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Be thankful for memory. We take it for granted, except when it malfunctions. But it is our memory that accounts for time and defines our life. It is our memory that enables us to recognize family, speak
our language, find our way home, and locate food and water. It is our memory that enables us to enjoy an experience and then mentally replay and enjoy it again. Our shared memories help bind us together as Irish or Aussies, as Serbs or Albanians. And it is our memory that occasionally pits us against those whose offenses we cannot forget.

In large part, we are what we remember. Without memory—our storehouse of accumulated learning—there would be no savoring of past joys, no guilt or anger over painful recollections. We would instead live in an enduring present, each moment fresh. But each person would be a stranger present, each moment fresh. But each person would be a stranger, every language foreign, every task—dressing, cooking, biking—a new challenge. You would even be a stranger to yourself, lacking that continuous sense of self that extends from your distant past to your momentary present.
What is memory?

**Memory** is learning that has persisted over time, information that has been stored and can be retrieved. To a psychologist, evidence that learning persists takes three forms:

- **Recall** — retrieving information that is not currently in your conscious awareness but that was learned at an earlier time. A fill-in-the-blank question tests your recall.
- **Recognition** — identifying items previously learned. A multiple-choice question tests your recognition.
- **Relearning** — learning something more quickly when you learn it a second or later time. When you study for a final exam or engage a language used in early childhood, you will relearn the material more easily than you did initially.

Research on memory’s extremes has helped us understand how memory works. At age 92, my father suffered a small stroke that had but one peculiar effect. He was as mobile as before. His genial personality was intact. He knew us and enjoyed poring over family photo albums and reminiscing about his past. But he had lost most of his ability to lay down new memories of conversations and everyday episodes. He could not tell me what day of the week it was, or what he’d had for lunch. Told repeatedly of his brother-in-law’s death, he was surprised and saddened each time he heard the news.

At the other extreme are people who would be gold medal winners in a memory Olympics. Russian journalist Shereshevski, or S, had merely to listen while other reporters scribbled notes (Luria, 1968). You and I could parrot back a string of about 7—maybe even 9—digits. S could repeat up to 70, if they were read about 3 seconds apart in an otherwise silent room. Moreover, he could recall digits or words backwards as easily as forward. His accuracy was unerring, even when recalling a list as much as 15 years later. “Yes, yes,” he might recall. “This was a series you gave me once when we were in your apartment. . . . You were sitting at the table and I in the rocking chair. . . . You were wearing a gray suit. . . .” Amazing? Yes, but consider your own impressive memory. You remember countless voices, sounds, and songs; tastes, smells, and textures; faces, places, and happenings. Imagine viewing more than 2500 slides of faces and places for 10 seconds each. Later, you see 280 of these slides, paired with others you’ve never seen. Actual participants in this experiment recognized 90 percent of the slides they had viewed in the first round (Haber, 1970). In a follow-up experiment, people exposed to 2800 images for only 3 seconds each spotted the repeats with 82 percent accuracy (Konkle et al., 2010).

Or imagine yourself looking at a picture fragment, such as the one in **Figure 8.1**. Also imagine that you had seen the complete picture for a couple of seconds 17 years earlier. This, too, was a real experiment, and participants who had previously seen the complete drawings were more likely to identify the objects than were members of a control group (Mitchell, 2006). Moreover, the picture memory reappeared even for those who did not consciously recall participating in the long-ago experiment!

How do we accomplish such memory feats? How does our brain pluck information out of the world around us and tuck that information away for later use? How can we remember things we have not thought about for years, yet forget the name of someone we met a minute ago? How are memories stored in our brains? Why will you be likely, later in this chapter, to misrecall this sentence: “The angry rioter threw the rock at the window”? In this chapter, we’ll consider these fascinating questions and more, including tips on how we can improve our own memories.
How do psychologists describe the human memory system? Architects make miniature house models to help clients imagine their future homes. Similarly, psychologists create memory models to help us think about how our brain forms and retrieves memories. Information-processing models are analogies that compare human memory to a computer’s operations. Thus, to remember any event, we must

- get information into our brain, a process called encoding.
- retain that information, a process called storage.
- later get the information back out, a process called retrieval.

Like all analogies, computer models have their limits. Our memories are less literal and more fragile than a computer’s. Moreover, most computers process information sequentially, even while alternating between tasks. Our dual-track brain processes many things simultaneously (some of them unconsciously) by means of parallel processing. To focus on this complex, simultaneous processing, one information-processing model, connectionism, views memories as products of interconnected neural networks (see Chapter 2). Specific memories arise from particular activation patterns within these networks. Every time you learn something new, your brain’s neural connections change, forming and strengthening pathways that allow you to interact with and learn from your constantly changing environment.

To explain our memory-forming process, Richard Atkinson and Richard Shiffrin (1968) proposed a three-stage model:

1. We first record to-be-remembered information as a fleeting sensory memory.
2. From there, we process information into short-term memory, where we encode it through rehearsal.
3. Finally, information moves into long-term memory for later retrieval.

Other psychologists have updated this model (FIGURE 8.2) to include important newer concepts, including working memory and automatic processing.

Working Memory

Alan Baddeley and others (Baddeley, 2001, 2002; Engle, 2002) challenged Atkinson and Shiffrin’s view of short-term memory as a small, brief storage space for recent thoughts and experiences. Research shows that this stage is not just a temporary shelf for holding incoming information. It’s an active desktop where your brain processes information, making sense of new input and linking it with long-term memories. Whether we hear “eye-scream” as “ice cream” or “I scream” will depend on how the context and our experience guide us in interpreting and encoding the sounds. To focus on the active processing that takes place in this middle stage, psychologists use the term working memory. Right now, you are using your working memory to link the information you’re reading with your previously stored information (Cowan, 2010; Kail & Hall, 2001).

FIGURE 8.2
A modified three-stage processing model of memory Atkinson and Shiffrin’s classic three-step model helps us to think about how memories are processed, but today’s researchers recognize other ways long-term memories form. For example, some information slips into long-term memory via a “back door,” without our consciously attending to it (automatic processing). And so much active processing occurs in the short-term memory stage that many now prefer the term working memory.
For most of you, the pages you are reading enter working memory through vision. You might also repeat the information using auditory rehearsal. As you integrate these memory inputs with your existing long-term memory, your attention is focused. Baddeley (1998, 2002) called this focused processing the central executive (FIGURE 8.4).

Without focused attention, information often fades. In one experiment, people read and typed new information they would later need, such as “An ostrich’s eye is bigger than its brain.” If they knew the information would be available online they invested less energy in remembering, and remembered the trivia less well (Sparrow et al., 2011). Sometimes Google replaces rehearsal.

**Dual-Track Memory: Effortful Versus Automatic Processing**

**8-3** How are explicit and implicit memories distinguished?

Atkinson and Shiffrin’s model focused on how we process our explicit memories—the facts and experiences that we can consciously know and declare (thus, also called declarative memories). But as we have seen throughout this text, our mind operates on two tracks. It processes explicit memories through conscious effortful processing. But behind the scenes, outside Atkinson-Shiffrin stages, other information skips our conscious encoding and barges directly into storage. This automatic processing, which happens without our awareness, produces implicit memories (also called nondeclarative memories).

The two-track memory system reinforces an important principle introduced in Chapter 6’s description of parallel processing: Mental feats such as vision, thinking, and memory may seem to be single abilities, but they are not. Rather, we split information into different components for separate and simultaneous processing.

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**FIGURE 8.3**

Now you know People who had seen this complete image were, 17 years later, more likely to recognize the fragment in Figure 8.1.

**FIGURE 8.4**


**Explicit memory** Memory of facts and experiences that one can consciously know and “declare.” (Also called declarative memory.)

**Effortful processing** Encoding that requires attention and conscious effort.

**Automatic processing** Unconscious encoding of incidental information, such as space, time, and frequency, and of well-learned information, such as word meanings.

**Implicit memory** Retention independent of conscious recollection. (Also called nondeclarative memory.)

**RETRIEVAL PRACTICE**

- What two new concepts update the classic Atkinson-Shiffrin three-stage information-processing model?
  - Answer: (1) Working memory (2) Central executive

- What are two basic functions of working memory?
  - Answer: (1) Storing incoming visual and auditory information and (2) focusing our spotlight of attention.
Building Memories

Encoding and Automatic Processing

What information do we automatically process?

Our implicit memories include procedural memory for automatic skills, such as how to ride a bike, and classically conditioned associations among stimuli. Visiting your dentist, you may, thanks to a conditioned association linking the dentist’s office with the painful drill, find yourself with sweaty palms. You didn’t plan to feel that way when you got to the dentist’s office; it happened automatically.

Without conscious effort you also automatically process information about

- space. While studying, you often encode the place on a page where certain material appears; later, when you want to retrieve information about automatic processing, you may visualize the location of that information on this page.
- time. While going about your day, you unintentionally note the sequence of its events. Later, realizing you’ve left your coat somewhere, the event sequence your brain automatically encoded will enable you to retrace your steps.
- frequency. You effortlessly keep track of how many times things happen, as when you suddenly realize, “This is the third time I’ve run into her today.”

Our two-track mind engages in impressively efficient information processing. As one track automatically tucks away many routine details, the other track is free to focus on conscious, effortful processing.

Encoding and Effortful Processing

Automatic processing happens so effortlessly that it is difficult to shut off. When you see words in your native language, perhaps on the side of a delivery truck, you can’t help but read them and register their meaning. Learning to read wasn’t automatic. You may recall working hard to pick out letters and connect them to certain sounds. But with experience and practice, your reading became automatic. Imagine now learning to read reversed sentences like this:

At first, this requires effort, but after enough practice, you would also perform this task much more automatically. We develop many skills in this way. We learn to drive, to text, to speak a new language with effort, but then these tasks become automatic.

Sensory Memory

How does sensory memory work?

Effortful processing begins with sensory memory (recall Figure 8.2), which feeds our active working memory. Our sensory memory records a momentary image of a scene or an echo of a sound. How much of this page could you sense and recall with less exposure than a lightning flash? In one experiment (Sperling, 1960), people viewed three rows of three letters each, for only one-twentieth of a second (FIGURE 8.5). After the nine letters disappeared, they could recall only about half of them.

