories, these are merely reconstructions based on photographs, family stories, and imagination. The "remembered" event may not even have taken place. Swiss psychologist Jean Piaget (1952) once reported a memory of nearly being kidnapped at the age of 2. Piaget remembered sitting in his pram, watching his nurse as she bravely defended him from the kidnapper. He remembered the scratches she received on her face. He remembered a police officer with a short cloak and white baton who finally chased the kidnapper away. But when Piaget was 15, his nurse wrote to his parents confessing that she had made up the entire story. Piaget noted, "I therefore must have heard, as a child, the account of this story . . . and projected it into the past in the form of a visual memory, which was a memory of a memory, but false."

Thinking Critically about "Memories" from Infancy

Of course, we all retain procedural memories from the toddler stage, when we first learned to use a fork, drink from a cup, and pull a wagon. We also retain semantic memories acquired early in life: the rules of counting, the names of people and things, knowledge about objects in the world, words and meanings. Moreover, toddlers who are only 1 to 2 years old often reveal nonverbally that they remember past experiences (for example, by imitating something they saw earlier); and some 4-year-olds can remember experiences that occurred before age (Bauer, 2002; McDonough & Mandler, 1994; Tustin & Hayne, 2006). What young children do not do well is encode and retain their early episodic memories—memories of particular events—and carry them into later childhood or adulthood. They can't start doing this consistently until about age 4 ½ (Fivush & Nelson, 2004).

Freud thought that childhood amnesia was a special case of repression, but memory researchers today think that repression has nothing to do with it, and they point to better explanations:

1 **Brain development.** Parts of the brain involved in the formation or storage of events, and other areas involved in working memory and decision

childhood (infantile) amnesia The inability to remember events and experiences that occurred during the first two or three years of life.

Psychologists have devised ingenious methods to measure memory in infants. This infant, whose leg is attached by a string to a colorful mobile, will learn within minutes to make the mobile move by kicking it. She may still remember the trick a week later, an example of procedural memory (Rovee-Collier, 1993). However, when she is older, she will not remember the experience itself. Like the rest of us, she will fall victim to childhood amnesia.

making, are not well developed until a few years after birth, especially the prefrontal cortex (McKee & Squire, 1993; Newcombe et al., 2000). In addition, the brains of infants and toddlers are busily attending to all the new experiences of life, but this very fact makes it difficult for them to focus on just one event and shut out everything else that's going on—the kind of focus necessary for encoding and remembering (Gopnik, 2009).

2 Cognitive development. Before you can carry memories about yourself with you into adulthood, you have to have a self to remember. The emergence of a self-concept usually does not take place before age 2 (Howe, Courage, & Peterson, 1994). In addition, the cognitive schemas that preschoolers use are very different from those that older children and adults use. Only after acquiring language and starting school do children form schemas that contain the information and cues necessary for recalling earlier experiences (Howe, 2000). Young children's limited vocabularies and language skills also prevent them from narrating some aspects of an experience to themselves or others. Later, after their linguistic abilities have matured, they still cannot use those abilities to recall earlier, preverbal memories, because the earlier memories were not encoded linguistically (Simcock & Hayne, 2002).

3 Social development. Preschoolers have not yet mastered the social conventions for reporting events, nor have they learned what is important to others. They focus on the routine aspects of an experience rather than the distinctive ones that will provide retrieval cues later, and they encode their experiences far less elaborately than adults do. Instead, they tend to rely on adults' questions to provide retrieval cues ("Where did we go for breakfast?" "Who did you go trick or treating with?"). This dependency on adults may prevent them from building up a stable core of remembered material that will be available when they are older (Fivush & Hamond, 1991).

Nonetheless, our first memories, even when they aren't accurate, may provide useful insights into our personalities, current concerns, ambitions, and attitudes toward life. What are *your* first memories—or, at least, what do you think they are? What might they tell you about yourself?

