CHAPTER 10

Memory and Thought

Psychology Journal

Think back to your childhood and recall your earliest memory. Describe this memory in your journal. ■

Psychology Online

Chapter Overview
Visit the *Understanding Psychology* Web site at glencoe.com and click on **Chapter 10—Chapter Overviews** to preview the chapter.

SECTION 1

Taking in and Storing Information

Reader's Guide

Main Idea

There are three processes involved in memory: encoding, storage, and retrieval.

Vocabulary

- memory
- encoding
- storage
- retrieval
- sensory memory
- short-term memory
- maintenance rehearsal
- chunking
- semantic memory
- episodic memory
- declarative memory
- procedural memory

Objectives

- Explain the three processes of memory.
- Describe the information-processing model of memory.

Exploring Psychology

A Life Without Memory

John Kingsley came to our attention in a shocking news story about an 83-year-old Alzheimer's patient who was found unattended in his wheelchair at a dog race track outside of Spokane, Washington. Attached to his chair was a note misidentifying him. John did not know who he was or how he got to the races. He could not help authorities find his family or his previous caregivers. John Kingsley, like many other patients during advanced stages of Alzheimer's disease, is alive, but without life. Without a memory of his past, or the ability to remember anything new, John's life is nothing but the existing moment.

—**from** *Psychology: Science, Behavior, and Life* **by R.H. Ettinger, Robert L. Crooks, and Jean Stein, 1994**

What would life without memory be like? Can you even imagine it? Consider all the material stored in your memory: your Social Security number, the capital of South Dakota, "The Star-Spangled Banner," your first love's phone number, the important generals of the Civil War, the starting lineup for the Boston Red Sox, your best friend in first grade, and so on. What kind of incredible filing system allows you to instantly recover a line from your favorite movie? How does all that information fit in your head?

THE PROCESSES OF MEMORY

memory: the input, storage, and retrieval of what has been learned or experienced

Memory is the input, storage, and retrieval of what has been learned or experienced. Who sings your favorite song? Who were your friends in eighth grade? To recall this information, you use one memory process, assuming two others occurred previously. (see Figure 10.1).

encoding: the transforming of information so the nervous system can process it

The first memory process is **encoding**—the transforming of information so that the nervous system can process it. Basically you use your senses—hearing, sight, touch, taste, temperature, and others—to encode and establish a memory. You use *acoustic codes* when you try to remember something by saying it out loud, or to yourself, repeatedly. For example, in trying to remember the notes that make up the spaces in the treble clef of a musical measure, you would repeat the letters "F," "A," "C," and "E." When you attempt to keep a mental picture of the letters, you are using *visual codes*. Another way you might try to remember the notes is by using *semantic codes*. In this way, you try to remember the letters by making sense of them. For example, if you wanted to remember the letters "F," "A," "C," "E," you might remember the word *face*. In this way, you have to remember only the word rather than the individual letters.

storage: the process by which information is maintained over a period of time

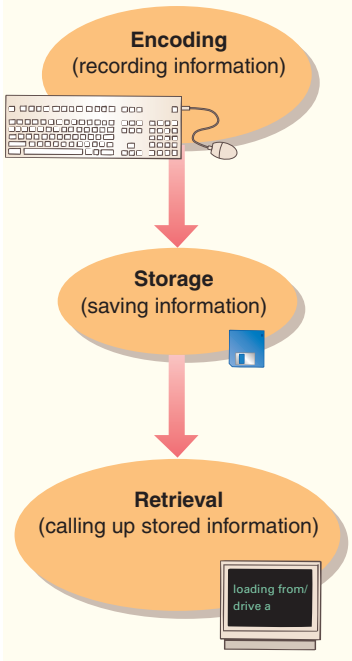
After information is encoded, it goes through the second memory process, **storage.** This is the process by which information is maintained over time. How much information is stored depends on how much effort was put into encoding the information and its importance. Information can be stored for a few seconds or for much longer.

retrieval: the process of obtaining information that has been stored in memory

The third memory process, **retrieval,** occurs when information is brought to mind from storage. The ease with which information can be retrieved depends on how efficiently it was encoded and stored (as well as on other factors, such as genetic background).