Was it because they had insufficient time to glimpse them? No. The researcher, George Sperling, cleverly demonstrated that people actually could see and recall all the letters, but only momentarily. Rather than ask them to recall all nine letters at once, he sounded a high, medium, or low tone immediately after flashing the nine letters. This tone directed participants to report only the letters of the top, middle, or bottom row, respectively. Now they rarely missed a letter, showing that all nine letters were momentarily available for recall.
Sperling’s experiment demonstrated *iconic memory*, a fleeting sensory memory of visual stimuli. For a few tenths of a second, our eyes register a photographic or picture-image memory of a scene, and we can recall any part of it in amazing detail. But if Sperling delayed the tone signal by more than half a second, the image faded and participants again recalled only about half the letters. Our visual screen clears quickly, as new images are superimposed over old ones.

We also have an impeccable, though fleeting, memory for auditory stimuli, called *echoic memory* (Cowan, 1988; Lu et al., 1992). Picture yourself in conversation, as your attention veers to the TV. If your mildly irked companion tests you by asking, “What did I just say?” you can recover the last few words from your mind’s echo chamber. Auditory echoes tend to linger for 3 or 4 seconds.

### Capacity of Short-Term and Working Memory

**Questions:**

**8-6** What is the capacity of our short-term and working memory?

George Miller (1956) proposed that short-term memory can retain about seven information bits (give or take two). Other researchers have confirmed that we can, if nothing distracts us, recall about seven digits, or about six letters or five words (Baddeley et al., 1975). How quickly do our short-term memories disappear? To find out, Lloyd Peterson and Margaret Peterson (1959) asked people to remember three-consonant groups, such as CHJ. To prevent rehearsal, the researchers asked them, for example, to start at 100 and count aloud backwards by threes. After 3 seconds, people recalled the letters only about half the time; after 12 seconds, they seldom recalled them at all (FIGURE 8.6). Without the active processing that we now understand to be a part of the “working memory” concept, short-term memories have a limited life.

Working-memory capacity varies, depending on age and other factors. Compared with children and older adults, young adults have more working-memory capacity, so they can use their mental workspace more efficiently. This means their ability to multitask is relatively greater. But whatever our age, we do better and more efficient work when focused, without distractions, on one task at a time. The bottom line: It’s probably a bad idea to try to watch TV, text your friends, and write a psychology paper all at the same time (Willingham, 2010)!

Unlike short-term memory capacity, working-memory capacity appears to reflect intelligence level (Cowan, 2008; Shelton et al., 2010). Imagine seeing a letter of the alphabet, then a simple question, then another letter, followed by another question, and so on. In such experiments, those who could juggle the most mental balls—who could remember the most letters despite the interruptions—tended in everyday life to exhibit high intelligence and an ability to maintain their focus (Kane et al., 2007; Unsworth & Engle, 2007). When beeped to report in at various times, they were less likely than others to report that their mind was wandering.

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**FIGURE 8.6**

**Short-term memory decay** Unless rehearsed, verbal information may be quickly forgotten. (From Peterson & Peterson, 1959; see also Brown, 1958.)

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**Percentage who recalled consonants**

- **Rapid decay with no rehearsal**

<table>
<thead>
<tr>
<th>Time in seconds between presentation of consonants and recall request (no rehearsal allowed)</th>
<th>Percentage who recalled consonants</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>90%</td>
</tr>
<tr>
<td>6</td>
<td>80%</td>
</tr>
<tr>
<td>9</td>
<td>70%</td>
</tr>
<tr>
<td>12</td>
<td>60%</td>
</tr>
<tr>
<td>15</td>
<td>50%</td>
</tr>
<tr>
<td>18</td>
<td>40%</td>
</tr>
</tbody>
</table>
What are some effortful processing strategies that can help us remember new information?

Research shows that several effortful processing strategies can boost our ability to form new memories. Later, when we try to retrieve a memory, these strategies can make the difference between success and failure.

**Chunking**
Glance for a few seconds at row 1 of FIGURE 8.7, then look away and try to reproduce what you saw. Impossible, yes? But you can easily reproduce the second row, which is no less complex. Similarly, you will probably find row 4 much easier to remember than row 3, although both contain the same letters. And you could remember the sixth cluster more easily than the fifth, although both contain the same words. As these units demonstrate, chunking information—organizing items into familiar, manageable units—enables us to recall it more easily. Try remembering 43 individual numbers and letters. It would be impossible, unless chunked into, say, seven meaningful chunks, such as “Try remembering 43 individual numbers and letters.”

Chunking usually occurs so naturally that we take it for granted. If you are a native English speaker, you can reproduce perfectly the 150 or so line segments that make up the words in the three phrases of item 6 in Figure 8.7. It would astonish someone unfamiliar with the language. I am similarly awed at a Chinese reader’s ability to glance at FIGURE 8.8 and then reproduce all the strokes; or of a varsity basketball player’s recall of the positions of the players after a 4-second glance at a basketball play (Allard & Burnett, 1985). We all remember information best when we can organize it into personally meaningful arrangements.

**Mnemonics**
To help them encode lengthy passages and speeches, ancient Greek scholars and orators also developed *mnemonics* (nih-MOH-iks). Many of these memory aids use vivid imagery, because we are particularly good at remembering mental pictures. We more easily remember concrete, visualizable words than we do abstract words. (When I quiz you later, which three of these words—bicycle, void, cigarette, inherent, fire, process—will you most likely recall?) If you still recall the rock-throwing rioter sentence, it is probably not only because of the meaning you encoded but also because the sentence painted a mental image.

The *peg-word* system harnesses our superior visual-imagery skill. This mnemonic requires you to memorize a jingle: “One is a bun; two is a shoe; three is a tree; four is a door; five is a hive; six is sticks; seven is heaven; eight is a gate; nine is swine; ten is a hen.” Without much effort, you will soon be able to count by peg-words instead of numbers: bun, shoe, tree . . . and then to visually associate the peg-words with to-be-remembered items. Now you are ready to challenge anyone to give you a grocery list to remember. Carrots? Stick them into the imaginary bun. Milk? Fill the shoe with it. Paper towels? Drape them over the tree branch. Think bun, shoe, tree and you see their associated images: carrots, milk, paper towels. With few errors, you will be able to recall the items in any order and to name any given item (Bugelski et al., 1968). Memory whizzes understand the power of such systems. A study of star performers in the World Memory Championships showed them not to have exceptional intelligence, but rather to be superior at using mnemonic strategies (Maguire et al., 2003).

Chunking and mnemonic techniques combined can be great memory aids for unfamiliar material. Want to remember the colors of the rainbow in order of wavelength? Think of the mnemonic ROY G. BIV (red, orange, yellow, green, blue, indigo, violet). Need to recall the names of North America’s five Great Lakes? Just remember HOMES (Huron, Ontario, Michigan, Erie, Superior). In each case, we chunk information into a more familiar form by creating a word (called an *acronym*) from the first letters of the to-be-remembered items.
Hierarchies When people develop expertise in an area, they process information not only in chunks but also in hierarchies composed of a few broad concepts divided and subdivided into narrower concepts and facts. This section, for example, aims to help you organize memory concepts (FIGURE 8.9).

Organizing knowledge in hierarchies helps us retrieve information efficiently, as Gordon Bower and his colleagues (1969) demonstrated by presenting words either randomly or grouped into categories. When the words were organized into categories, recall was two to three times better. Such results show the benefits of organizing what you study—of giving special attention to chapter outlines, headings, the numbered “Learning Objective” questions (such as 8-8 below), Retrieval Practice questions, and chapter reviews. Taking lecture and text notes in outline format—a type of hierarchical organization—may also prove helpful.

Distributed Practice We retain information (such as classmates’ names) better when our encoding is distributed over time. More than 300 experiments over the last century have consistently revealed the benefits of this spacing effect (Cepeda et al., 2006). Massed practice (cramming) can produce speedy short-term learning and feelings of confidence. But to paraphrase pioneer memory researcher Hermann Ebbinghaus (1885), those who learn quickly also forget quickly. Distributed practice produces better long-term recall. After you’ve studied long enough to master the material, further study becomes inefficient (Rohrer & Pashler, 2007). Better to spend that extra reviewing time later—a day later if you need to remember something 10 days hence, or a month later if you need to remember something 6 months hence (Cepeda et al., 2008).

Spreading your learning over several months, rather than over a shorter term, can help you retain information for a lifetime. In a 9-year experiment, Harry Bahrick and three of his family members (1993) practiced foreign language word translations for a given number of times, at intervals ranging from 14 to 56 days. Their consistent finding: The longer the space between practice sessions, the better their retention up to 5 years later.

One effective way to distribute practice is repeated self-testing, a phenomenon that researchers Henry Roediger and Jeffrey Karpicke (2006) call the testing effect. In this text, for example, the Retrieval Practice features offer such an opportunity. Better to practice retrieval (as any exam will demand) than merely to reread material (which may lull you into a false sense of mastery).

The point to remember: Spaced study and self-assessment beat cramming and rereading.

Levels of Processing

Memory researchers have discovered that we process verbal information at different levels, and that depth of processing affects our long-term retention. Shallow processing encodes on a very basic level, such as a word’s letters or, at a more intermediate level,
a word’s sound. **Deep processing** encodes semantically, based on the meaning of the words. The deeper (more meaningful) the processing, the better our retention.

In one classic experiment, researchers Fergus Craik and Endel Tulving (1975) flashed words at people. Then they asked the viewers a question that would elicit different levels of processing. To experience the task yourself, rapidly answer the following sample questions:

<table>
<thead>
<tr>
<th>Sample Questions to Elicit Processing</th>
<th>Word Flashed</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Is the word in capital letters?</td>
<td>CHAIR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Does the word rhyme with train?</td>
<td>brain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Would the word fit in this sentence? The girl put the _______ on the table.</td>
<td>doll</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Which type of processing would best prepare you to recognize the words at a later time? In Craik and Tulving’s experiment, the deeper, semantic processing triggered by the third question yielded a much better memory than did the shallower processing elicited by the second question or the very shallow processing elicited by question 1 (which was especially ineffective) (**FIGURE 8.10**).