Memory and Narrative: The Stories of Our Lives

The communications researcher George Gerbner once observed that human beings are unique because we are the only animal that tells stories—and lives by the stories we tell. This view of human beings as the "storytelling animal" has had a huge impact in cognitive psychology. The *narratives* we compose to simplify and make sense of our lives have a profound influence on our plans, memories, love affairs, hatreds, ambitions, and dreams.

Thus we say, "I have no academic motivation because I flunked the third grade." We say, "Let me tell you the story of how we fell in love." We say, "When you hear what happened, you'll understand why I felt entitled to take such coldhearted revenge." These stories are not necessarily fictions; rather, they are attempts to organize and give meaning to the events of our lives. But because these narratives rely heavily on memory, and because memories are reconstructed and are constantly shifting in response to current needs, beliefs, and experiences, our autobiographies are also, to some degree, works of interpretation and imagination. Adult memories thus reveal as much about the present as they do about the past.

When you construct a narrative about an incident in your life, you have many choices about how to do it. Your story depends on who the audience is; you are apt to put in, leave out, understate, and embellish different things depending on whether you are telling about an event in your life to a therapist, your boss, or friends on Facebook. Your story is also influenced by your purpose in relating it: Is it to convey facts, entertain, or elicit sympathy? As a result of these influences, distortions are apt to creep in, even when you think you are being accurate. And once those distortions have become embedded in your story, they are likely to become part of your memory of the events themselves (Marsh & Tversky, 2004). Explore

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Your culture also affects how you encode and tell your story. American college students live in a culture that emphasizes individuality, personal feelings, and self-expression. Their earliest childhood memories reflect that fact: They tend to report lengthy, emotionally elaborate memories of events, memories that focus on—who else?—themselves. In contrast, Chinese students, who live in a culture that emphasizes group harmony, social roles, and personal humility, tend to report early memories of family or neighborhood activities, conflicts with friends or relatives that were resolved, and emotionally neutral events (Wang, 2008).

Once you have formulated a story's central theme ("My father never liked us"; "My partner was always so competitive with me"), that theme may then serve as a cognitive schema that guides what you remember and what you forget (Mather, Shafir, & Johnson, 2000). For example, teenagers who have strong and secure attachments to their mothers remember previous quarrels with their moms as being less intense and conflicted than they reported at the time, whereas teenagers who have more ambivalent and insecure attachments remember such quarrels as being worse than they were (Feeney & Cassidy, 2003).

"And here I am at two years of age. Remember? Mom? Pop? No? Or how about this one. My first day of school. Anyone?"

A story's theme may also influence our judgments of events and people in the present. If you have a fight with your lover, the central theme in your story about the fight might be negative ("He was a jerk") or neutral ("It was a mutual misunderstanding"). This theme may bias you to blame or forgive your partner long after you have forgotten what the conflict was all about or who said what (McGregor & Holmes, 1999). You can see that the spin you give a story is critical, so be careful about the stories you tell!

Quick Quiz

You can't blame childhood amnesia if you have forgotten the answers to these questions.

1. A friend of yours claims to remember her birth, her first tooth, and her first birthday party. She is most likely to be (a) lying, (b) confabulating, (c) repressing, (d) revealing wishful thinking, (e) accurately remembering.
2. Give three explanations for childhood amnesia (be specific).
3. Why are the themes in our life stories so important?

Answers:

1. b, d **2.** the immaturity of certain brain structures, making it difficult for very young children to focus attention, encode, and remember; cognitive factors such as immature cognitive schemas, lack of linguistic skills, and lack of a self-concept; lack of knowledge of social conventions for encoding and reporting events **3.** They guide what we remember and forget about our personal pasts, and affect our judgments of events and people.