Figure 10.1 The Processes of Memory

Memory involves three processes. ***What does the first process of memory involve?***



THREE STAGES OF MEMORY

Once the senses encode a memory in the brain, the brain must hold on to the input and store it for future reference. One model distinguishes three types of memory—sensory, short-term, and long-term—each of which has a different function and time span (see Figure 10.2).

Sensory Memory

sensory memory: very brief memory storage immediately following initial stimulation of a receptor

In **sensory memory,** the senses of sight and hearing (among other senses) are

able to hold an input for a fraction of a second before it disappears. For example, when you watch a motion picture, you do not notice the gaps between frames. The actions seem smooth because each frame is held in sensory storage until the next frame arrives.

George Sperling (1960) demonstrated this phenomenon in an ingenious experiment. He used a tachistoscope (a device that presents a picture for a very brief time) to present a group of letters and numbers to people for a twentieth of a second. Previous studies had shown that if you present a stimulus like this,

8	1	V	F
X	L	5	3
B	7	W	4

people will usually be able to tell you four or five of the items. Sperling believed that the stimulus created a visual image of the letters and that only a few could be read back before the image faded. Psychologists refer to this visual sensory memory as *iconic memory*. (Iconic memories hold visual information for up to a second.)

Sperling then told the participants in his experiment that after he flashed the letters on the tachistoscope screen, he would present a tone. Upon hearing a high tone, the participants were to tell him the top row; a medium tone, the middle row; and a low tone, the bottom row. Once people learned this system, they were indeed able to remember about 75 percent of any one row if asked to recall immediately. Thus, he proved that the participant retains a brief image of the whole picture so that he or she can still read off the items in the correct row after the picture has left the screen. Psychologists refer to auditory sensory memory as *echoic memory*. This is a type of sensory memory that holds auditory information for 1 or 2 seconds.

Sensory memory serves three functions. First, it prevents you from being overwhelmed. Every second of every day, you are bombarded with various incoming stimuli. If you had to pay attention to all of these stimuli—what you are immediately seeing, hearing, smelling, and feeling—you might easily feel overwhelmed. Since the information in sensory memory is short-lived, anything that you do not pay attention to vanishes in seconds. Second, sensory memory gives you some decision time. The information in sensory memory is there for only a few seconds—just long enough for you to decide whether it is worth paying attention to this information. If you choose to pay attention, the information is automatically

Figure 10.2 Stages of Memory

Psychologists often compare human memory to a computer; however, unlike a computer, people can never fill their long-term memories so full that there is no room left for storage. ***How do the capacities of sensory memory and short-term memory differ?***

	Sensory memory	Short-term memory	Long-term memory
Capacity	Virtually everything you see or hear at one instant	About 7 items in healthy adults	Vast; uncountable
Duration	Fraction of a second	Less than 20 seconds if not rehearsed	Perhaps a lifetime
Example	You see something for an instant, and then someone asks you to recall one detail	You look up a telephone number and rehearse it long enough to dial it	You remember the house where you lived when you were 7 years old

Reading Check
What is the difference between iconic and echoic memory?

transferred to short-term memory. Finally, sensory memory allows for continuity and stability in your world. For instance, iconic memory makes images in your world smooth and continuous, whereas echoic memory lets you play back auditory information, giving you time to recognize sounds as words. The information held momentarily by the senses has not yet been narrowed down or analyzed. It is short-lived, temporary, and fragile. However, by the time information gets to the next stage—short-term memory—it has been analyzed, identified, and simplified so that it can be conveniently stored and handled for a longer time.

short-term memory: memory that is limited in capacity to about seven items and in duration by the subject's active rehearsal