![Levels of processing](image)

**FIGURE 8.10** Levels of processing  Processing a word deeply—by its meaning (semantically)—produces better recognition of it at a later time than does shallower processing by attending to its appearance or sound. (From Craik & Tulving, 1975.)

**Making Material Personally Meaningful**

If new information is not meaningful or related to our experience, we have trouble processing it. Put yourself in the place of the students who John Bransford and Marcia Johnson (1972) asked to remember the following recorded passage:

The procedure is actually quite simple. First you arrange things into different groups. Of course, one pile may be sufficient depending on how much there is to do. . . . After the procedure is completed one arranges the materials into different groups again. Then they can be put into their appropriate places. Eventually they will be used once more and the whole cycle will then have to be repeated. However, that is part of life.

When the students heard the paragraph you have just read, without a meaningful context, they remembered little of it. When told the paragraph described washing clothes (something meaningful to them), they remembered much more of it—as you probably could now after rereading it.

Can you repeat the sentence about the rioter that I gave you at this chapter’s beginning? (“The angry rioter threw . . . ”) Perhaps, like those in an experiment by William

**Spacing effect** the tendency for distributed study or practice to yield better long-term retention than is achieved through massed study or practice.

**Testing effect** enhanced memory after retrieving, rather than simply reading, information. Also sometimes referred to as a retrieval practice effect or test-enhanced learning.

**Shallow processing** encoding on a basic level based on the structure or appearance of words.

**Deep processing** encoding semantically, based on the meaning of the words; tends to yield the best retention.

Here is another sentence I will ask you about later: The fish attacked the swimmer.
What is the capacity and location of our long-term memories?

In Arthur Conan Doyle’s *A Study in Scarlet*, Sherlock Holmes offers a popular theory of memory capacity:

“I consider that a man’s brain originally is like a little empty attic, and you have to stock it with such furniture as you choose. . . . It is a mistake to think that that little room has elastic walls and can distend to any extent. Depend upon it, there comes a time when for every addition of knowledge you forget something that you knew before.”

Contrary to Holmes’ “memory model,” our capacity for storing long-term memories is essentially limitless. Our brains are not like attics, which once filled can store more items only if we discard old ones.

Retaining Information in the Brain

I marveled at my aging mother-in-law, a retired pianist and organist. At age 88 her blind eyes could no longer read music. But let her sit at a keyboard and she would flawlessly play any of hundreds of hymns, including ones she had not thought of for 20 years. Where did her brain store those thousands of sequenced notes?
For a time, some surgeons and memory researchers believed that what appeared to be vivid memories triggered by brain stimulation during surgery were indications that our whole past, not just well-practiced music, must be “in there,” in complete detail, just waiting to be relived. But on closer analysis, the seeming flashbacks appeared to have been invented, not relived (Loftus & Loftus, 1980). In a further demonstration that memories do not reside in single, specific spots, psychologist Karl Lashley (1950) trained rats to find their way out of a maze, then surgically removed pieces of their brain’s cortex and retested their memory. No matter what small brain section he removed, the rats retained at least a partial memory of how to navigate the maze.

The point to remember: Despite the brain’s vast storage capacity, we do not store information as libraries store their books, in discrete, precise locations. Instead, many parts of the brain interact as we encode, store, and retrieve the information that forms our memories.

**Explicit-Memory System: The Frontal Lobes and Hippocampus**

As with perception, language, emotion, and much more, memory requires brain networks. The network that processes and stores your explicit memories includes your frontal lobes and hippocampus. When you summon up a mental encore of a past experience, many brain regions send input to your frontal lobes for working memory processing (Pink et al., 1996; Gabrieli et al., 1996; Markowitsch, 1995). The left and right frontal lobes process different types of memories. Recalling a password and holding it in working memory, for example, would activate the left frontal lobe. Calling up a visual party scene would more likely activate the right frontal lobe.

Cognitive neuroscientists have found that the hippocampus, a temporal-lobe neural center located in the limbic system, is the brain’s equivalent of a “save” button for explicit memories (Anderson et al., 2007). Brain scans, such as PET scans of people recalling words, and autopsies of people who had amnesia, have revealed that new explicit memories of names, images, and events are laid down via the hippocampus (Squire, 1992). Damage to this structure therefore disrupts recall of explicit memories. Chickadees and other birds can store food in hundreds of places and return to these unmarked caches months later—but not if their hippocampus has been removed (Kamil & Cheng, 2001; Sherry & Vaccarino, 1989). With left-hippocampus damage, people have trouble remembering verbal information, but they have no trouble recalling visual designs and locations. With right-hippocampus damage, the problem is reversed (Schacter, 1996).

Subregions of the hippocampus also serve different functions. One part is active as people learn to associate names with faces (Zeineh et al., 2003). Another part is active as memory champions engage in spatial mnemonics (Maguire et al., 2003b). The rear area, which processes spatial memory, grows bigger the longer a London cabbie has navigated the street maze (Maguire et al., 2003a).

Memories are not permanently stored in the hippocampus. Instead, this structure seems to act as a loading dock where the brain registers and temporarily holds the elements of a remembered episode—its smell, feel, sound, and location. Then, like older files shifted to a basement storeroom, memories migrate for storage elsewhere. Removing a rat’s hippocampus 3 hours after it learns the location of some tasty new food disrupts this process and prevents long-term memory formation; removal 48 hours later does not (Tse et al., 2007).
Sleep supports memory consolidation. During deep sleep, the hippocampus processes memories for later retrieval. After a training experience, the greater the hippocampus activity during sleep, the better the next day’s memory will be (Peigneux et al., 2004). Researchers have watched the hippocampus and brain cortex displaying simultaneous activity rhythms during sleep, as if they were having a dialogue (Euston et al., 2007; Mehta, 2007). They suspect that the brain is replaying the day’s experiences as it transfers them to the cortex for long-term storage. Cortex areas surrounding the hippocampus support the processing and storing of explicit memories (Squire & Zola-Morgan, 1991).

**Implicit-Memory System: The Cerebellum and Basal Ganglia**

What role do the cerebellum and basal ganglia play in our memory processing?

Your hippocampus and frontal lobes are processing sites for your explicit memories. But you could lose those areas and still, thanks to automatic processing, lay down implicit memories for skills and conditioned associations. Joseph LeDoux (1996) recounted the story of a brain-damaged patient whose amnesia left her unable to recognize her physician as, each day, he shook her hand and introduced himself. One day, she yanked her hand back, for the physician had pricked her with a tack in his palm. The next time he returned to introduce himself she refused to shake his hand but couldn’t explain why. Having been classically conditioned, she just wouldn’t do it.

The cerebellum plays a key role in forming and storing the implicit memories created by classical conditioning. With a damaged cerebellum, people cannot develop certain conditioned reflexes, such as associating a tone with an impending puff of air—and thus do not blink in anticipation of the puff (Daum & Schugens, 1996; Green & Woodruff-Pak, 2000). When researchers surgically disrupted the function of different pathways in the cerebellum of rabbits, the rabbits became unable to learn a conditioned eyeblink response (Krupa et al., 1993; Steinmetz, 1999). Implicit memory formation needs the cerebellum (FIGURE 8.12).

The basal ganglia, deep brain structures involved in motor movement, facilitate formation of our procedural memories for skills (Mishkin, 1982; Mishkin et al., 1997). The basal ganglia receive input from the cortex but do not return the favor of sending information back to the cortex for conscious awareness of procedural learning. If you have learned how to ride a bike, thank your basal ganglia.

Our implicit memory system, enabled by the cerebellum and basal ganglia, helps explain why the reactions and skills we learned during infancy reach far into our future. Yet as adults, our conscious memory of our first three years is blank, an experience called infantile amnesia. In one study, events children experienced and discussed with their mothers at age 3 were 60 percent remembered at age 7 but only 34 percent remembered at age 9 (Bauer et al., 2007). Two influences contribute to infantile amnesia: First, we index much of our explicit memory using words that nonspeaking children have not learned. Second, the hippocampus is one of the last brain structures to mature.
The Amygdala, Emotions, and Memory

How do emotions affect our memory processing?

Our emotions trigger stress hormones that influence memory formation. When we are excited or stressed, these hormones make more glucose energy available to fuel brain activity, signaling the brain that something important has happened. Moreover, stress hormones provoke the amygdala (two limbic system, emotion-processing clusters) to initiate a memory trace in the frontal lobes and basal ganglia and to boost activity in the brain’s memory-forming areas (Buchanan, 2007; Kensinger, 2007). The result? Emotional arousal can scar certain events into the brain, while disrupting memory for neutral events around the same time (Birnbaum et al., 2004; Brewin et al., 2007).

Emotions often persist without our conscious awareness of what caused them. In one ingenious experiment, patients with hippocampal damage (which left them unable to form new explicit memories) watched a sad film and later a happy film. After the viewing, they did not consciously recall the films, but the sad or happy emotion persisted (Feinstein et al., 2010).

Significantly stressful events can form almost indelible memories. After traumatic experiences—a wartime ambush, a house fire, a rape—vivid recollections of the horrific event may intrude again and again. It is as if they were burned in: “Stronger emotional experiences make for stronger, more reliable memories,” noted James McGaugh (1994, 2003). This makes adaptive sense. Memory serves to predict the future and to alert us to potential dangers. Conversely, weaker emotions mean weaker memories. People given a drug that blocks the effects of stress hormones will later have more trouble remembering the details of an upsetting story (Cahill, 1994).

Emotion-triggered hormonal changes help explain why we long remember exciting or shocking events, such as our first kiss or our whereabouts when learning of a loved one’s death. In a 2006 Pew survey, 95 percent of American adults said they could recall exactly where they were or what they were doing when they first heard the news of the 9/11 attack. This perceived clarity of memories of surprising, significant events leads some psychologists to call them flashbulb memories. It’s as if the brain commands, “Capture this!”

The people who experienced a 1989 San Francisco earthquake did just that. A year and a half later, they had perfect recall of where they had been and what they were doing (verified by their recorded thoughts within a day or two of the quake). Others’ memories for the circumstances under which they merely heard about the quake were more prone to errors (Neisser et al., 1991; Palmer et al., 1991).