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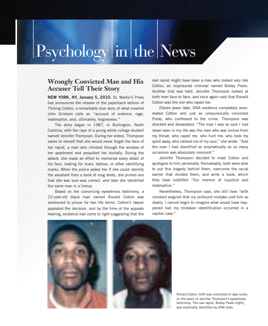
Psychology in the News REVISITED



Psychological research is having a significant impact on people's ability to think critically about memory. Most notably, awareness of the fallibility of memory is growing among police, interrogators, prosecutors, and judges. The case of Ronald Cotton, described at the start of this chapter, is far from unique. When psychological scientists examined 40 cases in which wrongful conviction had been established beyond a doubt, they found that 90 percent of those cases had involved a false identification by one or more eyewitnesses (Wells et al., 1998). Of course, not all

eyewitness testimony is erroneous. But the potential for errors in identification shows how important it is to gather evidence carefully, ensure adequate legal representation for defendants, conduct police interviews using proper procedures, reduce pressure on witnesses, and obtain a DNA analysis whenever possible.

Inspired by the Innocence Project at the Cardozo School of Law in New York City, grassroots organizations of lawyers and students have been successfully challenging questionable convictions. Since the early 1990s, these efforts have led to the exoneration of more than 250 innocent people, some of whom had been condemned to death. One man in Illinois, who had been on death row for 16 years, was just hours from execution when a group of Northwestern University journalism students produced evidence that another man had committed the crime.

How would you feel if your testimony resulted in the conviction of an innocent person? Would you, like Jennifer Thompson, be able to admit your mistake, or would you, as most people do, cling more stubbornly than ever to the accuracy of your memory? Thompson learned from personal experience what you have learned from this chapter: Eyewitnesses can and do make mistakes, ethnic differences can increase these mistakes, even memories for shocking or traumatic experiences are vulnerable to distortion and influence by others, and our confidence in our memories is not a reliable guide to their accuracy. To this day, Thompson and Cotton have made it their personal goal to educate the public and the criminal justice system, so that the mistake she made will be less likely to be repeated by others (Thompson-Cannino, Cotton, & Torneo, 2009).

After Ronald Cotton was exonerated of the rape of Jennifer Thompson, the two became friends. Thompson says she has lived with constant anguish because of her mistaken identification.

By now, if you have been reading this chapter actively, you should be able to recall the many factors that can trip you up when you call upon your memory: confabulation, source misattribution, poor encoding and rehearsal strategies, interference, inadequate retrieval cues, suggestibility, and biases. By now, therefore, you should not be surprised that memory can be as fickle as it can be accurate. As cognitive psychologists have shown repeatedly, we are not merely actors in our personal life dramas; we also write the scripts.

Taking Psychology with You

How to Remember What You Study

Someday, a "memory pill" may be available to perk up our memories. For the time being, however, those of us who hope to improve our memories must rely on mental strategies. Some simple mnemonics can be useful, but complicated ones are often more bother than they're worth. A better approach is to remember and practice the principles in this chapter:

Pay attention! It seems obvious, but often we fail to remember because we never encoded the information in the first place. For example, which of these is the real Lincoln penny?

Most Americans have trouble recognizing the real penny because they have never attended to the details of a penny's design (Nickerson & Adams, 1979). We are not advising you to do so, unless you happen to be a coin collector or a counterfeiting expert. Just keep in mind that when you do have something to remember, such as the material in this book, you will do better if you encode it well. (The real penny, by the way, is the left one in the bottom row.)

Add meaning. The more meaningful the material, the more likely it is to link up with information already in long-term memory. Meaningfulness also reduces the number of chunks of information you have to learn. Common ways of adding meaning include making

up a story about the material, thinking of examples, and forming visual images. (Some people find that the odder the image, the better.) If your license plate happens to be 236MPL, you might think of 236 maples. If you are trying to remember the concept of procedural memory from this chapter, you might make the concept meaningful by thinking of an example from your own life, such as your ability to ride a mountain bike, and then imagine a *P* superimposed on an image of yourself on your bike.

Take your time. Leisurely learning, spread out over several sessions, usually produces better results than harried cramming (although *reviewing* material just before a test can be helpful). In terms of hours spent, "distributed" (spaced) learning sessions are more efficient than "massed" ones; in other words, three separate one-hour study sessions may result in more retention than one session of three hours.

