PSYCHOLOGY:
FROM SCIENCE TO PRACTICE

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Robert A. Baron, Rensselaer Polytechnic Institute
Michael J. Kalsher, Rensselaer Polytechnic Institute

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SAMPLE CHAPTER 6
The pages of this Sample Chapter may have slight variations in final published form.
Several years ago, I (Robert Baron) was having a conversation with my father, and I asked him, “What ever happened to great-grandfather’s uniform?” (My great-grandfather had been an officer in a European Army before he came to the United States, and I had vivid memories of his uniform.) My father looked puzzled for a moment and then said, “Grandfather threw it away in the 1930s—when I was in high school, so I don’t think you could ever have seen it.” “You must be mistaken, Dad,” I replied. “I remember it very well. It was black and had gold braid on the right shoulder.” My father agreed that I was correct but repeated his belief that I could never have seen it, because it was gone long before I was born. I was sure he was mistaken, because I could visualize the uniform perfectly, hanging there in my grandfather’s closet. I remembered how it felt and how it smelled (of mothballs), and wanting to play with the medals. To this day, I have never solved this mystery: Did I ever see my great-grandfather’s uniform? Or was my memory playing tricks on me?
As this incident suggests, memory is indeed a tricky thing: We forget information we would like to remember, only to have it pop into our minds at a later time—perhaps when we don’t need it so much! We remember experiences we would prefer to forget; and sometimes we “remember” events that could never possibly have happened to us. So memory is certainly not a perfect system for retaining information. Yet, life without it would be impossible. If we did not possess memory, we would be unable to remember the past, could not retain new information, solve problems, or plan for the future. Psychologists have long recognized the importance of memory. Indeed, it was the focus of some of the earliest research in the field, performed by Hermann Ebbinghaus (1885) one hundred and twenty years ago. What have we learned from these decades of scientific effort? A great deal. In fact, it is probably safe to say that we know more about memory than any other aspect of cognition. To provide you with an overview of this intriguing knowledge, we’ll proceed as follows. First, we’ll consider the picture of human memory that has emerged from psychological research—a picture suggesting that we possess several different kinds of memory rather than one. Next, we’ll explore the nature and operation of each of these aspects of memory—working memory, memory for facts, memory for skills, and memory for events in our own lives. Please note that animals, too, have memories; in fact, chimpanzees can remember how many bananas are placed in two opaque containers and then choose the one with more bananas (Beran & Beran, 2004). After this, we’ll examine forgetting—how information is lost from memory—and how, sometimes, information is distorted or changed over time so that, in a sense, it becomes less accurate. Next, we’ll consider the role of memory in everyday life—for instance, how we remember to do things we plan to do—and memory for emotional events. Finally, we’ll briefly consider memory impairments and what these tell us about the biological basis of memory.

**Human Memory: An Information-Processing Approach**

Because we can’t observe memory directly (even with modern brain scans), psychologists have found it useful to construct models of it—representations of how it functions and the systems it must include in order to produce the kind of effects that it does, for instance, long-term storage of vast amounts of information, and shorter-term storage of small amounts of information, such as a phone number you dial but then promptly forget (e.g., Anderson, 1993; Baadley & Hitsch, 1994; Raajimakers & Shiffrin, 1981). Many different models have been proposed, but one that has proven to be very useful is known as the information-processing approach (Atkinson & Shiffrin, 1968).

This model takes note of the fact that there are certain similarities between computer memory and human memory. For instance, both computer memory and human memory must perform three basic tasks: (1) encoding—converting information into a form that can be entered into memory, (2) storage—somehow retaining information over varying periods of time; and (3) retrieval—locating and accessing specific information when it is needed at later times (see Figure 6.1).

For computers, encoding involves complex programs that convert what you type on the computer keyboard into codes the program can process. For humans, encoding involves converting information brought from our senses into neural information that can be processed in our brains. Storage presents a more complex picture. Computers generally contain two kinds of systems for storing information: random-access memory—what’s open on your desktop at any given moment—and a larger and more permanent memory in which information is stored for longer periods of time (a hard drive). The information-processing model of memory suggests that, in contrast, human memory involves three distinct systems for storing...
information. One of these, known as sensory memory, provides temporary storage of information brought to us by our senses. If you’ve ever watched someone wave a flashlight in a dark room and perceived trails of light behind it, you are familiar with the operation of sensory memory. A second type of memory is known as short-term memory. Short-term memory holds relatively small amounts of information for brief periods of time, usually thirty seconds or less. This is the type of memory system you use when you look up a phone number and dial it. Our third memory system, long-term memory, allows us to retain vast amounts of information for very long periods of time. It is this type of memory system that permits you to remember events that happened a few hours ago, yesterday, last month, or many years in the past. And it is long-term memory that allows you to remember factual information such as the capital of your state, the name of the president, and the information in this book.

With respect to retrieval, both computers and human memory must be able to find information that has previously been stored. Computer memory requires that you precisely specify the location of the information for it to be found. In contrast, you can often find information in your own memory, even on the basis of partial information (“I know his name . . . it rhymes with ‘home’ . . . oh yeah, Broam!”). Also, when information is lost from computer memory, it is often lost permanently, or at least becomes very difficult to restore. In contrast, information we cannot retrieve from our own memories is often still present and sometimes pops into mind at a later time, when we are not actively trying to find it.

How does information move from one memory system to another? Although there’s not complete agreement about this important point, much evidence suggests that information in sensory memory enters short-term memory when it becomes the focus of our attention, that is, when we notice it or concentrate on it. In contrast, information in short-term memory enters long-term storage through elaborative rehearsal—when we think about its meaning and relate it to other information already in long-term memory. Unless we engage in such cognitive effort, information in short-term memory too quickly fades away and is lost. (See Figure 6.1 for a summary of the information-processing model.)

In sum, the key points to remember are these: The information-processing perspective suggests that (1) memory involves encoding, storage, and retrieval of information; and (2) we possess several different kinds or types of memory. Though this model has proven very useful, we should note that it is certainly not the only one psychologists have found useful. In recent years, other views—especially, ones that emphasize the kind of parallel processing of information in our brains that we described in Chapter 2—have received growing attention. These models (e.g., Lindsay & Reed, 1995) suggest that because our brains process information in many locations at once, memories, too, must be represented in this manner and must involve activity in many different modules or neural units in the brain. Full description of these complex models is beyond the scope of this discussion, but we do want to note that a new picture of human memory that closely reflects our growing understanding of how our brains function to produce consciousness is emerging and is certain to become more influential in the years ahead.

FIGURE 6.1
Human Memory: The Information-Processing View
One view of memory (the information-processing perspective) suggests that we possess three basic memory systems: sensory memory, short-term memory, and long-term memory. Each of these systems must deal with the tasks of encoding information, storing it, and retrieving it when needed.

Source: Based on suggestions by Atkinson & Shiffrin, 1968.
KEY QUESTIONS

- According to the information-processing model, what key tasks are carried out by memory?
- What are sensory memory, short-term memory, and long-term memory?

OUR DIFFERENT MEMORY SYSTEMS

As you already know from your own experience, your memory holds many kinds of information. Some of it is factual and relates either to (1) general information you can remember (e.g., “Hawaii is located in the Pacific Ocean,” and “George Washington was the first President of the United States”) or (2) events and experiences in your own life that you can recall (e.g., “I really liked my first grade teacher,” “I saw my friend Joe this morning for the first time in more than two months”). But your memory holds much more than factual information. Can you play a musical instrument? Ride a bicycle? If so, you realize that you also have another, distinctly different type of information stored in memory—information that allows you to perform such activities. And here’s the interesting point: Although you can verbally state that your friend is moving or that Hawaii is in the middle of the ocean, you really can’t describe the information that allows you to play the piano or guitar, to ride your bicycle without hands (don’t do it!), or type without thinking of individual keys (see Figure 6.2). And what about information in memory that tells you when to do something, for instance, take your medicine, leave for school or work, and so on? This is yet another kind of information stored in memory until it is needed. So memory actually holds several kinds of information. We’ll now examine the memory systems that allow us to store these different kinds of information.

Working Memory: The Workbench of Consciousness

Have you ever had the following kind of experience? You obtain some useful piece of information—a telephone number, a personal identification code, a word in a foreign language—and can use it right after you see or hear it. But then, a few minutes later, it is totally gone and you can’t remember it no matter how hard you try. What’s going on here? What happened to that wonderful system we term memory? The answer involves the operation of what psychologists term working memory. Initially, this term and short-term memory were used interchangeably, but now memory experts generally distinguish between them. Short-term memory, as we saw earlier, refers to the temporary storage of information. In contrast, the term work-
ing memory involves both storage capacity and a mechanism of attention that regulates the contents of this system (Engle, 2001). In a sense, working memory is the “workbench” of consciousness—the “place” where information we are using right now is held and processed. Let’s take a look, first, at short-term memory, and then at how working memory operates.