Our flashbulb memories are noteworthy for their vividness and the confidence with which we recall them. But as we relive, rehearse, and discuss them, these memories may come to err, as misinformation seeps in (Conway et al., 2009; Talarico et al., 2003; Talarico & Rubin, 2007).
Synaptic Changes

How do changes at the synapse level affect our memory processing?

As you read this chapter and think and learn about memory characteristics and processes, your brain is changing. Given increased activity in particular pathways, neural interconnections are forming and strengthening (see Chapter 4).

The quest to understand the physical basis of memory—how information becomes embedded in brain matter—has sparked study of the synaptic meeting places where neurons communicate with one another via their neurotransmitter messengers. Eric Kandel and James Schwartz (1982) observed synaptic changes during learning in the sending neurons of the California sea slug, *Aplysia*, a simple animal with a mere 20,000 or so unusually large and accessible nerve cells. Chapter 7 noted how the sea slug can be classically conditioned (with electric shock) to reflexively withdraw its gills when squirted with water, much as a shell-shocked soldier jumps at the sound of a snapping twig. By observing the slugs’ neural connections before and after conditioning, Kandel and Schwartz pinpointed changes. When learning occurs, the slug releases more of the neurotransmitter serotonin onto certain neurons. These cells then become more efficient at transmitting signals.

In experiments with people, rapidly stimulating certain memory-circuit connections has increased their sensitivity for hours or even weeks to come. The sending neuron now needs less prompting to release its neurotransmitter, and more connections exist between neurons (FIGURE 8.13). This increased efficiency of potential neural firing, called **long-term potentiation (LTP)**, provides a neural basis for learning and remembering associations (Lynch, 2002; Whitlock et al., 2006). Several lines of evidence confirm that LTP is a physical basis for memory:

- Drugs that block LTP interfere with learning (Lynch & Staubli, 1991).
- Mutant mice engineered to lack an enzyme needed for LTP can’t learn their way out of a maze (Silva et al., 1992).
- Rats given a drug that enhances LTP will learn a maze with half the usual number of mistakes (Service, 1994).
- Injecting rats with a chemical that blocks the preservation of LTP erases recent learning (Pastalkova et al., 2006).

After long-term potentiation has occurred, passing an electric current through the brain won’t disrupt old memories. But the current will wipe out very recent memories. Such is the experience both of laboratory animals and of severely depressed people (see Chapter 16) given **electroconvulsive therapy (ECT)**. A blow to the head can do the same.
Football players and boxers momentarily knocked unconscious typically have no memory of events just before the knock-out (Yarnell & Lynch, 1970). Their working memory had no time to consolidate the information into long-term memory before the lights went out.

Some memory-biology explorers have helped found companies that are competing to develop memory-altering drugs. The target market for memory-boosting drugs includes millions of people with Alzheimer's disease, millions more with mild cognitive impairment that often becomes Alzheimer's, and countless millions who would love to turn back the clock on age-related memory decline. From expanding memories perhaps will come bulging profits.

One approach to improving memory focuses on drugs that boost the LTP-enhancing neurotransmitter glutamate. Another approach involves developing drugs that boost production of CREB, a protein that also enhances the LTP process (Fields, 2005). Boosting CREB production might trigger increased production of other proteins that help reshape synapses and transfer short-term memories into long-term memories. Sea slugs, mice, and fruit flies with enhanced CREB production have displayed enhanced learning.

Other people wish for memory-blocking drugs. Among them are those who would welcome a drug that, when taken after a traumatic experience, might blunt intrusive memories. In mice, blocking CREB-producing amygdala neurons has permanently erased an auditory fear memory (Han et al., 2009). In another experiment, victims of car accidents, rapes, and other traumas received, for 10 days following their horrific event, either one such drug, propranolol, or a placebo. When tested three months later, half the placebo group but none of the drug-treated group showed signs of stress disorder (Pitman et al., 2002, 2005).

In your lifetime, will you have access to safe and legal drugs that boost your fading memory without nasty side effects and without cluttering your mind with trivia best forgotten? That question has yet to be answered. But in the meantime, one effective, safe, and free memory enhancer is already available on your college campus: effective study techniques followed by adequate sleep! (You’ll find study tips in the Prologue at the beginning of this text, and sleep coverage in Chapter 3.)

**FIGURE 8.14** summarizes the encoding of both implicit (automatic) and explicit (effortful) memories, and how the brain stores memories in its two-track system.

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**long-term potentiation (LTP)**: an increase in a cell’s firing potential after brief, rapid stimulation. Believed to be a neural basis for learning and memory.

If you suffered a traumatic experience, would you want to take a drug to blunt that memory?
Retrieval: Getting Information Out

After the magic of brain encoding and storage, we still have the daunting task of retrieving the information. What triggers retrieval? How do psychologists study this phenomenon?

Measures of Retention

What are three measures of retention?

Earlier in this chapter, we pointed out that recall, recognition, and relearning speed are three ways that psychologists measure retention of memories. Long after you cannot recall most of the people in your high school graduating class, you may still be able to recognize their yearbook pictures from a photographic lineup and pick their names from a list of names. In one experiment, people who had graduated 25 years earlier could not recall many of their old classmates, but they could recognize 90 percent of their pictures and names (Bahrick et al., 1975). If you are like most students, you, too, could probably recognize more names of Snow White’s Seven Dwarfs than you could recall (Miserandino, 1991).

Our recognition memory is impressively quick and vast. “Is your friend wearing a new or old outfit?” “Old.” “Is this five-second movie clip from a film you’ve ever seen?” “Yes.” “Have you ever seen this person before—this minor variation on the same old human features (two eyes, one nose, and so on)?” “No.” Before the mouth can form our answer to any of millions of such questions, the mind knows, and knows that it knows.

Our speed at relearning also reveals memory. Hermann Ebbinghaus showed this more than a century ago in his learning experiments, using nonsense syllables. He randomly selected a sample of syllables, practiced them, and tested himself. To get a feel for his experiments, rapidly read aloud, eight times over, the following list (from Baddeley, 1982), then look away and try to recall the items:

JIH, BAZ, FUB, YOX, SUJ, XIR, DAX, LEQ, VUM, PID, KEL, WAV, TUV, ZOF, GEK, HIW.
The day after learning such a list, Ebbinghaus could recall few of the syllables. But they weren’t entirely forgotten. As FIGURE 8.15 portrays, the more frequently he repeated the list aloud on day 1, the fewer repetitions he required to relearn the list on day 2. Additional rehearsal (overlearning) of verbal information increases retention, especially when practice is distributed over time.

*The point to remember:* Tests of recognition and of time spent relearning demonstrate that we remember more than we can recall.

**Retrieval Cues**

How do external cues, internal emotions, and order of appearance influence memory retrieval?

Imagine a spider suspended in the middle of her web, held up by the many strands extending outward from her in all directions to different points. If you were to trace a pathway to the spider, you would first need to create a path from one of these anchor points and then follow the strand down into the web.

The process of retrieving a memory follows a similar principle, because memories are held in storage by a web of associations, each piece of information interconnected with others. When you encode into memory a target piece of information, such as the name of the person sitting next to you in class, you associate with it other bits of information about your surroundings, mood, seating position, and so on. These bits can serve as retrieval cues that you can later use to access the information. The more retrieval cues you have, the better your chances of finding a route to the suspended memory.

“Memory is not like a container that gradually fills up; it is more like a tree growing hooks onto which memories are hung.”

Ask a friend two rapid-fire questions: (a) How do you pronounce the word spelled by the letters s-h-a-r-e? (b) What do you do when you come to a green light? If your friend answers “stop” to the second question, you have demonstrated priming.

**FIGURE 8.16**
Priming—awakening associations
After seeing or hearing rabbit, we are later more likely to spell the spoken word as h-a-r-e. The spreading of associations unconsciously activates related associations. This phenomenon is called priming. (Adapted from Bower, 1986.)

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**Priming**

The best retrieval cues come from associations we form at the time we encode a memory—smells, tastes, and sights that can evoke our memory of the associated person or event. To call up visual cues when trying to recall something, we may mentally place ourselves in the original context. After losing his sight, John Hull (1990, p. 174) described his difficulty recalling such details:

“I knew I had been somewhere, and had done particular things with certain people, but where? I could not put the conversations . . . into a context. There was no background, no features against which to identify the place. Normally, the memories of people you have spoken to during the day are stored in frames which include the background.”

Often our associations are activated without our awareness. Philosopher-psychologist William James referred to this process, which we call **priming**, as the “wakening of associations.” Seeing or hearing the word *rabbit* primes associations with *hare*, even though we may not recall having seen or heard *rabbit* (FIGURE 8.16).

Priming is often “memoryless memory”—invisible memory, without your conscious awareness. If, walking down a hallway, you see a poster of a missing child, you will then unconsciously be primed to interpret an ambiguous adult-child interaction as a possible kidnapping (James, 1986). Although you no longer have the poster in mind, it predisposes your interpretation. Meeting someone who reminds us of a person we’ve previously met can awaken our associated feelings about that earlier person, which may transfer into the new context (Andersen & Saribay, 2005; Lewicki, 1985). (And as we saw in Chapter 6, even subliminal stimuli can briefly prime responses to later stimuli.)

Priming can influence behaviors as well. Dutch children primed with items associated with Saint Nicholas (Santa Claus) shared more candy than did other children primed with a figure not associated with kindness and generosity (Joly & Stapel, 2009). Priming effects are not always positive. In another study, participants primed with money-related words were less likely to help another person when asked (Vohs, 2006). In such cases, money may prime our materialism and self-interest rather than the social norms that encourage us to help (Ariely, 2009).

**Context-Dependent Memory**

Putting yourself back in the context where you experienced something can prime your memory retrieval. As **FIGURE 8.17** illustrates, when scuba divers listened to a word list in two different settings (either 10 feet underwater or sitting on the beach), they recalled more words if retested in the same place (Godden & Baddeley, 1975).

You may have experienced similar context effects. Consider this scenario: While taking notes from this book, you realize you need to sharpen your pencil. You get up and walk into another room, but then you cannot remember why. After returning to your desk it hits you: “I wanted to sharpen this pencil!” What happens to create this frustrating experience? In one context (desk, reading psychology), you realize your pencil needs sharpening. When you go to the other room and are in a different context, you have few cues to lead you back to that thought. When you are once again at your desk, you are back in the context in which you encoded the thought (“This pencil is dull”).