Take time out. If possible, minimize interference by using study breaks for rest or recreation. A good night's sleep or an afternoon nap reduce such interference and improve the chances that a new memory will be consolidated.

Overlearn. You can't remember something you never learned well in the first place. Overlearning—studying information even after you think you know it—is one of the best ways to ensure that you'll remember it.

Read, recite, review. Test yourself frequently, rehearse thoroughly, and review periodically to see how you are doing. Don't just evaluate your learning immediately after reading the material, though; because the information is still in short-term memory, you are likely to feel a false sense of confidence about your ability to recall it later. If you delay making a judgment for at least a few minutes, your evaluation will probably be more accurate (Nelson & Dunlosky, 1991).

Most of all, you will find that active learning produces more comprehension and better retention than does passive reading or listening. Even then, you should not expect to remember everything you read or hear. Nor should you want to. Piling up facts without distinguishing the important from the trivial is just confusing. Popular books and tapes that promise to give you a perfect or photographic memory, or instant recall of everything you learn, fly in the face of what psychologists know about how the mind operates. Our advice: Forget them.

Summary

Reconstructing the Past

- Unlike a tape recorder or video camera, human memory is highly selective and is *reconstructive*: People add, delete, and change elements in ways that help them make sense of information and events. They often experience *source misattribution*, the inability to distinguish information stored during an event from information added later. Even vivid *flashbulb memories* tend to become less accurate or complete over time.
- Because memory is reconstructive, it is subject to *confabulation,* the confusion of imagined events with actual ones. Confabulation is especially likely when people have thought, heard, or told others about the imagined event many times and thus experience *imagination inflation*, the image of the event contains many details, or the event is easy to imagine. Confabulated memories can feel vividly real yet be false.

Memory and the Power of Suggestion

- The reconstructive nature of memory makes memory vulnerable to suggestion. Eyewitness testimony is especially vulnerable to error when the suspect's ethnicity differs from that of the witness, when leading questions are put to witnesses, or when the witnesses are given misleading information.
- Like adults, children often remember the essential aspects of an event accurately. However, like adults, they can also be suggestible, especially when responding to biased interviewing by adults—when they are asked questions that blur the line between fantasy and reality, are asked leading questions, are told what "other kids" had supposedly said, and are praised for making false allegations.

In Pursuit of Memory

- The ability to remember depends in part on the type of performance called for. In tests of *explicit memory* (conscious recollection), *recognition* is usually better than *recall.* In tests of *implicit memory,* which is measured by indirect methods such as *priming* and the *relearning method*, past experiences may affect current thoughts or actions even when these experiences are not consciously remembered.
- In *information-processing models*, memory involves the *encoding, storage*, and *retrieval* of information. In the *three-box model*, there are three interacting systems: the sensory register, short-term memory, and long-term memory. Some cognitive scientists prefer a

parallel distributed processing (PDP) or *connectionist* model, which represents knowledge as connections among numerous interacting processing units, distributed in a vast network and all operating in parallel. But the three-box model continues to offer a convenient way to organize the major findings on memory.

The Three-Box Model of Memory

- In the three-box model, incoming sensory information makes a brief stop in the *sensory register,* which momentarily retains it in the form of sensory images.
- *Short-term memory (STM)* retains new information for up to 30 seconds by most estimates (unless rehearsal takes place). The capacity of STM is extremely limited but can be extended if information is organized into larger units by *chunking.* Early models of STM portrayed it mainly as a storage and rehearsal buffer, but many models now envision it also as a *working memory*, which includes the mental processes that control the retrieval of information from long-term memory and that interpret that information appropriately depending on the task being performed. Working memory permits us to control attention, resist distraction, and therefore maintain information in an active, accessible state.
- *Long-term memory (LTM)* contains an enormous amount of information that must be organized to make it manageable. Words (or the concepts they represent) are often organized by semantic categories. Many models of LTM represent its contents as a network of interrelated concepts. The way people use these networks depends on experience and education. Research on *tip-of-the-tongue (TOT) states* shows that words are also indexed in terms of sound and form.
- *Procedural memories* ("knowing how") are memories for how to perform specific actions; *declarative memories* ("knowing that") are memories for abstract or representational knowledge. Declarative memories include *semantic memories* (general knowledge) and *episodic memories* (memories for personally experienced events).
- The three-box model is often invoked to explain the *serial-position effect* in memory, but although it can explain the *primacy effect*, it cannot explain why a *recency effect* sometimes occurs after a considerable delay.