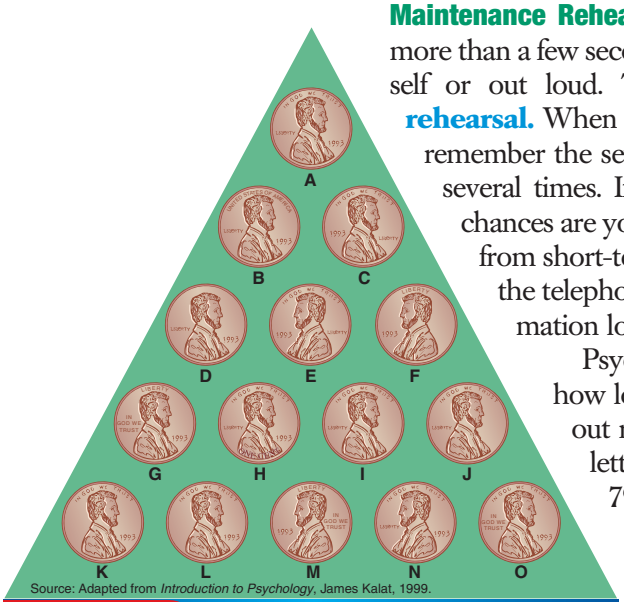
maintenance rehearsal: a system for remembering that involves repeating information to oneself without attempting to find meaning in it

Short-Term Memory

The things you have in your conscious mind at any one moment are being held in **short-term memory.** Short-term memory does not necessarily involve paying close attention. You have probably had the experience of listening to someone only partially and then having that person accuse you of not paying attention. You deny it, and to prove your innocence, you repeat, word for word, the last words he or she said. You can do this because you are holding the words in short-term memory.

Maintenance Rehearsal To keep information in short-term memory for more than a few seconds, you usually have to repeat the information to yourself or out loud. This is what psychologists mean by **maintenance rehearsal.** When you look up a telephone number, for example, you can remember the seven digits long enough to dial them if you repeat them several times. If you are distracted or make a mistake in dialing, the chances are you will have to look up the number again. It has been lost from short-term memory. By using maintenance rehearsal (repeating the telephone number over and over again), you can keep the information longer in short-term memory.

Psychologists have measured short-term memory by seeing how long a participant can retain a piece of information without rehearsal. The experimenter shows the participant three letters, such as CPQ, followed by three numerals, such as 798, one second later. To prevent rehearsal, the participant has been instructed to start counting backward by threes and reporting the result in time with a metronome striking once per second. (A *metronome* is an instrument designed to mark exact time by a regularly repeated tick.) If the participant performs this task for only a short time, she or he will usually remember the letters. If kept from rehearsing for 18 seconds, however, recall will be no better than a random guess; the information is forgotten. Short-term memory lasts a bit less than 20 seconds without rehearsal.



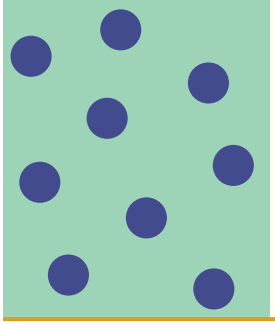
Source: Adapted from *Introduction to Psychology*, James Kalat, 1999.

Figure 10.3 Spot the Real Penny

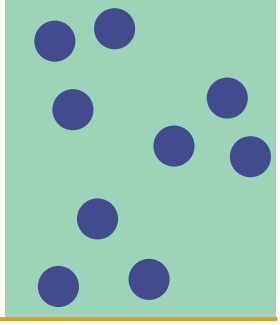
Which is the genuine penny among the fakes? (Ask your teacher for the correct answer.) Even though you live in the United States and probably see hundreds of pennies a week, it is difficult to identify the real one. Mere repetition, such as seeing something over and over again, does not guarantee a strong memory. ***What could you do to remember exactly how a penny looks?***

Chunking Short-term memory is limited not only in its duration but also in its capacity. It can hold only about seven unrelated items. Suppose, for