In several experiments, Carolyn Rovee-Collier (1993) found that a familiar context can activate memories even in 3-month-olds. After infants learned that kicking a crib mobile would make it move (via a connecting ribbon from the ankle), the infants kicked more when tested again in the same crib with the same bumper than when in a different context.
State-Dependent Memory

Closely related to context-dependent memory is state-dependent memory. What we learn in one state—be it drunk or sober—may be more easily recalled when we are again in that state. What people learn when drunk they don’t recall well in any state (alcohol disrupts storage). But they recall it slightly better when again drunk. Someone who hides money when drunk may forget the location until drunk again.

Our mood states provide an example of memory’s state dependence. Emotions that accompany good or bad events become retrieval cues (Fiedler et al., 2001). Thus, our memories are somewhat mood congruent. If you’ve had a bad evening—your date never showed, your Toledo Mud Hens hat disappeared, your TV went out 10 minutes before the end of a show—your gloomy mood may facilitate recalling other bad times. Being depressed sours memories by priming negative associations, which we then use to explain our current mood. In many experiments, people put in a buoyant mood—whether under hypnosis or just by the day’s events (a World Cup soccer victory for the German participants in one study)—have recalled the world through rose-colored glasses (DeSteno et al., 2000; Forgas et al., 1984; Schwarz et al., 1987). They judged themselves competent and effective, other people benevolent, happy events more likely.

Knowing this mood-memory connection, we should not be surprised that in some studies currently depressed people have recalled their parents as rejecting, punitive, and guilt promoting, whereas formerly depressed people’s recollections more closely resembled the more positive descriptions given by those who never suffered depression (Lewinsohn & Rosenbaum, 1987; Lewis, 1992). Similarly, adolescents’ ratings of parental warmth in one week gave little clue to how they would rate their parents six weeks later (Bornstein et al., 1991). When teens were down, their parents seemed inhuman; as their mood brightened, their parents morphed from devils into angels. You and I may nod our heads knowingly. Yet, in a good or bad mood, we persist in attributing to reality our own changing judgments, memories, and interpretations. In a bad mood, we may read someone’s look as a glare and feel even worse. In a good mood, we may encode the same look as interest and feel even better. Passions exaggerate.

This retrieval effect helps explain why our moods persist. When happy, we recall happy events and therefore see the world as a happy place, which helps prolong our good mood. When depressed, we recall sad events, which darkens our interpretations of current events. For those of us with a predisposition to depression, this process can help maintain a vicious, dark cycle.

"I can’t remember what we’re arguing about, either. Let’s keep yelling, and maybe it will come back to us."

"When a feeling was there, they felt as if it would never go; when it was gone, they felt as if it had never been; when it returned, they felt as if it had never gone."

George MacDonald, What’s Mine’s Mine, 1886

**mood-congruent memory**

The tendency to recall experiences that are consistent with one’s current good or bad mood.
Serial Position Effect

Another memory-retrieval quirk, the **serial position effect**, can leave us wondering why we have large holes in our memory of a list of recent events. Imagine it’s your first day in a new job, and your manager is introducing co-workers. As you meet each person, you silently repeat everyone’s name, starting from the beginning. As the last person smiles and turns away, you feel confident you’ll be able to greet your new co-workers by name the next day.

Don’t count on it. Because you have spent more time rehearsing the earlier names than the later ones, those are the names you’ll probably recall more easily the next day. In experiments, when people view a list of items (words, names, dates, even odors) and immediately try to recall them in any order, they fall prey to the serial position effect (Reed, 2000). They briefly recall the last items especially quickly and well (a recency effect), perhaps because those last items are still in working memory. But after a delay, when they have shifted their attention away from the last items, their recall is best for the first items (a primacy effect; see **FIGURE 8.18**).

"Amnesia seeps into the crevices of our brains, and amnesia heals."

Joyce Carol Oates, “Words Fail, Memory Blurs, Life Wins,” 2001

### Retrieval Practice

- **What is priming?**
  
  *Recall a boss as nasty.*
  
  EXAMPLE: **Wrong association**. Example: On my first day of high school, I chose a name for my locker that started with “H” (so I was named Heather). That was one of the only people that liked me in high school. **ANSWER:** Priming is the activation (often without our awareness) of associations. Seeing a gun lets us know someone is dangerous. Hearing the word “Lima” makes us think of the capital of Peru and opens the door for us to recall that Peru is a Spanish-speaking country. If the word “Lima” is paired with something else, it’s more likely to be used again in the future.

- **When we are tested immediately after viewing a list of words, we tend to recall the first and last items best, which is known as the **serial position effect**.**

### Forgetting

**8-16** Why do we forget?

Amid all the applause for memory—all the efforts to understand it, all the books on how to improve it—have any voices been heard in praise of forgetting? William James (1890, p. 680) was such a voice: “If we remembered everything, we should on most occasions be
as ill off as if we remembered nothing.” To discard the clutter of useless or out-of-date information—where we parked the car yesterday, a friend’s old phone number, restaurant orders already cooked and served—is surely a blessing. The Russian memory whiz S, whom we met at the beginning of this chapter, was haunted by his junk heap of memories. They dominated his consciousness. He had difficulty thinking abstractly—generalizing, organizing, evaluating. After reading a story, he could recite it but would struggle to summarize its gist.

A more recent case of a life overtaken by memory is “A. J.,” whose experience has been studied and verified by a University of California at Irvine research team (Parker et al., 2006). A. J., who has identified herself as Jill Price, compares her memory to “a running movie that never stops. It’s like a split screen. I’ll be talking to someone and seeing something else . . . . Whenever I see a date flash on the television (or anywhere for that matter) I automatically go back to that day and remember where I was, what I was doing, what day it fell on, and on and on and on and on. It is nonstop, uncontrollable, and totally exhausting.” A good memory is helpful, but so is the ability to forget. If a memory-enhancing pill becomes available, it had better not be too effective.

More often, however, our unpredictable memory dismays and frustrates us. Memories are quirky. My own memory can easily call up such episodes as that wonderful first kiss with the woman I love, or trivial facts like the air mileage from London to Detroit. Then it abandons me when I discover I have failed to encode, store, or retrieve a student’s name or where I left my sunglasses.

Forgetting and the Two-Track Mind

English novelist and critic C. S. Lewis described the forgetting that plagues us all:

Each of us finds that in [our] own life every moment of time is completely filled. [We are] bombarded every second by sensations, emotions, thoughts . . . nine-tenths of which [we] must simply ignore. The past [is] a roaring cataract of billions upon billions of such moments: Any one of them too complex to grasp in its entirety, and the aggregate beyond all imagination. . . . At every tick of the clock, in every inhabited part of the world, an unimaginable richness and variety of ‘history’ falls off the world into total oblivion.

For some, memory loss is severe and permanent. Consider Henry Molaison (known as “H. M.,” 1926–2008). For 55 years after having brain surgery to stop severe seizures, Molaison was unable to form new conscious memories. He was, as before his surgery, intelligent and did daily crossword puzzles. Yet, reported neuroscientist Suzanne Corkin (2005), “I’ve known H. M. since 1962, and he still doesn’t know who I am.” For about 20 seconds during a conversation he could keep something in mind. When distracted, he would lose what was just said or what had just occurred. Thus, he never figured out how to use a TV remote (Dittrich, 2010).

Molaison suffered from anterograde amnesia—he could recall his past, but he could not form new memories. (Those who cannot recall their past—the old information stored in long-term memory—suffer from retrograde amnesia.)

Neurologist Oliver Sacks (1985, pp. 26–27) described another patient, Jimmie, who had anterograde amnesia resulting from brain damage. Jimmie had no memories—thus, no sense of elapsed time—beyond his injury in 1945.

When Jimmie gave his age as 19, Sacks set a mirror before him: “Look in the mirror and tell me what you see. Is that a 19-year-old looking out from the mirror?”

Jimmie turned ashen, gripped the chair, cursed, then became frantic: “What’s going on? What’s happened to me? Is this a nightmare? Am I crazy? Is this a joke?” When his attention was diverted to some children playing baseball, his panic ended, the dreadful mirror forgotten.
Sacks showed Jimmie a photo from *National Geographic*. “What is this?” he asked.

“It’s the Moon,” Jimmie replied.

“No, it’s not,” Sacks answered. “It’s a picture of the Earth taken from the Moon.”

“Doc, you’re kidding? Someone would’ve had to get a camera up there!”

“Naturally.”

“Hell! You’re joking—how the hell would you do that?” Jimmie’s wonder was that of a bright young man from 60 years ago reacting with amazement to his travel back to the future.

Careful testing of these unique people reveals something even stranger: Although incapable of recalling new facts or anything they have done recently, Molaison, Jimmie, and others with similar conditions can learn nonverbal tasks. Shown hard-to-find figures in pictures (in the *Where’s Waldo?* series), they can quickly spot them again later. They can find their way to the bathroom, though without being able to tell you where it is. They can learn to read mirror-image writing or do a jigsaw puzzle, and they have even been taught complicated job skills (Schacter, 1992, 1996; Xu & Corkin, 2001). They can be classically conditioned. However, they do all these things with no awareness of having learned them.

Molaison and Jimmie lost their ability to form new explicit memories. But their automatic processing ability remained intact. Like Alzheimer’s patients, whose explicit memories for people and events are lost, they can form new implicit memories (Lustig & Buckner, 2004). They can learn how to do something, but they will have no conscious recall of learning their new skill. Such sad cases confirm that we have two distinct memory systems, controlled by different parts of the brain.

For most of us, forgetting is a less drastic process. Let’s consider some of the reasons we forget.

### Encoding Failure

Much of what we sense we never notice, and what we fail to encode, we will never remember (FIGURE 8.19). Age can affect encoding efficiency. The brain areas that jump into action when young adults encode new information are less responsive in older adults. This slower encoding helps explain age-related memory decline (Grady et al., 1995).