The Biology of Memory

- Short-term memory involves temporary changes within neurons that alter their ability to release neurotransmitters, whereas long-term memory involves lasting structural changes in neurons and synapses. *Long-term potentiation*, an increase in the strength of synaptic responsiveness, seems to be an important mechanism of long-term memory. Neural changes associated with long-term potentiation take time to develop, which helps explain why long-term memories require a period of *consolidation.*
- The amygdala is involved in the formation, consolidation, and retrieval of emotional memories. Areas of the frontal lobes are especially active during short-term and working memory tasks. The prefrontal cortex and parts of the temporal lobes are involved in the efficient encoding of words and pictures. The hippocampus plays a critical role in the formation and retrieval of long-term declarative memories. Other areas, such as the cerebellum, are crucial for the formation of procedural memories. Studies of patients with amnesia suggest that different brain systems are active during explicit and implicit memory tasks. The various components of a memory are probably stored at different sites, with all of these sites participating in the representation of the event as a whole.
- Hormones released by the adrenal glands during stress or emotional arousal, including epinephrine and norepinephrine, enhance memory. But very high hormone levels can interfere with the retention of information; a moderate level is optimal for learning new tasks.

How We Remember

- To remember material well, we must encode it accurately in the first place. Some kinds of information, such as material in a college course, require *effortful*, as opposed to *automatic*, encoding. Rehearsal of information keeps it in short-term memory and increases the chances of long-term retention. *Elaborative rehearsal* is more likely to result in transfer to long-term memory than is *maintenance rehearsal*, and *deep processing* is usually a more effective retention strategy than *shallow processing.* The *read-recite-review* strategy encourages active learning and produces better results than simply reading and rereading material. *Retrieval practice* is necessary if a memory is going to be consolidated, and therefore last and be available for a long time. *Mnemonics* can enhance retention by promoting elaborative encoding and chunking the material to be recalled.

Why We Forget

- Forgetting can occur for several reasons. Information in sensory and short-term memory appears to *decay* if it does not receive further processing. New information may erase and replace old information in long-term memory. *Proactive* and *retroactive interference* may take place. *Cue-dependent forgetting* may occur when *retrieval cues* are inadequate. The most effective retrieval cues are those that were present at the time of the initial experience. A person's mental or physical state may also act as a retrieval cue, evoking a *state-dependent memory.* We tend to remember best those events that are congruent with our current mood (*mood-congruent memory*).

- *Amnesia*, the forgetting of personal information, usually occurs because of disease or injury to the brain. *Psychogenic amnesia*, which involves a loss of personal identity and has psychological causes, is rare. *Traumatic amnesia*, which allegedly involves the forgetting of specific traumatic events for long periods of time, is highly controversial, as is *repression*, the psychodynamic explanation of traumatic amnesia. Because these concepts lack good empirical support, psychological scientists are skeptical about their validity and about the accuracy of "recovered memories." Critics argue that many therapists, unaware of the power of suggestion and the dangers of confabulation, have encouraged false memories of victimization.

Autobiographical Memories

- Most people cannot recall any events from earlier than the third or fourth year of life. The reasons for such *childhood amnesia* include the immaturity of certain brain structures, making it difficult for very young children to focus attention, encode, and remember; cognitive factors such as immature cognitive schemas, lack of linguistic skills, and lack of a self-concept; and lack of knowledge of social conventions for encoding and reporting events.
- A person's *narrative* "life story" organizes the events of his or her life and gives them meaning.