Figure 10.4 Using Short-Term Memory



Glance quickly at the left figure in this pair, then look away. How many dots did you see? Now do the same with the right figure. You were probably surer and more accurate in your answer for the right figure. ***Why is this so?***



example, someone quickly reels off a series of numbers to you. You will be able to keep only about seven or eight of them in your immediate memory. Beyond that number, confusion about the numbers will set in. The same limit is there if the unrelated items are a random set of words. We may not notice this limit to our capacity because we usually do not have to store so many unrelated items in our immediate memory. Either the items are related (as when we listen to someone speak), or they are rehearsed and placed in long-term memory.

The most interesting aspect of this limit, discovered by George Miller (1956), is that it involves about seven items (plus or minus two items) of any kind. Each item may consist of a collection of many other items, but if they are all packaged into one chunk, then there is still only one item. Thus we can remember about seven unrelated sets of initials, such as COMSAT, HIV, SST, or the initials of our favorite radio stations, even though we could not remember all the letters separately. This is referred to as **chunking** because we have connected, or chunked, them together; in other words, HIV is one item, not three.

chunking: the process of grouping items to make them easier to remember

One of the tricks of memorizing a lot of information quickly is to chunk together the items as fast as they come in. If we connect items in groups, we have fewer to remember. For example, we remember new phone numbers in two or three chunks (555-6794 or 555-67-94) rather than as a string of seven digits (5-5-5-6-7-9-4). As Figure 10.4 illustrates, we use chunking to remember visual as well as verbal inputs.

Even with chunking, storage in short-term memory is only temporary. Information is available, generally, for less than 20 seconds and no more than 30 seconds, assuming no rehearsal has occurred. After that, it is part of the long-term memory, or it is lost. Short-term memory contains information that is of possible interest. Information worth holding on to must be rehearsed with the intent to learn in order to transfer it to long-term memory. Rehearsal without intent to learn yields no transfer, no memory.

PSYCHOLOGY Online

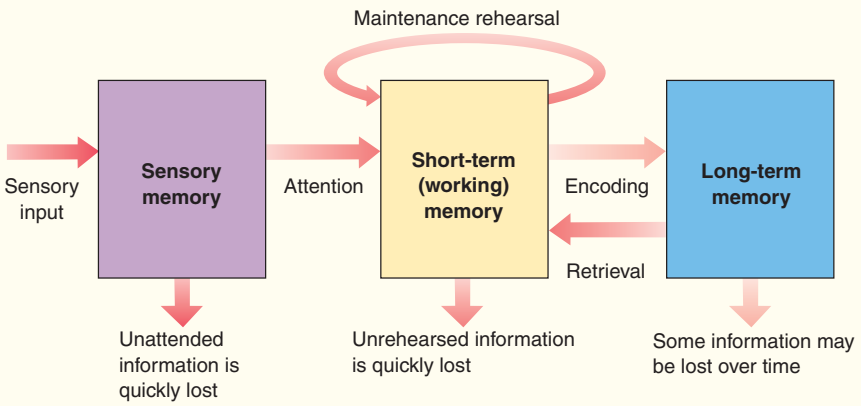
Student Web Activity
Visit the *Understanding Psychology* Web site at glencoe.com and click on **Chapter 10—Student Web Activities** for an activity about memory.

The Primacy-Recency Effect Read the grocery list at the right. Immediately after reading this list, write down as many of the items as you can. Which terms did you remember? The *primacy-recency* effect refers to the fact that we are better able to recall information presented at the beginning and end of a list. Most likely, you remembered the first four

milk
cheese
butter
eggs
flour
apples
grapes
shampoo
bread
ground beef
cereal
catsup
green beans
jam

Figure 10.5 Three Systems of Memory

The moment you pay attention to information in sensory memory, that information enters short-term memory. Then that information remains in short-term memory for a few seconds. If you rehearse that information, it stays; if you do not, it disappears. ***When does the process of encoding take place?***



or five items in the list because you had more time to rehearse them. This is the *primacy effect*. You may have also recalled the last four or five items in the list because they were still accessible in short-term memory. This is the *recency effect*. However, you may have forgotten the middle items in the list. When trying to remember the middle items in a list, such as this one, your attention is split between trying to remember previous items and trying to rehearse new ones.