But no matter how young we are, we selectively attend to few of the myriad sights and sounds continually bombarding us. Consider this example: If you live in North America, Britain, or Australia, you have looked at thousands of pennies in your lifetime. You can surely recall their color and size, but can you recall what the side with the head looks like? If not, let’s make the memory test easier: If you are familiar with U.S. coins, can you, in FIGURE 8.20, just recognize the real thing? Most people cannot (Nickerson & Adams, 1979). Likewise, few British people can draw from memory the details of a
one-pence coin (Richardson, 1993). The details of these coins are not very meaningful, nor are they essential for distinguishing them from other coins. Coin collectors may have subjected the coins’ critical features to the effortful processing needed to encode them. But for the rest of us, the details were never encoded. Without effort, many potential memories never form.

### Storage Decay

Even after encoding something well, we sometimes later forget it. To study the durability of stored memories, Ebbinghaus (1885) learned more lists of nonsense syllables and measured how much he retained when relearning each list, from 20 minutes to 30 days later. The result, confirmed by later experiments, was his famous forgetting curve: *The course of forgetting is initially rapid, then levels off with time* (FIGURE 8.21; Wixted & Ebbesen, 1991). Harry Bahrick (1984) found a similar forgetting curve for Spanish vocabulary learned in school. Compared with those just completing a high school or college Spanish course, people 3 years out of school had forgotten much of what they had learned (FIGURE 8.22 on the next page). However, what people remembered then, they still remembered 25 and more years later. Their forgetting had leveled off.

![Ebbinghaus’ forgetting curve](image)

**FIGURE 8.21**  
Ebbinghaus’ forgetting curve  
After learning lists of nonsense syllables, Ebbinghaus studied how much he retained up to 30 days later. He found that memory for novel information fades quickly, then levels out. (Adapted from Ebbinghaus, 1885.)

![Test your memory](image)

**FIGURE 8.20**  
Test your memory  
Which of these pennies is the real thing? (If you live outside the United States, try drawing one of your own country’s coins.) (From Nickerson & Adams, 1979.) See answer below.

The first penny (a) is the real penny.

(a) (b) (c)  
(d) (e) (f)
One explanation for these forgetting curves is a gradual fading of the physical memory trace. Cognitive neuroscientists are getting closer to solving the mystery of the physical storage of memory and are increasing our understanding of how memory storage could decay. Like books you can’t find in your campus library, memories may be inaccessible for many reasons. Some were never acquired (not encoded). Others were discarded (stored memories decay). And others are out of reach because we can’t retrieve them.

## Retrieval Failure

Often, forgetting is not memories faded but memories unretrieved. We store in long-term memory what’s important to us or what we’ve rehearsed. But sometimes important events defy our attempts to access them (FIGURE 8.23). How frustrating when a name lies poised on the tip of our tongue, just beyond reach. Given retrieval cues (“It begins with an M”), we may easily retrieve the elusive memory. Retrieval problems contribute to the occasional memory failures of older adults, who more frequently are frustrated by tip-of-the-tongue forgetting (Abrams, 2008).

Do you recall the gist of the second sentence I asked you to remember? If not, does the word shark serve as a retrieval cue? Experiments show that shark (likely what you visualized) more readily retrieves the image you stored than does the sentence’s actual word, fish (Anderson et al., 1976). (The sentence was “The fish attacked the swimmer.”)

But retrieval problems occasionally stem from interference and, perhaps, from motivated forgetting.
Interference

As you collect more and more information, your mental attic never fills, but it surely gets cluttered. An ability to tune out clutter helps people to focus, and focusing helps us recall information. In one experiment, people were given the task of remembering certain new word pairs from a multiple-choice list (“ATTIC-dust,” “ATTIC-junk,” and so forth). Those who were better at forgetting the irrelevant pairs (as verified by diminished activity in a pertinent brain area) also focused more on the to-be-remembered pairs and recalled them better on later tests (Kuhl et al., 2007).

Sometimes, however, clutter wins, and new learning and old collide. Proactive (forward-acting) interference occurs when prior learning disrupts your recall of new information. If you buy a new combination lock, your memory of the old combination may interfere.

Retroactive (backward-acting) interference occurs when new learning disrupts recall of old information. If someone sings new lyrics to the tune of an old song, you may have trouble remembering the original words. It is rather like a second stone tossed in a pond, disrupting the waves rippling out from the first. (See Close-Up: Retrieving Passwords on the next page.)

Information presented in the hour before sleep is protected from retroactive interference because the opportunity for interfering events is minimized (Benson & Feinberg, 1977; Fowler et al., 1973; Nesca & Koulack, 1994). Researchers John Jenkins and Karl Dallenbach (1924) first discovered this in a now-classic experiment. Day after day, two people each learned some nonsense syllables, then tried to recall them after up to eight hours of being awake or asleep at night. As FIGURE 8.24 shows, forgetting occurred more rapidly after being awake and involved with other activities. The investigators surmised that “forgetting is not so much a matter of the decay of old impressions and associations as it is a matter of interference, inhibition, or obliteration of the old by the new” (1924, p. 612).

The hour before sleep is a good time to commit information to memory (Scullin & McDaniel, 2010), though information presented in the seconds just before sleep is seldom remembered (Wyatt & Bootzin, 1994). If you’re considering learning while sleeping, forget it. We have little memory for information played aloud in the room during sleep, although the ears do register it (Wood et al., 1992).

Old and new learning do not always compete with each other, of course. Previously learned information (Latin) often facilitates our learning of new information (French). This phenomenon is called positive transfer.
Motivated Forgetting

To remember our past is often to revise it. Years ago, the huge cookie jar in our kitchen was jammed with freshly baked chocolate chip cookies. Still more were cooling across racks on the counter. Twenty-four hours later, not a crumb was left. Who had taken them? During that time, my wife, three children, and I were the only people in the house. So while memories were still fresh, I conducted a little memory test. Andy admitted wolfing down as many as 20. Peter thought he had eaten 15. Laura guessed she had stuffed her then-6-year-old body with 15 cookies. My wife, Carol, recalled eating 6, and I remembered consuming 15 and taking 18 more to the office. We sheepishly accepted responsibility for 89 cookies. Still, we had not come close; there had been 160.

Why do our memories fail us? This happens in part because, as Carol Tavris and Elliot Aronson have pointed out, memory is an “unreliable, self-serving historian” (2007, pp. 6, 79). In one study, researchers told some people about the benefits of frequent toothbrushing. Those participants then recalled (more than others did) having frequently brushed their teeth in the preceding two weeks (Ross et al., 1981).

FIGURE 8.25 reminds us that as we process information we filter, alter, or lose much of it. So why were my family and I so far off in our estimates of the cookies we had eaten? Was it an encoding problem? (Did we just not notice what we had eaten?) Was it a storage problem? (Might our memories of cookies, like Ebbinghaus’ memory of nonsense syllables, have melted away almost as fast as the cookies themselves?) Or was the information still intact but not retrievable because it would be embarrassing to remember? 1

Sigmund Freud might have argued that our memory systems self-censored this information. He proposed that we repress painful or unacceptable memories to protect our self-concept and to minimize anxiety. But the repressed memory lingers, he believed, and can be retrieved by some later cue or during therapy. Repression was central to Freud’s theory (see Chapter 13) and was a popular idea in mid-twentieth century psychology.

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1 One of my cookie-scaring sons, on reading this in his father’s textbook years later, confessed he had fibbed “a little.”
One Norwegian study found that educated people tend to believe in repressed memories more than those with less formal education (Magnussen et al., 2006). In an American study, 9 in 10 university students agreed that “memories for painful experiences are sometimes pushed into unconsciousness” (Brown et al., 1996). Therapists often assume it. Today, however, increasing numbers of memory researchers think repression rarely, if ever, occurs. People’s efforts to intentionally forget neutral material often succeed, but not when the to-be-forgotten material is emotional (Payne & Corrigan, 2007). Thus, we may have intrusive memories of the very traumatic experiences we would most like to forget.

Memory Construction Errors

Memory is not precise. Like scientists who infer a dinosaur’s appearance from its remains, we infer our past from stored information plus what we later imagined, expected, saw, and heard. We don’t just retrieve memories, we reweave them, notes Daniel Gilbert (2006, p. 79): “Information acquired after an event alters memory of the event.” We often construct our memories as we encode them, and every time we “replay” a memory, we replace the original with a slightly modified version (Hardt et al., 2010). (Memory researchers call this reconsolidation.) So, in a sense, said Joseph LeDoux (2009), “your memory is only as good as your last memory. The fewer times you use it, the more pristine it is.” This means that, to some degree, “all memory is false” (Bernstein & Loftus, 2009). Let’s examine some of the ways we rewrite our past.
**Misinformation and Imagination Effects**

In more than 200 experiments, involving more than 20,000 people, Elizabeth Loftus has shown how eyewitnesses reconstruct their memories after a crime or an accident. In one experiment, two groups of people watched a film of a traffic accident and then answered questions about what they had seen (Loftus & Palmer, 1974). Those asked, “How fast were the cars going when they smashed into each other?” gave higher speed estimates than those asked, “How fast were the cars going when they hit each other?” A week later, when asked whether they recalled seeing any broken glass, people who had heard smashed were more than twice as likely to report seeing glass fragments (FIGURE 8.26). In fact, the film showed no broken glass.

In many follow-up experiments around the world, others have witnessed an event, received or not received misleading information about it, and then taken a memory test. The repeated result is a misinformation effect: Exposed to misleading information, we tend to misremember. A yield sign becomes a stop sign, hammers become screwdrivers, Coke cans become peanut cans, breakfast cereal becomes eggs, and a clean-shaven man morphs into a man with a mustache (Loftus et al., 1992). So powerful is the misinformation effect that it can influence later attitudes and behaviors (Bernstein & Loftus, 2009).

Because the misinformation effect happens outside our awareness, it is nearly impossible to sift the suggested ideas out of the larger pool of real memories (Schooler et al., 1986). Perhaps you can recall describing a childhood experience to a friend, and filling in memory gaps with reasonable guesses and assumptions. We all do it, and after more retellings, those guessed details—now absorbed into our memories—may feel as real as if we had actually experienced them (Roediger et al., 1993).