**Short-Term Memory: How Much Can It Hold?**

Initial research on short-term memory focused on the following question: How much can it hold? Research findings suggested a clear answer: As a storage system, short-term memory can hold only about seven (plus or minus two) discrete items. Beyond that point, the system was overloaded, and if new information entered, existing information was lost (e.g., Miller, 1956). However, each of these “items” can contain several separate bits of information—bits that are somehow related and can be grouped together into meaningful units. When this is the case, each piece of information is described as a chunk, and the total amount of information held in chunks can be quite large. For example, consider the following list of letters: IBFIMBWBMATWIAC. After hearing or reading it once, how many could you remember? Probably no more than about seven. But imagine that, instead, the letters were presented as follows: FBI, IBM, BMW, TWA, CIA. Could you remember more now? In all likelihood you could, because now you could combine them into meaningful chunks—acronyms for famous organizations. Because of the process of chunking, short-term memory can hold a larger amount of information than you might guess, even though it can retain only seven to nine separate items at once.

**Working Memory: Short-Term Storage with a Very Important Plus**

If all short-term memory could do is store small amounts of information for limited periods of time, it would not be very interesting. But in fact, this aspect of our memory is much more than simply a temporary holding place for incoming information. On the contrary, active processing of information occurs in it as well—processing that may well determine how effectively we can perform very complex tasks such as reasoning (Engle et al., 1999). This is why psychologists now distinguish between short-term memory and working memory; the later term suggests that something active is happening, and, in fact, it is. Not only does working memory store information, it also involves a mechanism of attention that permits us to determine what information is retained in short-term storage and what information is ignored or actively blocked from entry. In fact, one influential model of working memory (Baddeley, 1992) suggests that working memory involves three different parts: (1) temporary storage of information (short-term memory), (2) a mechanism that permits rehearsal of this information so that it is maintained and perhaps moves into long-term storage, and (3) a mechanism of attention that permits some information to enter while ignoring other information (see Figure 6.3 on page 168).

The third of these components—the attentional mechanism—has important implications not just for memory, but for our ability to perform a wide range of complex cognitive tasks. To understand why, first consider the fact that working memory capacity (or span) is not the same as short-term memory capacity. Short-term memory capacity refers to the amount of information people can retain for brief periods of time. Working-memory capacity, in contrast, refers to the ability to use attention to maintain or suppress information—in essence, to pay attention to what it is important to remember. For instance, one measure of working memory capacity is obtained in the following manner. Individuals read sentences out loud, with each sentence being followed by an unrelated word. After the last sentence–word combination, they try to recall the list of unrelated words. The more they can recall, the higher their working memory capacity.

Now, here’s the truly interesting part: the higher individuals’ working memory capacity (as measured by tasks such as this one), the better their performance on complex cognitive tasks such as following directions, understanding complex
written passages, writing, reasoning, and even writing computer programs (Engle, 2001). In other words, the ability to focus one’s attention on what’s important is related to an important aspect of general intelligence—fluid intelligence, the ability to think and reason.

Is working memory capacity really related to being able to focus our attention? Research findings indicate that it is. For instance, consider a task in which individuals read the names of various colors (e.g., red, green) printed in ink that is either the same color as the word (red ink for the word red) or a different color (green ink for the word red). Their task is to name the color of the ink. If the word and ink color are different, many errors occur: People say the word rather than name the color of the ink. Performance on this task should involve the ability to focus attention on what’s important—in this case, the color of the ink—while ignoring the words themselves. In one recent study (Kane & Engle, 2001), the proportion of words in which the ink and word were different was varied (0 percent, 50 percent, 75 percent). If working memory capacity reflects an efficient attentional mechanism, then persons with high working memory capacity should do better on this task, especially when 75 percent of the color names are printed in a different color (e.g., the word blue in yellow). As you can see from Figure 6.4, that’s exactly what happened.

Where does all this leave us? With a view of working memory as much more than a temporary “holding area” for information. In fact, it is our system for paying attention to what’s most important with respect to a given task or situation. And this ability, it appears, is closely linked to our capacity to perform many complex cognitive tasks.

**KEY QUESTIONS**

- What is the difference between short-term memory and working memory?
- What are the three major components of working memory?
Memory for Factual Information: Episodic and Semantic Memory

Now that we have examined the nature of working memory, we'll turn to several aspects of long-term memory—our memory systems for retaining large amounts of information for long periods of time. We'll begin with the systems that permit us to retain factual information. As noted earlier, such information can relate to general knowledge about the world, which is stored in semantic memory, or to events that happen to us personally, which are stored in episodic memory. Let's take a closer look at both kinds of memory.

Episodic Memory: Some Factors that Affect It

As a student, you have lots of first-hand experience with the functioning of episodic memory. Often, you must memorize definitions, terms, or formulas. Such information is stored in episodic memory because we know that we learned it at a specific time, in a specific place (e.g., a course in college). What can you do to improve such memory? Research on semantic memory suggests that many factors influence it, but among these, the most important are the amount and spacing of practice. The first finding seems fairly obvious; the more often we practice information, the more of it we can retain. However, the major gains occur at first, and then further improvements in memory slow down. For this reason, spacing (or distribution) of practice is important, too. Therefore, spreading out your efforts to memorize information over time is helpful. For instance, two sessions of thirty minutes are often better, in terms of retaining information, than one session of sixty minutes.

Another factor that has a powerful effect on retention is the kind of processing we perform. When we study a list of words, we can simply read them or, alternatively, we can think about them in various ways. As you probably know from your own studying, it is possible to read the same pages in a text over and over again without remembering much of the information they contain. However, if you actively try to understand the material and think about it (e.g., its meaning, its relationship to other information), you stand a better chance of remembering it when the exam booklets are handed out.

Two psychologists, Craik and Lockhart (1972), took careful account of this fact in an influential view of memory known as the levels of processing view. They suggested that the more deeply information is processed, the more likely it is to be retained. What are these levels of processing like? Shallow processing involves little mental effort and might consist of repeating a word or making a simple sensory judgment about it—for example, do two words or letters look alike? A deeper level of processing might involve more complex comparisons—for example, do two words rhyme? A much deeper level of processing would include attention to meaning—for instance, do two words have the same meaning? Does a word make sense when used in a specific sentence?

Considerable evidence suggests that the deeper the level of processing that takes place when we encounter new information, the more likely it is to enter long-term memory. (e.g., Craik and Tulving, 1975). However, important questions still exist with respect to this model. For example, it is difficult to specify, in advance, just what constitutes a deep versus a shallow level of processing.

Another, and very important, factor that influences episodic memory involves what are known as retrieval cues—stimuli that are associated with information stored in memory and so can help bring it to mind at times when it cannot be recalled spontaneously. Many studies suggest that such cues can often help us remember; indeed, the more retrieval cues we have, the better our ability to remember information entered into episodic memory (e.g., Tulving & Watkins, 1973)—and they don’t have to be as obvious as the ones shown in Figure 6.5 on page 170 to work! Perhaps the most intriguing research on this topic involves what

Semantic Memory
A memory system that stores general, abstract knowledge about the world—information we cannot remember acquiring at a specific time and place.

Episodic Memory
Memory for factual information that we acquired at a specific time.

Levels of Processing View
A view of memory suggesting that the greater the effort expended in processing information, the more readily it will be recalled at later times.

Retrieval Cues
Stimuli associated with information stored in memory that can aid in its retrieval.
is known as **context-dependent memory**—the fact that material learned in one environment or context is easier to remember in a similar context or environment than it is in a very different one. Many illustrations of this effect exist, but one of the most intriguing—and unusual—is a study conducted by Godden and Baddeley (1975).

In this experiment, participants were experienced deep-sea divers. They learned a list of words either on the beach or beneath fifteen feet of water. Then, they tried to recall the words either in the same environment in which they had learned them or in the other setting. Results offered clear support for the impact of context—in this case, physical setting. Words learned on land were recalled much better in this location than underwater, and vice versa. Interestingly, additional findings suggest that it is not necessary to be in the location or context where information was first entered into long-term memory; merely imagining this setting may be sufficient (Smith, 1979). In other words, we seem capable of generating our own context-related retrieval cues. So, if you study for an exam in your room, and then take the exam in a very different setting, it may be helpful to imagine yourself back in your room when you try to remember specific information. Doing so may provide you with additional, self-generated retrieval cues.

External cues are not the only ones that can serve as aids to memory, however; a growing body of evidence indicates that our own internal states can sometimes play this role, too. The most general term for this kind of effect is **state-dependent retrieval**, which refers to the fact that it is often easier to recall information stored in long-term memory when our internal state is similar to that which existed when the information was first entered into memory. For example, suppose that while studying for an exam, you drink lots of coffee. Thus, the effects of caffeine are present while you memorize the information in question. On the day of the test, should you also drink lots of coffee? The answer appears to be “yes,” and not just for the boost in alertness the caffeine may provide. In addition, being in the same physical state may provide you with retrieval cues that may help boost your performance (Eich, 1985). The basic principle that underlies all these effects is sometimes described as the **encoding specificity principle**: Retrieval of information is successful to the extent that the retrieval cues match the cues the learner used during the study phase. The more these are similar, the more memory is facilitated.