Psychology in the News, Revisited

- Across the country, as DNA evidence has exonerated many people who were falsely convicted of rape, murder, and other crimes, people are becoming more aware of the limitations of eyewitness testimony and the fallibility of memory.

Taking Psychology with You

- The best techniques for improving memory are to pay attention, add meaning, take your time instead of cramming, take time out, overlearn, practice "read-recite-review," and learn actively rather than passively. Remember this advice!

Key Terms

memory **263**
reconstructive memory **265**
source misattribution **265**
flashbulb memories **265**
confabulation **265**
imagination inflation **266**
leading questions **267**
explicit memory **270**
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Answers to the Get Involved exercises on pages 271 and 272
Rudolph's eight friends were Dasher, Dancer, Prancer, Vixen, Comet, Cupid, Donner ("Donder" in some versions), and Blitzen.

Memory refers to the capacity to retain and retrieve information, and also to the structures that account for this capacity.

Reconstructing the Past

The Manufacture of Memory

- Human memory is *reconstructive:* People add, delete, and change elements.
- **Source misattribution** is the inability to distinguish information stored during an event from information added later.
- Even *flashbulb memories*, though emotionally powerful and vivid, are often embellished or change over time.

The Conditions of Confabulation

Confabulation is the confusion of imagined events with real ones, or confusing an event that happened to someone else with one that happened to you. Such confabulations are especially likely under certain circumstances:

- One has thought, heard, or told others about the imagined event many times.
- The image of the event contains lots of details that make it feel real.
- The event is easy to imagine.

Memory and the Power of Suggestion

The Eyewitness on Trial

Eyewitness testimony is especially vulnerable to error when:

- The suspect's ethnicity differs from the witness's.
- Leading questions are put to the witness.
- Witnesses are exposed to misleading information.

Children's Testimony

Children can be suggestible when:

- Interviewers use leading questions or suggestive techniques, or pressure the child to give particular answers.
- Children are affected by rumor and hearsay.

In Pursuit of Memory

Measuring Memory

- In tests of **explicit memory**, or conscious recollection, **recognition** is usually better than **recall.**
- In tests of **implicit memory,** which is measured by indirect methods such as **priming** and the **relearning method,** past experiences may affect current thoughts or actions.

Models of Memory

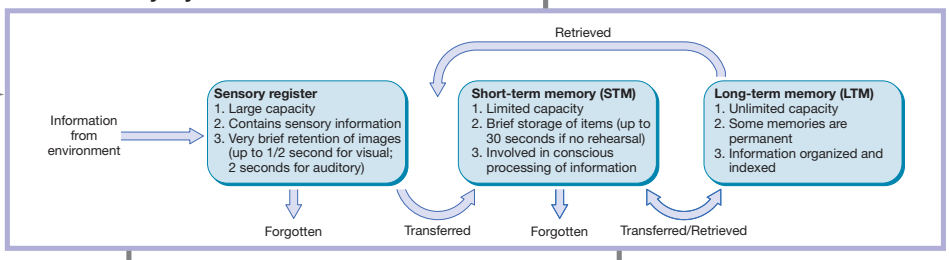
- In *information-processing models*, memory involves encoding, storage, and retrieval.
- **Parallel distributed processing** (**PDP**): knowledge is represented as connections among thousands of interacting processing units, all operating in parallel.

The Three-Box Model of Memory

Sensory Register

Incoming information stops in the **sensory register**, which momentarily retains it in the form of sensory images.

Three Memory Systems



Short-Term Memory (STM)

Short-term memory (**STM**) retains information for up to 30 seconds, although estimates extend to a few minutes for certain tasks.

- **Chunking** extends the capacity of STM.
- **Working memory** consists of STM, the mental processes that control the retrieval of information from long-term memory, and executive processes that control attention and the manipulation and interpretation of information required for a task.

Long-Term Memory (LTM)

Information in **long-term memory** (**LTM**) is organized as a network of interrelated concepts and includes:

- **Procedural memories**
- **Declarative memories**
  - — **Semantic**
  - — **Episodic**
- The **serial-position effect** is the tendency for strongest recall of the first and last items on a list.