Just hearing a vivid retelling of an event may implant false memories. One experiment falsely suggested to some Dutch university students that, as children, they became ill after...
eating spoiled egg salad (Geraerts et al., 2008). After absorbing that suggestion, a significant minority were less likely to eat egg-salad sandwiches, both immediately and four months later.

Even repeatedly imagining nonexistent actions and events can create false memories. American and British university students were asked to imagine certain childhood events, such as breaking a window with their hand or having a skin sample removed from a finger. One in four of them later recalled the imagined event as something that had really happened (Garry et al., 1996; Mazzoni & Memon, 2003).

Digitally altered photos have also produced this imagination inflation. In experiments, researchers have altered photos from a family album to show some family members taking a hot-air balloon ride. After viewing these photos (rather than photos showing just the balloon), children reported more false memories and indicated high confidence in those memories. When interviewed several days later, they reported even richer details of their false memories (Strange et al., 2007; Wade et al., 2002).

Misinformation and imagination effects occur partly because visualizing something and actually perceiving it activate similar brain areas (Gonsalves et al., 2004). Imagined events also later seem more familiar, and familiar things seem more real. The more vividly we can imagine things, the more likely they are to become memories (Loftus, 2001; Porter et al., 2000).

In British and Canadian university surveys, nearly one-fourth of students have reported autobiographical memories that they later realized were not accurate (Mazzoni et al., 2010). I empathize. For decades, my cherished earliest memory was of my parents getting off the bus and walking to our house, bringing my baby brother home from the hospital. When, in middle age, I shared that memory with my father, he assured me they did not bring their newborn home on the Seattle Transit System. The human mind, it seems, comes with built-in Photoshopping software.
Source Amnesia

Among the frailest parts of a memory is its source. We may recognize someone but have no idea where we have seen the person. We may dream an event and later be unsure whether it really happened. We may misrecall how we learned about something (Henkel et al., 2000). Psychologists are not immune to the process. Famed child psychologist Jean Piaget was startled as an adult to learn that a vivid, detailed memory from his childhood—a nursemaid’s thwarting his kidnapping—was utterly false. He apparently constructed the memory from repeatedly hearing the story (which his nursemaid, after undergoing a religious conversion, later confessed had never happened). In attributing his “memory” to his own experiences, rather than to his nursemaid’s stories, Piaget experienced source amnesia (also called source misattribution). Misattribution is at the heart of many false memories. Authors and songwriters sometimes suffer from it. They think an idea came from their own creative imagination, when in fact they are unintentionally plagiarizing something they earlier read or heard.

Debra Poole and Stephen Lindsay (1995, 2001, 2002) demonstrated source amnesia among preschoolers. They had the children interact with “Mr. Science,” who engaged them in activities such as blowing up a balloon with baking soda and vinegar. Three months later, on three successive days, their parents read them a story describing some things the children had experienced with Mr. Science and some they had not. When a new interviewer asked what Mr. Science had done with them—“Did Mr. Science have a machine with ropes to pull?”—4 in 10 children spontaneously recalled him doing things that had happened only in the story.

Source amnesia also helps explain déjà vu (French for “already seen”). Two-thirds of us have experienced this fleeting, eerie sense that “I’ve been in this exact situation before.” It happens most commonly to well-educated, imaginative young adults, especially when tired or stressed (Brown, 2003, 2004; McAneny, 1996). Some wonder, “How could I recognize a situation I’m experiencing for the first time?” Others may think of reincarnation (“I must have experienced this in a previous life”) or precognition (“I viewed this scene in my mind before experiencing it”).

Alan Brown and Elizabeth Marsh (2009) devised an intriguing way to induce déjà vu in the laboratory. They invited participants to view symbols on a computer screen and to report whether they had ever seen them before. What the viewers didn’t know was that these symbols had earlier been subliminally flashed on the screen, too briefly for conscious awareness. The result? Half the participants reported experiencing déjà vu—a sense of familiarity without awareness of why. Brown and Marsh suggest that real-life experiences may include glancing very briefly at a visual scene, looking away without consciously processing it, then looking again—only to feel the uncanny sense of having seen it before.

The key to déjà vu seems to be familiarity with a stimulus without a clear idea of where we encountered it before (Cleary, 2008). Normally, we experience a feeling of familiarity (thanks to temporal lobe processing) before we consciously remember details (thanks to hippocampus and frontal lobe processing). When these functions (and brain regions) are out of sync, we may experience a feeling of familiarity without conscious recall. Our amazing brains try to make sense of such an improbable situation, and we get an eerie feeling that we’re reliving some earlier part of our life. After all, the situation is familiar, even though we have no idea why. Our source amnesia forces us to do our best to make sense of an odd moment.

Discerning True and False Memories

Because memory is reconstruction as well as reproduction, we can’t be sure whether a memory is real by how real it feels. Much as perceptual illusions may seem like real perceptions, unreal memories feel like real memories.
False memories created by suggested misinformation and misattributed sources not only can feel as real as true memories, they can be very persistent. Imagine that I were to read aloud a list of words such as candy, sugar, honey, and taste. Later, I ask you to recognize the presented words from a larger list. If you are at all like the people tested by Henry Roediger and Kathleen McDermott (1995), you would err three out of four times—by falsely remembering a nonpresented similar word, such as sweet. We more easily remember the gist than the words themselves.

Memory construction helps explain why 79 percent of 200 convicts exonerated by later DNA testing had been misjudged based on faulty eyewitness identification (Garrett, 2008). It explains why “hypnotically refreshed” memories of crimes so easily incorporate errors, some of which originate with the hypnotist’s leading questions (“Did you hear loud noises?”). It explains why dating partners who fall in love overestimate their first impressions of one another (“I was love at first sight”), while those who break up underestimate their earlier liking (“We never really clicked”) (McFarland & Ross, 1987). And it explains why people asked how they felt 10 years ago about marijuana or gender issues have recalled attitudes closer to their current views than to the views they had actually reported a decade earlier (Markus, 1986). How people feel today tends to be how they recall they have always felt (Mazzoni & Vannucci, 2007; and recall from Chapter 1 our tendency to hindsight bias).

One research team interviewed 73 ninth-grade boys and then reinterviewed them 35 years later. When asked to recall how they had reported their attitudes, activities, and experiences, most men recalled statements that matched their actual prior responses at a rate no better than chance. Only 1 in 3 now remembered receiving physical punishment, though as ninth-graders 82 percent had said they had (Offer et al., 2000). As George Vaillant (1977, p. 197) noted after following adult lives through time, “It is all too common for caterpillars to become butterflies and then to maintain that in their youth they had been little butterflies. Maturation makes liars of us all.”

Children’s Eyewitness Recall

How reliable are young children’s eyewitness descriptions, and why are reports of repressed and recovered memories so hotly debated?

If memories can be sincere, yet sincerely wrong, might children’s recollections of sexual abuse be prone to error? “It would be truly awful to ever lose sight of the enormity of child abuse,” observed Stephen Ceci (1993). Yet Ceci and Maggie Bruck’s (1993, 1995) studies of children’s memories have made them aware of how easily children’s memories can be molded. For example, they asked 3-year-olds to show on anatomically correct dolls where a pediatrician had touched them. Of the children who had not received genital examinations, 55 percent pointed to either genital or anal areas.

In other experiments, the researchers studied the effect of suggestive interviewing techniques (Bruck & Ceci, 1999, 2004). In one study, children chose a card from a deck of possible happenings, and an adult then read the card to them. For example, “Think real hard, and tell me if this ever happened to you. Can you remember going to the hospital with a mousetrap on your finger?” In interviews, the same adult repeatedly asked children to think about several real and fictitious events. After 10 weeks of this, a new adult asked the same question. The stunning result: 58 percent of preschoolers produced false (often vivid) stories regarding one or more events they had never experienced (Ceci et al., 1994). Here’s one of those stories:

My brother Colin was trying to get Blowtorch [an action figure] from me, and I wouldn’t let him take it from me, so he pushed me into the wood pile where the mousetrap was. And then my finger got caught in it. And then we went to the hospital, and my mommy, daddy, and Colin drove me there, to the hospital in our van, because it was far away. And the doctor put a bandage on this finger.
Given such detailed stories, professional psychologists who specialize in interviewing children could not reliably separate the real memories from the false ones. Nor could the children themselves. The above child, reminded that his parents had told him several times that the mousetrap incident never happened—that he had imagined it—protested, “But it really did happen. I remember it!” In another experiment, preschoolers merely overheard an erroneous remark that a magician’s missing rabbit had gotten loose in their classroom. Later, when the children were suggestively questioned, 78 percent of them recalled actually seeing the rabbit (Principe et al., 2006). “[The] research leads me to worry about the possibility of false allegations. It is not a tribute to one’s scientific integrity to walk down the middle of the road if the data are more to one side,” said Ceci (1993).

Does this mean that children can never be accurate eyewitnesses? No. If questioned about their experiences in neutral words they understand, children often accurately recall what happened and who did it (Goodman, 2006; Howe, 1997; Pipe, 1996). When interviewers use less suggestive, more effective techniques, even 4- to 5-year-old children produce more accurate recall (Holliday & Albon, 2004; Pipe et al., 2004). Children are especially accurate when they have not talked with involved adults prior to the interview and when their disclosure is made in a first interview with a neutral person who asks nonleading questions.

**Repressed or Constructed Memories of Abuse?**

There are two tragedies related to adult recollections of child abuse. One happens when people don’t believe abuse survivors who tell their secret. The other happens when innocent people are falsely accused. What, then, shall we say about clinicians who have guided people in “recovering” childhood abuse memories? Were these well-intentioned therapists triggering false memories that damaged innocent adults? Or were they uncovering the truth?

The research on source amnesia and the misinformation effect raises concerns about therapist-guided recovered memories. Some have reasoned with patients that “people who’ve been abused often have your symptoms, so you probably were abused. Let’s see if, aided by hypnosis or drugs, or helped to dig back and visualize your trauma, you can recover it.” Patients exposed to such techniques may then form an image of a threatening person. With further visualization, the image grows more vivid. The patient ends up stunned, angry, and ready to confront or sue the remembered abuser. The equally stunned and devastated parent or relative vigorously denies the accusation.