**Semantic Memory: How Information Is Organized in Memory**

Now let’s turn to semantic memory—memory for information we don’t remember acquiring at a specific time or in a specific place. (For instance, can you remember when you first learned that drivers in the United States drive on the right?) Because each of us already possesses a very large amount of information in semantic memory, psychologists have focused primarily on how such information is organized, rather than on how it is entered into memory in the first place. One important basis of such organization is in terms of **concepts**—mental categories for objects or events that are similar to one another in certain ways.
bicycle, airplane, automobile, and elevator are included in the concept for vehicles or means of transportation. The words shoes, shirts, jeans, and jackets are included in the concept of clothing.

Concepts in semantic memory seem to exist in networks reflecting the relationships between them—semantic networks. One such network is shown in Figure 6.6. As you can readily see, this illustration shows a hierarchy of concepts: animals includes both birds and fish, and birds, in turn, includes ostriches and canaries. Similarly, fish includes sharks and salmon. However, unless the person whose semantic memory is represented here is confused, it does not contain porpoises, because they are mammals, not fish.

Because both episodic memory and semantic memory hold factual information, how do we know that they are really separate memory systems? Because research evidence indicates that they are distinct. For example, in some medical patients, disease or operations that have damaged certain parts of the brain leave semantic memory intact while diminishing episodic memory, or vice versa (Schachter, 1996). In addition, other research using PET scans or recordings from individual brain cells indicate that different brain regions are active when individuals attempt to recall general information (from semantic memory) versus information they acquired in a specific context and that related to experiences in their own lives (from episodic memory; e.g., Kounious, 1996). So, there do seem to be grounds for the distinction between semantic memory and episodic memory.

**KEY QUESTIONS**

- What are episodic memory and semantic memory?
- What is the levels of processing view?
- What are retrieval cues and what role do they play in memory?
- What are concepts and what role do they play in semantic memory?
Memory for Skills: Procedural Memory

Can you ride a bicycle? Most people can. But now, can you state, in words, how you perform this activity? Probably, you would find that hard to do. And the same principle applies to many other skills we have acquired—for instance, can a champion golfer like Tiger Woods explain how he hits the ball so far? Again, not very readily. Situations like this indicate that we often have information in memory that we can’t readily put into words. Our ability to store such information is known as procedural memory or sometimes as implicit memory (both semantic memory and episodic memory, in contrast, described as being aspects of explicit memory—we can intentionally recall such information and can readily put it into words). Both terms are informative: We often know how to perform some action but can’t describe this knowledge to others (e.g., can Mark McGwire tell us how he hits so many home runs?), what we can’t put into words is, in one sense, implicit (see Figure 6.7).

Evidence for the existence of procedural memory is provided by the way in which many skills are acquired. Initially, as we learn a skill, we think about what we are doing and can describe our actions and what we are learning. As we master the skill, however, this declarative (explicit) knowledge is replaced by procedural knowledge, and we gradually become less and less able to describe precisely how we perform the actions in question (Anderson, 1993). (Recall our discussion of automatic processing in Chapter 4; procedural memory plays a role in such behavior.) What about memory itself? Can it be viewed as a skill that can be improved? Absolutely. We’ll examine some techniques for improving memory in the Psychology Lends a Hand section on page 187 but, for now, we should note that memory does indeed improve with practice. For instance, consider this incident: Just before a concert, a musician in the orchestra came to the great conductor Arturo Toscanini and told him that one of the keys on his instrument was broken. Toscanini thought for a moment and then said, “It is alright—that note does not occur in tonight’s concert.” In a flash, he had somehow examined all of the notes to be played and concluded that the broken key wouldn’t matter! Could Toscanini explain how he did this? He was certainly demonstrating a very highly developed memory!

KEY QUESTION

• What is procedural memory?

FORGETTING: SOME CONTRASTING VIEWS

When are we most aware of memory? Typically, when it fails—when we are unable to remember information that we need at a particular moment. Often, it seems to let us down just when we need it most, for instance, during an exam! Why does this occur? Why is information entered into long-term memory sometimes lost, at least in part, with the passage of time? Many explanations have been offered, so here we’ll focus on the ones that have received the most attention.

The earliest view of forgetting was that information entered into long-term memory fades or decays with the passage of time. While this seems to fit with our subjective experience, many studies indicate that the amount of forgetting is not simply a function of how much time has elapsed; rather, what happens during that...
period of time is crucial (e.g., Jenkins & Dallenbach, 1924). For instance, in one unusual study, Minami and Dallenbach (1946) taught cockroaches to avoid a dark compartment by giving them an electric shock whenever they entered it. After the subjects had mastered this simple task, they were either restrained in a paper cone or permitted to wander around a darkened cage at will. Results indicated that the insects permitted to move about showed more forgetting over a given period of time than those who were restrained. So, what the roaches did in between learning and testing for memory was more important than the mere passage of time. Perhaps even more surprising, other studies indicated that recall sometimes improves over time (e.g., Erdelyi & Kleinbard, 1978). So, early on, psychologists rejected the notion that forgetting stems from passive decay of memories over time and turned, instead, to the views we’ll consider next.

Forgetting as a Result of Interference

If forgetting is not a function of the passage of time, then why does it occur? One possibility is that it stems mainly from interference between items of information stored in memory. Such interference can take two different forms. In retroactive interference, information currently being learned interferes with information already present in memory. If learning how to operate a new computer program causes you to forget how to operate one you learned previously, this would be an example of retroactive interference. In proactive interference, in contrast, previously learned information present in long-term memory interferes with information you are learning at present. Suppose you learned how to operate one DVD player; now you buy a new one that requires different steps for recording a television program. If you now make mistakes by trying to operate the new DVD player in the same way as your old one, this would constitute proactive interference (see Figure 6.8).

A large body of evidence offers support for the view that interference plays a key role in forgetting from long-term memory (e.g., Tulving & Psotka, 1971). For example, in many laboratory studies, the more similar the words or nonsense syllables participants learn from different lists, the more interference occurs among them, and the poorer their recall of these materials (Gruneberg, Morris, & Sykes, 1988). However, more recent findings raise complex questions about the view that forgetting derives mainly from interference. First, while interference does seem to play a major role in the forgetting of meaningless materials, such as nonsense syllables, it is far less important in the forgetting of meaningful passages. Memory for the basic meaning (i.e., the gist) of such passages is often retained even if the passages are quite similar to one another and would be expected to produce interference (e.g., Haberlandt, 1999). Similarly, for interference to occur, something that is potentially interfering must happen in the period between original learning and tests for memory. Yet, forgetting occurs even when individuals learn a single list or even a single item. Such forgetting might be due to interference from sources outside the experiment, but these have proven difficult to identify. Overall, then, interference, which was once viewed as the cause of forgetting, is no longer assigned this crucial role by most memory researchers. So what does cause forgetting? Recent research points to another, intriguing possibility.

Forgetting and Retrieval Inhibition

Suppose we asked you to remember the names of all fifty states in the United States. How many would you get right? Now, instead, imagine that we gave you the names of twenty-five of these states and let you study them. Would that help
you remember the remaining ones? Common sense suggests that it would, but re-
search using procedures similar to these indicates that you would actually do worse;
studying half the states would actually reduce your overall performance (e.g.,
Brown, 1968). Why? Psychologists explain this seemingly paradoxical finding as
follows: When we attempt to remember information in memory, we may recall the
items we seek but, at the same time, generate inhibition of the items we don’t try to
remember. As a result, these become more difficult to remember in the future. So,
when you study the names of twenty-five states, you generate inhibition that
blocks recall of the other twenty-five states. In short, the act of retrieval itself can
cause forgetting—not of the information you recall, but of other, related informa-
tion. This is known as retrieval inhibition, and its occurrence has been observed
in several experiments (e.g., Anderson, Bjork, & Bjork, 1994; Anderson & Spellman,
1995). The results of these investigations suggest that inhibition produced when
we actively try to retrieve information from memory may play an important role
in forgetting.

In sum, at present psychologists believe that forgetting stems from several dif-
ferent factors. Interference may play a role, especially with respect to relatively
meaningless materials, but other complex processes, such as inhibition generated
by retrieval itself, may also contribute to our inability to remember information we
would like to remember. We’ll examine another view of forgetting—the idea that
we repress memories we find painful or unpleasant—in a later discussion of mem-
ory for emotional events.

KEY QUESTIONS
• What is proactive interference? Retroactive interference? What roles do they play in
forgetting?
• What is retrieval inhibition?