Working Memory Short-term memory is also called *working memory*. Working memory serves as a system for processing and working with current information. Working memory includes both short-term memory (events that just occurred) and information stored in long-term memory, now recalled for current information.

Learning to perform activities requiring skills, such as in-line skating, is part of procedural memory.

Long-Term Memory

Long-term memory refers to the storage of information over extended periods of time. Information is not stored like a piece of paper in a filing cabinet; it is stored according to categories or features. You reconstruct what you must recall when you need it. When you say a friend has a good memory, you probably mean he or she can recall a wide variety of information accurately. The capacity of long-term memory appears to be limitless. Long-term memory contains representations of countless facts, experiences, and sensations. You may not have thought of your childhood home for years, but you can probably still visualize it.

Long-term memory involves all the processes we have been describing. Suppose you go to see a play. As the actors say their lines, the sounds flow through your sensory storage. These words accumulate in short-term memory and form meaningful phrases and sentences.

You attend to the action and changing scenery in much the same way. Together, they form chunks in your memory. An hour or two later, you will have forgotten all but the most striking lines, but you have stored the meaning of the lines and actions in long-term memory. The next day, you may be able to give a scene-by-scene description of the play. Throughout this process, the least important information is dropped and only the essentials are retained (see Figure 10.5). A month or two later, without much rehearsal, you may remember only a brief outline of the plot and perhaps a few particularly impressive moments. In time you may not remember anything about the play. Other, more recently stored items block access to earlier memories or may even replace them. Yet if you see the play again, you will probably recognize the lines of the play and anticipate the actions. Although it has become less accessible, elements of the play are still stored in long-term memory.

Did You Know?

Prosopagnosia Memory problems can sometimes take a surprising twist. One example is the peculiar condition known as *prosopagnosia,* in which the patient is unable to recognize familiar faces—even his or her own face. People who have this condition can still perceive other aspects of faces, however, such as whether a person's expression is happy or sad. This memory problem usually results from a stroke or head injury.

Types of Long-Term Memory For almost a century, the study of memory focused on how long information was stored for usage. Then a Canadian psychologist, Endel Tulving (1972), proposed that we have two types of memory. **Semantic memory** is our knowledge of language, including its rules, words, and meanings. We share that knowledge with other speakers of our language. **Episodic memory** is our memory of our own life, such as when you woke up this morning. Stored here are personal things where time of occurrence is important. Everyone's episodic memory is unique.

L.R. Squire (1987) proposed a related model of memory. **Declarative memory** involves both episodic and semantic memory. This is information you call forth consciously and use as you need it. **Procedural memory** does not require conscious recollection to have past learning or experiences impact our performance. One form of procedural memory involves *skills,* learned as we mature—including both complex skills such as swimming or driving a car and simple skills such as tying a tie. As we gain a skill, we gradually lose the ability to describe what we are doing. Other types of procedural memory, such as fear of bugs, include habits and things learned through classical conditioning.

semantic memory: knowledge of language, including its rules, words, and meanings

episodic memory: chronological retention of the events of one's life

declarative memory: stored knowledge that can be called forth consciously as needed

procedural memory: permanent storage of learned skills that does not require conscious recollection