Critics are not questioning the professionalism of most therapists. Nor are they questioning the accusers’ sincerity; even if false, their memories are heartfelt. Critics’ charges are specifically directed against clinicians who use “memory work” techniques, such as “guided imagery,” hypnosis, and dream analysis to recover memories. “Thousands of families were cruelly ripped apart,” with “previously loving adult daughters” suddenly accusing fathers (Gardner, 2006). Irate clinicians have countered that those who argue that recovered memories of abuse never happen are adding to abused people’s trauma and playing into the hands of child molesters.

In an effort to find a sensible common ground that might resolve psychology’s “memory war,” professional organizations (the American Medical, American Psychological, and American Psychiatric Associations; the Australian Psychological Society; the British Psychological Society; and the Canadian Psychiatric Association) have convened study panels and issued public statements. Those committed to protecting abused children and those committed to protecting wrongly accused adults have agreed on the following:

- **Sexual abuse happens.** And it happens more often than we once supposed. Although sexual abuse can leave its victims at risk for problems ranging from sexual...
dysfunction to depression (Freyd et al., 2007), there is no characteristic “survivor syndrome”—no group of symptoms that lets us spot victims of sexual abuse (Kendall-Tackett et al., 1993).

- **Injustice happens.** Some innocent people have been falsely convicted. And some guilty people have evaded responsibility by casting doubt on their truth-telling accusers.

- **Forgetting happens.** Many of those actually abused were either very young when abused or may not have understood the meaning of their experience—circumstances under which forgetting is common. Forgetting isolated past events, both negative and positive, is an ordinary part of everyday life.

- **Recovered memories are commonplace.** Cued by a remark or an experience, we all recover memories of long-forgotten events, both pleasant and unpleasant. What many psychologists debate is twofold: Does the unconscious mind sometimes forcibly repress painful experiences? If so, can these experiences be retrieved by certain therapist-aided techniques? (Memories that surface naturally are more likely to be verified [Geraerts et al., 2007].)

- **Memories of things happening before age 3 are unreliable.** We cannot reliably recall happenings from our first three years. As noted earlier, this infantile amnesia happens because our brain pathways have not yet developed enough to form the kinds of memories we will form later in life. Most psychologists—including most clinical and counseling psychologists—therefore doubt “recovered” memories of abuse during infancy (Gore-Felton et al., 2000; Knapp & VandeCreek, 2000). The older a child was when suffering sexual abuse, and the more severe the abuse, the more likely it is to be remembered (Goodman et al., 2003).

- **Memories “recovered” under hypnosis or the influence of drugs are especially unreliable.** Under hypnosis, people will incorporate all kinds of suggestions into their memories, even memories of “past lives.”

- **Memories, whether real or false, can be emotionally upsetting.** Both the accuser and the accused may suffer when what was born of mere suggestion becomes, like an actual trauma, a stinging memory that drives bodily stress (McNally, 2003, 2007). Some people knocked unconscious in unremembered accidents know this all too well. They have later developed stress disorders after being haunted by memories they constructed from photos, news reports, and friends’ accounts (Bryant, 2001).

The debate over repression and childhood sexual abuse, like many other scientific debates, has stimulated new research and new theories. Richard McNally and Elke Geraerts (2009) contend that victims of most childhood sexual abuse do not repress their abuse; rather, they simply stop devoting thought and emotion to it. McNally and Geraerts believe this letting go of the memory is most likely when

- the experience, when it occurred, was strange, uncomfortable, and confusing, rather than severely traumatic.

- the abuse happened once or only a few times.

- victims have not spent time thinking about the abuse, either because of their own resilience or because no reminders are available.

McNally and Geraerts agree that victims do sometimes accurately and spontaneously recall memories of childhood abuse. But these memories usually occur outside of therapy. Moreover, people who recall abuse spontaneously rarely form false memories when
in a lab setting. Conversely, those who form memories of abuse during suggestive therapy tend to have vivid imaginations and score high on false-memory tests in the lab (Clancy et al., 2000; McNally, 2003).

So, does repression of threatening memories ever occur? Or is this concept—the cornerstone of Freud’s theory and of so much popular psychology—misleading? In Chapter 13, we will return to this hotly debated issue. For now, this much appears certain: The most common response to a traumatic experience (witnessing a loved one’s murder, being terrorized by a hijacker or a rapist, losing everything in a natural disaster) is not banishment of the experience into the unconscious. Rather, such experiences are typically etched on the mind as vivid, persistent, haunting memories (Porter & Peace, 2007). As Robert Kraft (2002) said of the experience of those trapped in the Nazi death camps, “Horror sears memory, leaving . . . the consuming memories of atrocity.”

**RETRIEVAL PRACTICE**

- What—given the commonality of source amnesia—might life be like if we remembered all our waking experiences and all our dreams?

**ANSWER:** Real experiences would be confused with those we dreamed. When meeting someone, we might therefore be unsure whether we were reacting to something they previously did or to something we dreamed we experienced.

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**Improving Memory**

How can you use memory research findings to do better in this and other courses?

Biology’s findings benefit medicine. Botany’s findings benefit agriculture. So, too, can psychology’s research on memory benefit education. Sprinkled throughout this chapter, and summarized here for easy reference, are concrete suggestions that could help you remember information when you need it. The SQ3R—Survey, Question, Read, Retrieve, Review—study technique introduced in this book’s Prologue incorporates several of these strategies.

**Study repeatedly.** To master material, use distributed (spaced) practice. To learn a concept, give yourself many separate study sessions. Take advantage of life’s little intervals—riding a bus, walking across campus, waiting for class to start. New memories are weak; exercise them and they will strengthen. To memorize specific facts or figures, Thomas Landauer (2001) has advised, “rehearse the name or number you are trying to memorize, wait a few seconds, rehearse again, wait a little longer, rehearse again, then wait longer still and rehearse yet again. The waits should be as long as possible without losing the information.” Reading complex material with minimal rehearsal yields little retention. Rehearsal and critical reflection help more. It pays to study actively.

**Make the material meaningful.** You can build a network of retrieval cues by taking text and class notes in your own words. Apply the concepts to your own life. Form images. Understand and organize information. Relate the material to what you already know or have experienced. As William James (1890) suggested, “Knit each new thing on to some acquisition already there.” Restate concepts in your own words. Mindlessly repeating someone else’s words won’t supply many retrieval cues. On an exam, you may find yourself stuck when a question uses phrasing different from the words you memorized.
Activate retrieval cues. Mentally re-create the situation and the mood in which your original learning occurred. Jog your memory by allowing one thought to cue the next.

Use mnemonic devices. Associate items with peg-words. Make up a story that incorporates vivid images of the items. Chunk information into acronyms. Create rhythmic rhymes (“i before e, except after c”).

Minimize interference. Study before sleep. Do not schedule back-to-back study times for topics that are likely to interfere with each other, such as Spanish and French.

Sleep more. During sleep, the brain reorganizes and consolidates information for long-term memory. Sleep deprivation disrupts this process.

Test your own knowledge, both to rehearse it and to find out what you don’t yet know. Don’t be lulled into overconfidence by your ability to recognize information. Test your recall using the Retrieval Practice items found throughout each chapter, and the numbered Learning Objective Questions in the Review sections at the end of each chapter. Outline sections on a blank page. Define the terms and concepts listed at each chapter’s end before turning back to their definitions. Take practice tests; the Web sites and study guides that accompany many texts, including this one, are a good source for such tests.

**RETRIEVAL PRACTICE**

- What are the recommended memory strategies you just read about?

ANSWER: Study repeatedly to boost long-term recall. Schedule spaced (not crammed) study times. Spend more time rehearsing or actively thinking about the material. Make the material personally meaningful, with well-organized and vivid associations. Return to contexts and moods to activate retrieval cues. Use mnemonic devices. Minimize interference. Plan for a complete night’s sleep. Test yourself repeatedly—retrieval practice is a proven retention strategy.
8-6: What is the capacity of our short-term and working memory?

8-7: What are some effortful processing strategies that can help us remember new information?

8-8: What are the levels of processing, and how do they affect encoding?

Memory Storage

8-9: What is the capacity and location of our long-term memories?

8-10: What is the role of the frontal lobes and hippocampus in memory storage?

8-11: What role do the cerebellum and basal ganglia play in our memory processing?

8-12: How do emotions affect our memory processing?

8-13: How do changes at the synapse level affect our memory processing?

Retrieval: Getting Information Out

8-14: What are three measures of retention?

8-15: How do external cues, internal emotions, and order of appearance influence memory retrieval?

Forgetting

8-16: Why do we forget?

Memory Construction Errors

8-17: How do misinformation, imagination, and source amnesia influence our memory construction? How do we decide whether a memory is real or false?

8-18: How reliable are young children’s eyewitness descriptions, and why are reports of repressed and recovered memories so hotly debated?

Improving Memory

8-19: How can you use memory research findings to do better in this and other courses?
Terms and Concepts to Remember

RETRIEVAL PRACTICE Test yourself on these terms by trying to write down the definition before flipping back to the referenced page to check your answer.

- memory, p. 300
- recall, p. 300
- recognition, p. 300
- relearning, p. 300
- encoding, p. 300
- storage, p. 301
- retrieval, p. 301
- sensory memory, p. 301
- short-term memory, p. 301
- long-term memory, p. 301
- working memory, p. 301
- explicit memory, p. 302
- effortful processing, p. 302
- automatic processing, p. 302
- implicit memory, p. 302
- iconic memory, p. 304
- echoic memory, p. 304
- chunking, p. 305
- mnemonics [nih-MON-iks], p. 305
- spacing effect, p. 306
- testing effect, p. 306
- shallow processing, p. 306
- deep processing, p. 307
- hippocampus, p. 309
- flashbulb memory, p. 311
- long-term potentiation (LTP), p. 312
- priming, p. 316
- mood-congruent memory, p. 317
- serial position effect, p. 318
- anterograde amnesia, p. 319
- retrograde amnesia, p. 319
- proactive interference, p. 323
- retroactive interference, p. 323
- repression, p. 324
- misinformation effect, p. 326
- source amnesia, p. 326
- déjà vu, p. 328

RETRIEVAL PRACTICE Gain an advantage, and benefit from immediate feedback, with the interactive self-testing resources at www.worthpublishers.com/myers.