MEMORY DISTORTION AND MEMORY CONSTRUCTION

What happens to information once it is stored in memory? Our discussion up to
this point seems to suggest two possible outcomes: It is stored in a permanent, un-
changing form, or it is forgotten. But this is not the entire story; a growing body of
evidence suggests a third possibility: Information entered into memory is often al-
tered in various ways over time—alterations that can reduce its accuracy and
change its meaning. Such changes take many different forms, but most fall under
two major headings: memory distortion—alterations in information stored in mem-
ory, and memory construction—the addition of information that was not actually
entered into memory (e.g., the construction of false memories; Toglia, Neuschatz,
& Goodwin, 1999).

Distortion and the Influence of Schemas

Almost everyone has had first-hand experience with memory distortion. For
example, have you ever met someone and then, several weeks or months later, run
into them again? Perhaps you found that they now seemed taller (or shorter),
younger (or older) than you remembered. Because physical attributes are fairly
obvious and don’t usually change much over short periods of time, it is likely that
either your memory was faulty to start with or became distorted over time. Distor-
tions in memory also occur in response to false or misleading information provided
by others. If someone’s comments suggest a fact or detail that is not present in our
memories, we may add that fact or detail (Loftus, 1992). Unfortunately, such effects
often occur during trials, when attorneys pose leading questions to witnesses—
questions that encourage the witnesses to “remember” what the attorneys want them
to remember. For example, during a trial, an attorney may ask a witness, “Was the getaway car a light color or a dark color?” While the witness may not remember seeing a getaway car, the question puts subtle pressure on this person to answer—to make a choice. And once the answer is given, it may be incorporated into the witness’s memories and tend to distort them. Unfortunately, such effects seem to occur even if individuals are warned about them and offered cash for resisting their influence (Belli & Loftus, 1996)! We’ll return to such effects in a discussion of eyewitness testimony below.

What accounts for memory distortions? One important factor involves the operation of schemas—cognitive frameworks representing individuals’ knowledge about some aspect of the world (Wyer & Srull, 1994). Schemas are developed through experience and act something like mental scaffolds, providing basic frameworks for processing new information and relating it to existing knowledge, including knowledge held in long-term memory.

Once schemas are formed, they exert strong effects on the way information is encoded, stored, and later retrieved. These effects, in turn, can lead to important errors or distortions in memory. Perhaps such effects are most apparent with respect to encoding. Current evidence suggests that once schemas have been formed, information consistent with them becomes easier to notice and remember than information that is inconsistent (e.g., Stangor & Ruble, 1989). It is the operation of schemas that, in part, accounts for the fact that in many cases we are more likely to notice and remember information that supports our beliefs about the world than information that challenges them.

Another important cause of distortion in memory involves our motives: We often distort our memories in order to bring them “in line” with whatever goals we are currently seeking. For example, suppose that you like someone; this may lead you to want to remember positive information about him or her. Conversely, if you dislike someone, you want to remember negative information about this person. Effects of this kind are demonstrated clearly in research conducted by McDonald and Hirt (1997). Participants in the studies watched an interview between two students. Liking for one of the two individuals was varied by having this stranger act in a polite, a rude, or a neutral manner. When later asked to recall information about this person’s grades (information that was provided during the interview), those who were induced to like the stranger distorted their memories so as to place this person in a more favorable light, while those induced to dislike the stranger showed the opposite pattern. In this and many other situations, our memories can be distorted by our current motives (see Figure 6.9 for another example).

**Figure 6.9**

Memory Distortion: Often We Do Remember What We Want to Remember!

Our current motives can strongly influence what we remember. This is an example of the distortion of information stored in memory.

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**Schemas**

Cognitive frameworks representing our knowledge about specific aspects of the world.
Memory Construction: Fuzzy-Trace Theory and Remembering What Didn’t Happen

Memories can not only be distorted—they can also be constructed; in other words, people can recall events that did not actually occur or experiences they never really had. Such constructed or false memories can have important effects—for instance, they can lead to unfounded charges of child sexual abuse when adults construct memories of such treatment even though it never actually occurred (e.g., Acocella, 1998). Unfortunately, a growing body of research evidence suggests that false memories are both persistent and convincing; people strongly believe that they are real (Brainerd & Reyna, 1998; Reyna & Titcomb, 1996). Why? How can we form memories for events that never happened or experiences we never had? One answer is provided by fuzzy-trace theory (Reyna & Brainerd, 1995)—a theory about the relationship between memory and higher reasoning processes.

According to this theory, when we make decisions and judgments, we often focus on the general idea or gist of information stored in memory, not on the information itself. One result is that we then “remember” information consistent with the gist of our real memories even though it is false. Fuzzy-trace theory leads to some intriguing predictions. For instance, it predicts that at first, the more often we are exposed to information we wish to remember, the more false memories we will have. This is because “gist” memories form quickly and are more stable than memories for specific facts or information. So, up to some point, false memories are stronger than real ones. As repetitions continue, however, false memories are countered by accurate memories for specific information and tend to decrease (Seamon et al., 2002). Perhaps the most dramatic illustration of false memories we can provide involves eyewitness testimony, so let’s turn briefly to that topic.

Eyewitness Testimony: Is It as Accurate as We Believe?

Eyewitness testimony—evidence given by persons who have witnessed a crime—plays an important role in many trials. At first glance, this makes a great deal of sense: What better source of information about the events of a crime than the persons who actually saw them? After reading the previous discussions of distortion and construction in memory, however, you may already be wondering about an important question: Is such testimony really accurate?

The answer provided by careful research is clear. Eyewitnesses to crimes are far from perfect. In fact, they often falsely identify innocent persons as criminals (Wells, 1993), make mistakes about important details concerning a crime (Loftus, 1991), and sometimes report “remembering” events they did not actually see (Haugard et al., 1991). Why do such errors occur? Not, it appears, because the witnesses are purposely “faking” their testimony. On the contrary, most try to be as accurate as possible. Rather, these errors occur because of several factors that produce distortions in memory: suggestibility—witnesses are sometimes influenced by leading questions and similar techniques used by attorneys or police officers; and errors with respect to source monitoring—eyewitnesses often attribute their memories to the wrong source. For instance, they identify a suspect in a line-up as the person who committed a crime because they remember having seen this individual before, and assume this was at the scene of the crime; in fact, his or her face may be familiar because they saw it in an album of “mug shots.”

Given these potential sources of error (e.g., it appears that just being asked to imagine an event can sometimes create a false memory for it [Mazzoni & Memon, 2003]), it is no surprise that eyewitnesses are not nearly as accurate as our legal system assumes. And because jurors and even judges tend to place great weight on the testimony of eyewitnesses, such errors can have serious consequences: Innocent persons may be convicted of crimes they did not commit, or, conversely, persons guilty of serious crimes may be wrongly cleared of the charges against them. Indeed, recent evidence indicates that the single largest factor accounting for such miscarriages of justice is faulty eyewitness testimony (Wells, 1993).
Can anything be done to enhance eyewitnesses’ accuracy? Fortunately, research on memory offers some answers. Ones involves conducting improved interviews with witnesses—interviews that may enhance their ability to remember crucial information accurately (e.g., Geiselman & Fisher, 1997). In such cognitive interviews eyewitnesses are asked to report everything they can remember; this provides them with multiple retrieval cues and can increase accuracy of recall. In addition, they are sometimes asked to describe events from different perspectives and in several different orders, not just the one in which the events actually occurred. These and other steps seem to increase the accuracy of eyewitness testimony, but they are far from perfect, so the basic problem remains: Eyewitness testimony is not nearly as accurate as was once widely believed. For this reason, it is probably best to view it as an imperfect and potentially misleading source of information.

**KEY QUESTIONS**

- What are schemas and what role do they play in memory distortion?
- What are false memories and how persistent are they?
- How accurate is eyewitness testimony?

**MEMORY IN EVERYDAY LIFE**

Much of the research described so far has involved the performance of relatively artificial tasks: memorizing nonsense syllables or lists of unrelated words. Sometimes, we perform tasks like these outside the laboratory; for instance, as a student, you sometimes memorize lists of terms or definitions. In general, though, we use memory for very different purposes in our daily lives. Let’s see what psychologists have discovered about how memory functions in natural contexts. Three topics are of special interest: repression of emotionally traumatic events, autobiographical memory, and memory for emotional events.

**Repression: Do We Choose to Forget What’s Too Painful to Remember?**

Have you ever chosen, consciously, to avoid thinking about some unpleasant or traumatic event? If so, you may have been engaging in repression—the active elimination from consciousness of memories or experiences we find threatening. This process, which can be viewed as a kind of motivated forgetting, has been suggested as one major factor in the finding that many persons who were the victims of early childhood sexual abuse fail to remember it (e.g., Williams, 1994) and cannot readily report it unless they are helped to do so by therapists who use various procedures to help the victims bring these memories back into consciousness.