How We Remember

- Rehearsal of information keeps it in STM longer and increases the chances of retention.
- **Elaborative rehearsal** is more likely to result in transfer to LTM than is **maintenance rehearsal**.
- **Deep processing** is usually more effective than shallow processing.
- The *read-recite-review strategy* and *retrieval practice* are more effective than passively reading the material.
- **Mnemonics** are strategies or tricks for improving memory.

Why We Forget

- **Decay theory** holds that memory eventually disappears if it is not accessed; applies best to sensory and short-term memory.
- Another theory emphasizes the replacement of old information by new information.
- A third theory emphasizes **proactive** and **retroactive interference** in storage or retrieval.
- **Cue-dependent forgetting** may be the most common type of forgetting; it occurs because of inadequate retrieval cues. When one's physical or mental state acts as a retrieval cue, **state-dependent memory** may result. Similarly, when one's mood is consistent with the emotional nature of the material one is trying to remember, **mood-congruent memory** may result.

The Repression Controversy

- **Amnesia** usually occurs as a result of brain disease or head injury, and is usually temporary.
- *Psychogenic amnesia* has psychological causes and involves a loss of personal identity.
- *Traumatic amnesia*, which allegedly involves the burying of specific traumatic events for long periods of time, is highly controversial, as is **repression**, the psychodynamic explanation of traumatic amnesia.
- Critics argue that many therapists, unaware of the power of suggestion and the dangers of confabulation, have encouraged false memories of victimization.

The Biology of Memory

Changes in Neurons and Synapses

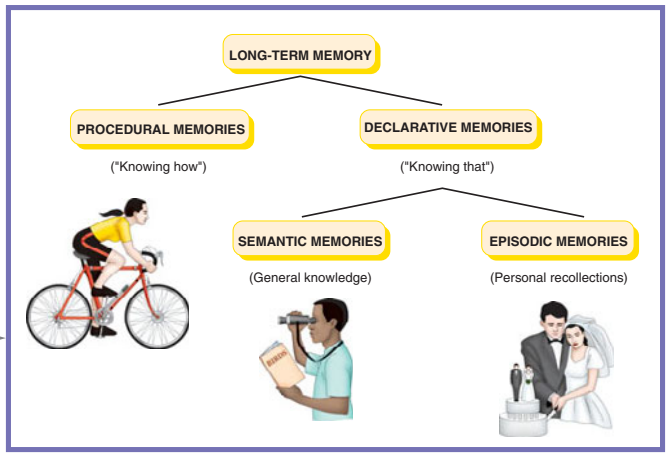
- In short-term memory, neurons temporarily change in their ability to release neurotransmitters.
- In long-term memory, dendrites grow and branch out, certain synapses increase in number, and some synaptic pathways become more excitable. These neuronal changes are known as **long-term potentiation.** These changes require some time for completion, during which memories undergo **consolidation.**

Locating Memories

- The amygdala is involved in the formation, consolidation, and retrieval of fearful and other emotional memories.
- The frontal lobes are involved in short-term and working memory.
- The hippocampus is critical to the formation of long-term declarative memories.
- The cerebellum helps form and retain certain procedural memories.
- The ultimate destinations of declarative memories seem to lie in parts of the cerebral cortex.

Hormones, Emotion, and Memory

- Hormones released by the adrenal glands can enhance memory.
- Extreme arousal, however, often impairs memory.



Autobiographical Memories

Childhood Amnesia

Childhood amnesia may be due to:

- Immaturity of brain parts involved in memory.
- Cognitive factors, such as lack of a self-concept and limited language skills necessary for forming cognitive schemas useful for later recall.
- Social factors, such as a lack of mastery of social conventions for reporting events to others.

Memory and Narrative

- A person's *narrative* (life story) organizes remembered life events and gives them meaning.
- Adult memories can reveal as much about the present as they do about the past.