But are such memories, when they are reported to therapists, really accurate? In other words, are they memories for actual, traumatic events, or are they false memories suggested, at least in part, by the techniques therapists used to “shake them loose” from repression? Several researchers have suggested that, sometimes, such memories may actually be false; in fact, they may be suggested by the therapists’ detailed questions (e.g., Shobe & Kihlstrom, 1997). Research findings suggest that such effects are especially likely to occur among young children, who often have difficulty determining whether their memories are based on events that really happened or on something they imagined (e.g., Johnson, Hashtroudi, & Lindsay, 1993). Indeed, recent evidence indicates that simply imagining an event can generate false memories about it. For instance, in an intriguing recent study (Mazzoni & Memon, 2003), students at a British university were asked to read and imagine one event, and read a one-page description of another. One of the events was one that students frequently experience—having a baby tooth removed by a dentist. The other was an event that could never happen because it was illegal in the United States. Unfortunately, both events were remembered as if they had actually occurred.
Kingdom—having a nurse remove a skin sample from their little finger. One group of participants was asked to imagine the impossible event and read a description of the frequent one; the other group imagined the frequent event and read a description of the impossible one. One week later, both groups were given a memory test for the events. As you can see from Figure 6.10, being asked to imagine these events increased memory for them; more importantly, it increased memory for the impossible event as much as for the possible one! Clearly, then, just imagining an event can generate memories for it, as if it really happened.

These results, plus those of many other studies conducted with both children and adults (e.g., Brainerd & Reyna, 1998; Goodman et al., 1996; Mazzoni et al., 1999) suggest the need for caution in interpreting supposedly repressed memories of early childhood sexual abuse. These may certainly be real, but the possibility exists that they are not entirely accurate, and may actually be produced, at least in part, by the probing questions posed by therapists or other persons (e.g., attorneys, law enforcement officials). Please don’t misunderstand: We are certainly not suggesting that all such memories reported are false. There is no doubt that childhood sexual abuse is a disturbingly frequent occurrence (e.g., Keary & Fitzpatrick 1994) and that some people who experience it do have difficulty remembering it (although recent findings indicate that many can and do remember such events; Goodman et al., 2003). However, there seem to be sufficient questions about the nature of repression, and sufficient evidence that some “memories” of traumatic events can be unintentionally constructed, to suggest the need for caution (Koocher et al., 1995).

**Autobiographical Memory: Remembering the Events of Our Own Lives**

How do we remember information about our own lives? Such autobiographical memory (which falls under the more general heading of episodic memory) has long been of interest to psychologists (e.g., Wagenaar, 1986). One question that has been addressed in this research is “When do autobiographical memories begin?” In other words, when are our earliest memories about our lives or ourselves formed?

- **When Do Autobiographical Memories Begin? Infantile Amnesia**

  What is your earliest memory, the earliest event in your life you can remember? For most people, such memories date from their third or fourth year of life, although a few people report even earlier memories (Usher & Neisser, 1995). This fact raises an interesting question: Can we remember events from before this time—from the first two years of our lives? And if we can’t, why not? Why does such infantile amnesia (Howe & Courage, 1993) exist?

  Growing evidence suggests that in fact, we can remember events from very early periods in our lives. However, because we don’t possess language skills at this time, we can’t report them in words (Bauer, 1996). For instance, consider a study by Meyers and his colleagues (1987). They allowed children six to forty weeks old to play with some toys in a laboratory room. Then two years later, they brought the same children back to this room and again allowed them to play with the toys; a control group of the same age had never played with these toys in this room. As expected, the behavior of the two groups differed; those who had played with the toys two years earlier showed more interest in them and played with them
more than did the control group. When asked if they remembered ever having seen
the toys before or having been in the room, though, they almost unanimously said,
“No.” Clearly, the children showed evidence of having some kind of memory of
their earlier experiences but couldn’t put these into words.

Other factors, too, may contribute to our inability to report memories from the
first two years of our lives. One possibility is that autobiographical memory is ab-
sent early in life because the brain structures necessary for such memory are not
sufficiently developed at this time (Moscovitch, 1985). Another possibility, sug-
gested by Howe and Courage (1993), is that we do not form a clear self-concept until
sometime between our second and third birthdays. Without this concept, we lack
the personal frame of reference necessary for autobiographical memory.

Whatever the precise mechanisms involved in our inability to verbally report
memories from our early lives, growing evidence suggests that we can store infor-
mation from this period in memory. So, by and large, the term infantile amnesia is a
misleading term because, in fact, certain types of memory are present even in very
early childhood. We simply can’t describe in words, as we can for memories stored
later.

Memory for Our Own Emotions: Coping with
the Present by Reconstructing the Past

In our earlier discussion of repressed memories, we focused on the question of
how accurately individuals can remember traumatic events that caused them
deep emotional pain. This is not the only issue that arises with respect to memory
and emotions, however. In addition, we can ask, “How accurately can we re-
member emotions we had in the past?” This is an important question, because,
often, our emotions—our “gut-level feelings”—are important guides for our be-
havior. For instance, if we meet someone and leave with the feeling that we don’t
like that person, we will probably avoid them in the future, even if we can’t re-
member why we didn’t like them. Similarly, in order to treat people suffering from
psychological problems such as depression, therapists often need to know how
strong these emotional reactions were in the past. So, how accurate are we in re-
calling our own emotions? In general, quite accurate: When individuals rate their
emotions and later try to recall them, the two ratings generally agree (Levine &
Safer, 2002). However, there are factors that can strongly distort our memories of
our own previous emotions.

First, our current emotional state can produce such effects. For instance, when
persons who have lost a spouse are asked to rate the intensity of their grief in the
past, their answers are more closely related to their current levels of grief than to
the grief they reported years earlier—the time they are trying to remember (Safer,
Bonano, & Field, 2001). And in a revealing recent study (Safer, Levine, & Drapalski,
2002), college students were asked to recall their anxiety before taking an im-
portant test. Half learned of their grade before responding to this question while
the others did not. Results indicated that, compared to the students who did not
know their grades, the students who had done well on the exam underestimated
their actual pre-exam anxiety, and those who learned that they had done poorly
overestimated it. In other words, they adjusted their memories of how they felt be-
fore the exam in the light of what they now knew about their grades. Clearly, then,
our current emotional states can lead to distortion of our memories for our own
emotions.

Second, and even more interesting, is the fact that often we tend to cope with
present problems by reconstructing the past—by changing our memories of our
own emotions. For instance, after going through a very painful experience, many
persons report that they have gained in wisdom or insight. In fact, though, this
change is often less than they imagine: To feel better about the event, they disparage
their wisdom or insight before the event, remembering it as less than it really was
McFarland & Alvaro, 2000). Similarly, patients who have successfully completed therapy overestimate their pre-therapy distress, thus perceiving greater positive change than actually occurred (Safer & Keuler, 2002). The basic principle seems to be that we really do reconstruct the past—change our memories of our own emotions—in order to maximize our current happiness or satisfaction. In this case, then, memory distortion can have beneficial effects, even if they rest on an illusory foundation (see Figure 6.11).

The Effects of Mood on Memory

Earlier, in our discussion of retrieval cues, we noted that our own internal states can serve as a cue for information stored in memory: It is often easier to recall information stored in long-term memory when our internal state is similar to that which existed when the information was first entered into memory. The effects of mood on memory are closely related to such state-dependent retrieval because our moods can be another internal state that serves as a retrieval cue. How can mood influence memory? In two related but distinct ways. First, memory can be enhanced when our mood state during retrieval is similar to that when we first encoded some information; this is known as mood-dependent memory. For instance, if you entered some information into memory when in a good mood, you are more likely to remember this information when in a similar mood once again: Your current mood serves as a kind of retrieval cue for the information stored in memory. Note that you will remember this information whatever it is—positive, negative, or unrelated to mood. For instance, if you learned a list of definitions while in a good mood, you will remember them better when in a good mood again, although they have nothing to do with producing your mood.

Second, we are more likely to store or remember positive information when in a positive mood and negative information when in a negative mood—in other words, we notice or remember information that is congruent with our current mood (Blaney, 1986); this is known as mood congruence effects. A simple way to think about the difference between mood-dependent memory and mood congruence effects is this: In mood-dependent memory, mood serves as a retrieval cue, helping us remember information we acquired when we were in that mood before.
This information may be almost anything, such as the list of definitions we mentioned earlier. In mood-congruence effects, we tend to remember information consistent with our present mood—positive information when we feel happy, negative information when we feel sad (see Figure 6.12). Mood congruence effects are vividly illustrated by an individual who suffered from periods of depression and was asked to remember trips to a swimming pool. When she felt depressed, she remembered painful aspects of these trips—how fat and unattractive she felt in her bathing suit. When she was happier, she remembered positive aspects of the same events—how much she enjoyed swimming (Baddely, 1990).

One reason why mood congruence effects are important is that they may be closely related to depression. Specifically, they help explain why depressed persons have difficulty remembering times when they felt better (Schachter & Kihlstrom, 1989). Their current negative mood leads them to remember unhappy past experiences, and this information causes them to feel more depressed. In other words, mood congruence effects may push them into a vicious, closed circle in which negative feelings breed negative thoughts and memories, which results in even deeper depression; see Chapter 12 for more information. (The fact that memory is subject to forgetting and to many forms of construction and distortion suggests that the task of performance appraisal is a difficult one. What can you do to help assure that the performance appraisals you receive at work are fair and accurate? For some hints, see the Psychology Goes to Work section.)

Diversity and Memory: Own-Race Bias in Remembering Faces

One memory task we often face in everyday life is that of recognizing people we have met before. While faces are certainly distinctive, we meet so many people in so many different contexts that sometimes our memory plays tricks on us and we mistakenly believe we have met someone before or, conversely, forget that we have met them. This is not at all surprising, but more disturbing is the fact that often we find it easier to remember people belonging to our own racial or ethnic group than people belonging to other ones. Many studies confirm this; in fact, a recent review of dozens of separate studies involving more than 5,000 participants suggests that people are indeed more successful in recognizing people they have met (or whose photos they have seen) who belong to their own race than in recognizing people who belong to another race (Meissner & Brigham, 2001). Moreover, this seems to be true whether they have actually met these people or merely seen photos of them (Ludwig, 2001). Even more unsettling is the fact that such effects are stronger for persons who are high in racial prejudice than for persons who are low in such prejudice (Brigham & Barkowitz, 1978; Meissner & Brigham, 2001).

Why do such effects occur? Perhaps because, at least until recently, many persons had more frequent contact with members of their own race than members of other races. Thus, they became more familiar with the physical traits of their own race and so had better retrieval cues for recognizing individual faces. Whatever the reason, the existence of this own-race bias has important implications. For instance, it may influence the accuracy with which eyewitnesses to various crimes can identify the actual offenders. And it might also add a note of friction between members of different races who become annoyed that persons they met before can’t recognize them! Fortunately, the increasing diversity of the United States and many
other countries may lead to a decrease in the magnitude of such effects; after all, as individuals have increasing contact with people in many ethnic and racial groups, they may come to recognize them all with equal accuracy. And then the detestable phrase “They all look alike to me” may finally be abolished once and for all.

KEY QUESTIONS

- What is repression? What role does it play in memory?
- What is autobiographical memory? When does it begin?
- Why do we sometimes distort memories of our own prior emotional states?
- What are mood-dependent memory and mood congruence effects?
- What is own-race bias in memory for races?

PSYCHOLOGY GOES TO WORK

Using Memory Principles to Boost the Fairness, Accuracy, and Favorableness of Your Own Performance Appraisals

In most organizations, employees receive performance appraisals—evaluations of their work—once or twice a year. These appraisals serve as the basis for setting raises and selecting people for promotion, and as a source of valuable feedback that can help people improve. In other words, they are often important. But think about how they are done: Once or twice a year, your boss must try to remember your performance over a period of several months. And then, she or he evaluates it on the basis of these memories. Given the many errors and distortions to which memory is subject, this can be a very tricky task! Are there steps you can take to help assure that what your boss remembers is really an accurate picture of your performance and contributions—and one that fully takes account of your important contributions? Here are some steps we think may be useful.

- Ask your boss to keep a record of your most important contributions. If your boss agrees, he or she will have a written record of what you contributed and will not have to try to retrieve this information from memory. If your boss is too busy, offer to provide such a summary yourself.
- Try to make sure that your boss is in a good mood when he or she prepares your appraisal. Mood congruence effects suggest that when people are in a good mood, they tend to remember positive information—and that’s certainly what you want to happen!
- Try to make sure that when you perform very well, your boss notices. Only information that is noticed can be entered into memory. So when you do something especially well, this is not the time to be modest! Call it to your boss’s attention so that she or he can enter it into memory and retrieve it when the time for appraisals comes around.
- Be sure to start out strong on any new job. First impressions count because once they are formed, they are entered into memory and tend to persist unless something important or dramatic happens to change them. So, if you start out well, your boss will form a favorable mental framework for you and your performance—and this will make it easier for her or him to remember your good contributions when doing your appraisal.
- Give your boss as many retrieval cues for your good performance as possible. Retrieving information from long-term memory is often difficult, and retrieval cues can help a lot. So be sure that your boss has many reminders of your good work and contributions (e.g., copies of any positive comments you received from satisfied customers or co-workers; concrete evidence that your work has produced positive outcomes).

By following these steps, you can increase the chances that your boss will remember favorable information about you when preparing your evaluation—and that can be an important boost to your career.
MEMORY AND THE BRAIN: EVIDENCE FROM MEMORY IMPAIRMENTS AND OTHER SOURCES

Let’s begin with a simple but basic assumption: When information is entered into memory, something must happen in our brains. Given that memories can last for decades, it is only reasonable to suggest that this “something” involves relatively permanent changes. But where, precisely, do these occur? And what kinds of alterations do they involve? Thanks to the development of tools and methods such as those described in Chapter 2, answers to these questions are beginning to emerge (e.g., Paller, Kutas, & McIsaac, 1995). Let’s see what research on these issues has revealed.

Amnesia and Other Memory Disorders: Keys for Unlocking Brain–Memory Links

One way of investigating the biological bases of memory is to study individuals who have experienced loss of memory—amnesia. Amnesia is far from rare and can stem from accidents that damage the brain, from drug abuse, or from operations performed to treat medical disorders. Two major types exist. In retrograde amnesia, memory of events prior to the amnesia-inducing event is impaired. Thus, persons suffering from such amnesia may be unable to remember events from specific periods in their lives. In anterograde amnesia, in contrast, individuals cannot remember events that occur after the amnesia-inducing event. For example, if they meet someone for the first time after the onset of amnesia, they cannot remember this person the next day, or, in some cases, a few minutes after being introduced (see Figure 6.13).

**FIGURE 6.13**
Two Kinds of Amnesia

In retrograde amnesia, memory of events prior to the amnesia-inducing event is impaired—people forget things that happened to them in the past. In anterograde amnesia, memory of events occurring after the amnesia-inducing event is impaired—people can’t remember things that happen to them after the onset of their amnesia.
S. P.: An Example of the Dissociation between Working Memory and Long-Term Learning

One of the most important findings to emerge from studies of people with amnesia is this: Often, they retain factual information stored in memory but can no longer enter new information into long-term storage. S. P., a patient described by the Swiss psychologist Schnider (Schnider, Regard, & Landis, 1994), provides a vivid example of such effects. S. P. was sixty-six years old when he suffered a major stroke. Magnetic resonance imaging indicated that the stroke had affected S. P.’s medial temporal lobes, the left hippocampus, and many other adjoining areas. After the stroke, S. P. showed a pattern demonstrated by many other persons with damage to the hippocampus: He seemed unable to enter information into long-term memory. If he left a room for a few moments, he could not find his way back to it. He could not remember physicians who examined him or people he met for the first time. (He did, however, recognize his wife and children.) He could talk, read, and write, and repeat words on a list as they were read, but could not remember the words after the list was completed. In short, he showed profound anterograde amnesia. Interestingly, he could enter new information into procedural memory: His performance on tasks such as drawing geometric figures without directly looking at them improved with practice, although he couldn’t remember performing the task or explain how he got better at it. This case, and many others like it, point to the importance of the hippocampus, a structure located on the inside edge of each hemisphere, adjacent to the temporal lobes. Damage to this structure seems to interfere with the ability to transfer information from working memory to a more permanent kind of storage. However, because damage to this structure does not eliminate the ability to acquire procedural knowledge (i.e., new skills), it does not seem to be involved in this kind of memory.

Clive Wearing: The Frontal Lobes, Working Memory, and Semantic Memory

Another dramatic case of amnesia is provided by Clive Wearing, a musician and producer of considerable fame during the 1980s. In 1985, he caught infectious encephalitis. This disease produced extensive damage to both temporal lobes of his brain and to the hippocampus, and resulted in profound memory deficits for Mr. Wearing—many of which were recorded by his wife Deborah. Most of these deficits involved semantic memory: He could not distinguish between words such as honey, jam, and marmalade. He ate a lemon, including the peel, believing it was another kind of fruit. He mistook soap for toothpaste. His score on standard tests of semantic memory was very low—a surprising change, because prior to his illness he had been an expert at solving crossword puzzles and had excellent semantic memory. Over time, his memory impairments became worse: He began to develop new, unique definitions for words. Researchers who studied his case concluded that his loss of semantic memory was due to damage to the temporal lobes (Wilson & Wearing, 1995), while losses in the ability for new learning, which occurred later on, were attributed to growing damage to the hippocampus. On the basis of this and many other cases, psychologists have concluded that the frontal lobes of the brain play an important role in working memory and in the encoding and retrieval of factual information (both episodic and semantic) from long-term memory.

Amnesia as a Result of Korsakoff’s Syndrome

Individuals who consume large amounts of alcohol for many years sometimes develop a serious illness known as Korsakoff’s syndrome. The many symptoms of Korsakoff’s syndrome include sensory and motor problems as well as heart, liver, and gastrointestinal disorders. In addition, the syndrome is often accompanied by both anterograde amnesia and severe retrograde amnesia—patients cannot remember events that took place many years before the onset of their illness. Careful medical examinations of such persons’ brains after their deaths indicate
that they experienced extensive damage to portions of the thalamus and hypothalamus. This suggests that these portions of the brain play a key role in long-term memory.

**The Amnesia of Alzheimer’s Disease**

One of the most tragic illnesses to strike human beings in the closing decades of life is Alzheimer’s disease. This illness occurs among 5 percent of all people over age sixty-five, including famous persons such as former President Reagan (see Figure 6.14). It begins with mild problems, such as increased difficulty in remembering names, phone numbers, or appointments. Gradually, though, patients’ conditions worsen until they become totally confused, are unable to perform even simple tasks like dressing or grooming themselves, and experience an almost total loss of memory. In the later stages, patients may fail to recognize their spouses or children. In short, people suffering from Alzheimer’s disease suffer a wide range of memory impairments: Semantic memory, episodic memory, memory for skills, working memory, and autobiographical memory are all disturbed. As one memory expert puts it (Haberlandt, 1999): “Along with their memories, the patients lose their pasts and their souls.”

Careful study of the brains of deceased Alzheimer’s patients has revealed that in most cases they contain tiny bundles of amyloid beta protein, a substance not found in similar concentrations in normal brains. Growing evidence (Yankner et al., 1990) suggests that this substance causes damage to neurons that project from nuclei in the basal forebrain to the hippocampus and cerebral cortex (Coyle, 1987). These neurons transmit information primarily by means of the neurotransmitter acetylcholine, so it appears that this substance may play a key role in memory. Further evidence that acetylcholine-based systems are important is provided by the fact that the brains of Alzheimer’s patients contain lower than normal amounts of acetylcholine. In addition, studies with animal subjects in which the acetylcholine-transmitting neurons are destroyed suggests that this does indeed produce major memory problems (Fibiger, Murray, & Phillips, 1983). However, very recent evidence suggests that other neurotransmitters are also involved, so the picture is more complex than was previously assumed.

**Memory and the Brain: A Modern View**

So what can we conclude from this evidence? Several things. First, memory functions do show some degree of localization within the brain: (1) The hippocampus plays a key role in converting information from a temporary state to a more permanent one, and in spatial learning; however, it does not seem to play a role in procedural memory, because damage to the hippocampus leaves such memory largely intact. (2) The frontal lobes play a role in working memory, executive functions in working memory, and in the encoding and retrieval of factual information from long-term memory. Damage to these areas disrupts these key functions but may leave other aspects of memory intact.

Why does damage to various brain structures produce amnesia and other memory deficits? Several possibilities exist. One is that damage to these areas prevents consolidation of the memory trace: These are formed but cannot be converted to a lasting state (e.g., Squire, 1995). Another is that when information is stored in memory, not only the information itself, but also its context—when and how it was acquired—is stored. Amnesia may result from an inability to enter this additional information into memory (Mayes, 1996). Finally, it may be that amnesia stems from an inability to monitor errors (Baddeley, 1996); this may be one reason why amnesic patients often can’t enter new information into memory, although their semantic memory remains intact (e.g., they can speak, read, and write).

What about the memory trace itself—where is it located and what is it? Over the years, the pendulum of scientific opinion concerning this issue has swung back
and forth between the view that memories are highly localized within the brain—they exist in specific places—to the view that they are represented by the pattern of neural activity in many different brain regions. At present, most experts on memory believe that both views are correct, at least to a degree. Some aspects of memory do appear to be represented in specific portions of the brain and even, perhaps, in specific cells. For instance, cells have been identified in the cortex of monkeys that respond to faces of other monkeys and humans but not other stimuli (Desimone & Ungerleider, 1989). So there do appear to be “local specialists” within the brain. At the same time, networks of brain regions seem to be involved in many memory functions. So, in reply to the question, “Where are memories located?” the best available answer is that there is no single answer. Depending on the type of information or type of memory being considered, memories may be represented in individual neurons, the connections between them, complex networks of structures throughout the brain, or all of the above. Given the complexity of the functions memory involves, this is not surprising; after all, no one ever said that the task of understanding anything as complicated and wonderful as human memory would be easy!

Finally, what is the memory trace—what happens within the brain when we enter information into memory? Again, we are still far from a final, complete answer, although we are definitely getting there. The picture provided by current research goes something like this: The formation of long-term memories involves alterations in the rate of production or release of specific neurotransmitters (especially acetylcholine). Such changes increase the ease with which neural information can move within the brain and may produce localized neural circuits. Evidence for the existence of such circuits, or neural networks, is provided by research in which previously learned conditioned responses are eliminated when microscopic areas of the brain are destroyed—areas that, presumably, contain the neural circuits formed during conditioning (Thompson, 1989).

Long-term memory also may involve changes in the actual structure of neurons—changes that strengthen communication across specific synapses (Teyler & DiScenna, 1984). For instance, as we noted in our discussion of plasticity of the brain in Chapter 2 (e.g., Kolb, Gibb, & Robinson, 2003), the shape of dendrites in specific neurons may be altered by learning and other experiences, and these changes may increase the neurons’ responsiveness to certain neurotransmitters. Some of these changes may occur very quickly, while others may require considerable amounts of time. Perhaps this is one reason why newly formed memories are subject to disruption for some period after they are formed (Squire & Spanis, 1984).

In sum, it appears that we are now in an exciting period of rapid progress; sophisticated research techniques (e.g., PET scans) have armed psychologists and other scientists with important tools for unraveling the biological bases of memory. When they do, the potential benefits for persons suffering from amnesia and other memory disorders will probably be immense. (How can you improve your memory? For some suggestions please see the Psychology Lends a Hand section.)

**KEY QUESTIONS**

- What are retrograde amnesia and anterograde amnesia?
- What roles do the hippocampus and frontal lobes play in memory?
- What are Korsakoff’s syndrome and Alzheimer’s disease? What do they tell us about the biological bases of memory?
- What does current research suggest about the location of the memory trace and its nature?
Improving Your Memory: Some Useful Steps

How good is your memory? If you are like most people, your answer is probably “Not good enough!” At one time or another, most of us have wished that we could improve our ability to retain facts and information. Fortunately, with a little work, almost anyone can improve her or his memory. Here are some tips for reaching this goal:

1. **Really think about what you want to remember.** If you wish to enter information into long-term memory, it is important to think about it. Ask questions about it, consider its meaning, and examine its relationship to information you already know. In other words, engage in “deep processing.” Doing so will help make the new information part of your existing knowledge frameworks—and increase your chances of remembering it at later time.

2. **Pay careful attention to what you want to remember.** Unless you pay careful attention to information you want to remember, it stands little chance of really getting “in”—into long-term memory. So, be sure to direct your full attention to information you want to remember. True, this involves a bit of hard work. But in the long run, it will save you time and effort.

3. **Minimize interference.** Interference is a major cause of forgetting, and, in general, the more similar materials are, the more likely they are to produce interference. In practical terms, this means that you should arrange your studying so that you don’t study similar subjects one right after the other. Instead, work on subjects that are unrelated; the result may be less interference. In general, the more similar materials are, the more likely they are to produce interference. In practical terms, this means that you should arrange your studying so that you don’t study similar subjects one right after the other. Instead, work on subjects that are unrelated; the result may be less interference. In practical terms, this means that you should arrange your studying so that you don’t study similar subjects one right after the other. Instead, work on subjects that are unrelated; the result may be less interference.

4. **Engage in distributed learning/practice.** Don’t try to cram all the information you want to memorize into long-term storage at once. Rather, if at all possible, space your studying over several sessions—preferably, several days. This is especially true if you want to retain the information for long periods of time rather than just until the next exam!

5. **Use visual imagery and other mnemonics.** You’ve probably heard the saying, “A picture is worth a thousand words.” Where memory is concerned, this is sometimes true; it is often easier to remember information associated with vivid mental images (e.g., Gehrig & Toglia, 1989). You can put this principle to use by adopting any one of several different mnemonics—tactics for improving memory. One of these, the method of loci, involves linking points you want to remember with visual images arranged in some familiar order. For instance, suppose you want to remember the points in a speech you will soon make. You can imagine walking through some familiar place, say, your own home. Then form a series of images in which each item you wish to remember is placed in a specific location. Perhaps the first point is “The greenhouse effect is real.” You might imagine a large, steamy greenhouse right outside your front door. The next point might be “Cutting down the rain forest is increasing the greenhouse effect.” For this one, you might imagine a large cut-down tree in your living room. You’d form other images, in a different location, for the other points you want to make. Then, by taking an imaginary walk through your house, you can “see” each of these images and so remember the points in your speech.

6. **Give yourself extra retrieval cues.** Remember the concept of state-dependent retrieval? As noted previously, you can use this principle to provide yourself with extra retrieval cues and so help enhance your memory. For instance, if you studied for a test while in one physical state, try to be in the same state when you take it—this may help. Similarly, use the principle of mood-dependent memory. If you learned some material while in a given mood and then want to remember it, try to put yourself in the same mood. This is not as hard as it sounds: You can often vary your own mood by imagining happy or sad events. To the degree that your mood now matches your mood when you learned the information, your memory for it may be improved.

7. **Develop your own shorthand codes.** To learn the names of the planets in our solar system, many children use the first-letter technique, in which the first letter of each word in a phrase stands for an item to be remembered. So, the sentence “Mary’s Violet Eyes Make John Stay Up Nights Pondering” (for Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto) is very helpful. This can be a very useful technique for remembering others lists of items, too, so use it whenever you can.

We could list additional techniques, but most would be related to the points already described. Whichever techniques you choose, you will learn that making them work requires effort. In memory training, as in any other kind of self-improvement, it appears that the saying “No pain, no gain” holds true.

**Summary and Review of Key Questions**

**Human Memory: An Information-Processing Approach**

- According to the information-processing model, what key tasks are performed by memory?

Encoding, which involves converting information into a form that can be entered into memory; storage, which involves retaining information over time; and retrieval, which involves locating information when it is needed.
• What are sensory memory, short-term memory, and long-term memory?
  Sensory memory holds fleeting representations of our sensory experiences. Short-term memory holds a limited amount of information for short periods of time. Long-term memory holds large amounts of information for long periods of time.

Our Different Memory Systems
• What is the difference between short-term memory and working memory?
  Short-term memory refers to our memory system for storing limited amounts of information for relative short periods of time. Working memory refers to short-term storage of information plus a mechanism for focusing attention and determining what information will be processed and what will be ignored or suppressed.

• What are the three major components of working memory?
  The major components are a mechanism for short-term retention of information, a mechanism for rehearsing such information, and an attentional mechanism.

• What are episodic memory and semantic memory?
  Episodic memory contains factual information individuals relate to their own lives and experiences. Semantic memory holds factual information of a more general nature.

• What is the levels of processing view?
  This view suggests that the more deeply information is processed, the more likely it is to be retained.

• What are retrieval cues and what role do they play in memory?
  These are stimuli that are associated with information stored in memory and so can help bring it to mind at times when it cannot be recalled spontaneously.

• What are concepts and what role do they play in semantic memory?
  These are mental categories for objects or events that are similar to one another in certain ways. They seem to be arranged in hierarchical networks in semantic memory.

• What is procedural memory?
  This is memory for information we cannot readily put into words, such as various skills.

Forgetting: Some Contrasting Views
• What is proactive interference? Retroactive interference?
  Retroactive interference occurs when information being learned currently interferes with information already present in memory. Proactive interference occurs when information already present in memory interferes with the acquisition of new information.

• What is retrieval inhibition?
  This refers to the fact that efforts to remember information in memory may generate inhibition that interferes with memory for items we don’t try to remember.

Memory Distortion and Memory Construction
• What are schemas and what role do they play in memory distortion?
  Schemas are cognitive structures representing individuals’ knowledge and assumptions about some aspect of the world. Once formed, they strongly influence the ways in which we process new information.

• What are false memories and how persistent are they?
  False memories are memories for events or experiences that never happened or we never had. Often, they are stronger than real memories and very persistent.

• How accurate is eyewitness testimony?
  The testimony of eyewitnesses to various crimes appears to be far less accurate than is widely believed.

Memory in Everyday Life
• What is repression? What role does it play in memory?
  Repression is the active elimination from consciousness of memories or experiences we find threatening. There is little evidence that it plays an important role in forgetting, although it has been suggested that repression influences memories of sexual abuse early in life.

• What is autobiographical memory? When does it begin?
  Autobiographical memory contains information about our own lives. It begins very early in life, although most people can’t describe memories from the first two years of life.

• Why do we sometimes distort memories of our own prior emotional states?
  We sometimes distort memories of our own prior emotional states to improve our present happiness by, for instance, perceiving that we benefited more than we really did from painful or traumatic events.

• What are mood-dependent memory and mood congruence effects?
  When our mood during retrieval is similar to that during encoding, memory may be enhanced; this is mood-dependent memory. We tend to remember information consistent with our current mood; this is mood congruence.

• What is own-race bias in memory for faces?
  This refers to a tendency to recognize persons belonging to our own racial or ethnic group more readily and accurately than persons belonging to other racial or ethnic groups.

Memory and the Brain: Evidence from Memory Impairments and Other Sources
• What are retrograde amnesia and anterograde amnesia?
  Retrograde amnesia involves loss of memory of events prior to the amnesia-inducing event. Anterograde amnesia is loss of memory for events that occur after the amnesia-inducing event.

• What roles do the hippocampus and frontal lobes play in long-term memory?
  The hippocampus seems to play a crucial role in the consolidation of memory—the process of shifting new information from short-term to longer-term storage. The frontal lobes appear to play a key role in various aspects of working memory and in the encoding and retrieval of factual information (both episodic and semantic).

• What is Korsakoff’s syndrome and Alzheimer’s disease? What do they tell us about the biological bases of memory?
Korsakoff’s syndrome is produced by long-term alcoholism and often involves severe forms of amnesia. It indicates that the hypothalamus and thalamus play important roles in memory. Alzheimer’s disease produces increasingly severe deficits in memory. It calls attention to the role of the neurotransmitter acetylcholine in memory.

What does current research suggest about the location of the memory trace and its nature?

Current research suggests that the memory trace may involve individual neurons, connections between them, and complex networks of neurons and brain structures. It may involve changes in the structure and function of individual neurons, or of complex networks of neurons.

Human Memory and Computer Memory: The Same or Different?

Each year, computers get faster and have larger memories. In fact, right now, we can place everything we have ever written—every book, every article, every lecture note—on a tiny fraction of the hard drives in computers. So, computer memory is certainly impressive. But is it as good as human memory? To answer this question, it is important to understand differences as well as similarities between human memory and computer memory. We think that comparing these two systems for storing information will help you more fully understand what psychologists have learned about the nature of memory. Below, please list (1) the ways in which human memory and computer memory are similar and (2) the ways in which they are different. After you complete these tasks, answer the following question: In what ways is human memory superior to computer memory and vice versa?

Procedural Memory: Knowledge That Can’t Readily Be Put into Words

As noted earlier, information stored in procedural memory plays a key role in skilled performance, but it is often difficult to put into words: You know how to do something, but you can’t really explain how you do it. Try the following exercise to see how you can apply this fact to your own life.

Suppose you are trying to teach someone a new skill—for instance, how to drive a car with manual transmission. How would you go about it? On a separate sheet of paper list at least five things you would do.

Now, examine your list. How many of them involved “explaining” what to do in words? Do you think these techniques would be effective? In contrast, how many of the items you listed involved getting the person to practice the skill, perhaps after watching you do it? Do you think these would be more effective? Why? In general, they would be for the following reason: Because we can’t describe procedural knowledge verbally, it is better to demonstrate it and to have the person learning a new skill practice it. Try this approach the next time you teach someone a new skill. Chances are, you will find it to be much more effective than trying to tell them what to do.

Making Psychology Part of Your Life

Now, examine your list. How many of them involved “explaining” what to do in words? Do you think these techniques would be effective? In contrast, how many of the items you listed involved getting the person to practice the skill, perhaps after watching you do it? Do you think these would be more effective? Why? In general, they would be for the following reason: Because we can’t describe procedural knowledge verbally, it is better to demonstrate it and to have the person learning a new skill practice it. Try this approach the next time you teach someone a new skill. Chances are, you will find it to be much more effective than trying to tell them what to do.

Key Terms

Alzheimer’s Disease, p. 185
Amnesia, p. 183
Anterograde Amnesia, p. 183
Autobiographical Memory, p. 178
Concepts, p. 170
Context-Dependent Memory, p. 170
Encoding, p. 164
Encoding Specificity Principle, p. 170
Episodic Memory, p. 169
Explicit Memory, p. 172
Eyewitness Testimony, p. 176
Fuzzy-Trace Theory, p. 176
Implicit Memory, p. 172
Infantile Amnesia, p. 178
Information-Processing Approach, p. 164
Korsakoff’s Syndrome, p. 184
Levels of Processing View, p. 169
Long-Term Memory, p. 165
Memory, p. 164
Mood Congruence Effects, p. 180
Mood-Dependent Memory, p. 180
Eyewitness Testimony, p. 176
Proactive Interference, p. 173
Procedural Memory, p. 172
Repression, p. 177
Retrieval, p. 164
Retrieval Cues, p. 169
Retrieval Inhibition, p. 174
Retroactive Interference, p. 173
Retrograde Amnesia, p. 183
Schemas, p. 175
Semantic Memory, p. 169
Sensory Memory, p. 164
Short-Term Memory. See Working Memory.
State-Dependent Retrieval, p. 170
Storage, p. 164
Working Memory, p. 166