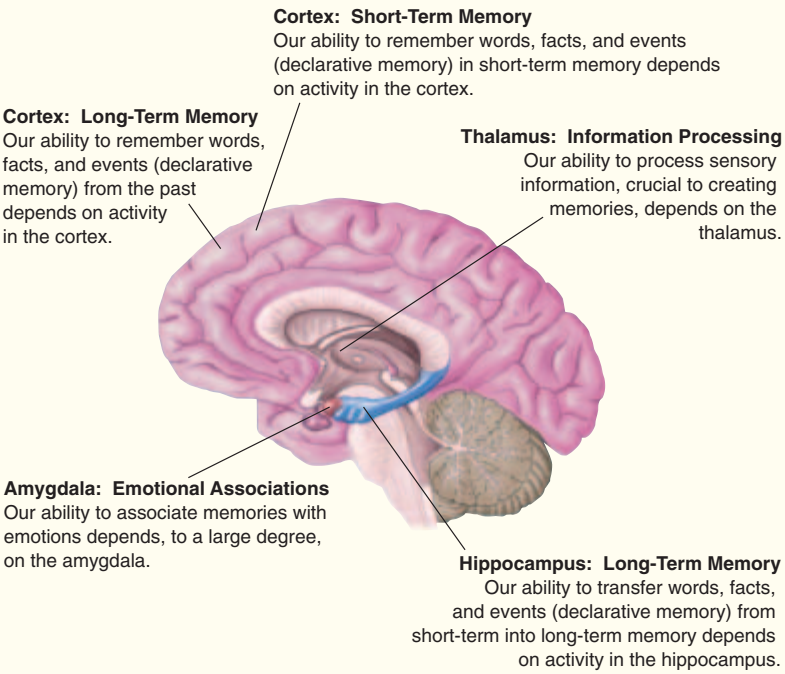
MEMORY AND THE BRAIN

What happens in the brain when something is stored in long-term memory? The answers are highly controversial. There is growing evidence that physiological changes occur in the brain, but psychologists are only beginning to identify how and where memories are stored.

What physiological changes occur when we learn something? Some psychologists theorize a change in the neuronal structure of nerves occurs. Others contend that learning is based on molecular or chemical changes in the brain. The evidence is more and more clear that both sides are correct.

Figure 10.6 Memory Centers in the Brain

Researchers have identified the parts of the brain that are involved in memory. ***What parts of the brain are involved in remembering the date of a special event?***



Source: Adapted from *Introduction to Psychology*, Rod Plotnik, 2005.

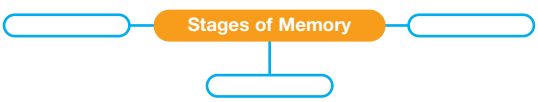
What changes occur depend on the level at which you are examining the changes that learning creates.

Where does learning occur? There is growing evidence that formation of procedural memories involves activity in an area of the brain called the *striatum*, deep in the front part of our cortex (see Figure 10.6). Declarative memories result from activity in the hippocampus and the amygdala (Mishkin, Saunders, & Murray, 1984).

It is not clear yet how individual nerve cells—called neurons—establish connections with one another when learning occurs. It is clear that a very complex chemical process precedes the formation of new connections between neurons. Some have credited increases in calcium. Others talk of decreased potassium flow. Processes as diverse as increased protein synthesis, heightened levels of glucose, and other biochemical processes are involved (Kalat, 2006). Exactly how it all fits together remains an active area of research.

SECTION 1 Assessment

1. **Review the Vocabulary** List and describe the processes of memory.
2. **Visualize the Main Idea** In a diagram similar to the one below, list the different stages of memory and write an example of each.



3. **Recall Information** What is the purpose of maintenance rehearsal? How does the process work?
4. **Think Critically** In what ways is your memory like a computer? In what ways is it different? Explain your responses.
5. **Application Activity** Create a skit that illustrates how you would perform activities such as swimming or bicycle riding if you did not have procedural memory. Share your skit.

Case Studies

The Case of H.M.

Period of Study: 1953

Introduction: In 1953 a man, known by the initials H.M., underwent major surgery in an effort to cease or minimize the occurrence of epileptic seizures. The doctors chose to remove the hippocampus. Knowledge regarding the function of the hippocampus, however, was limited at that time.

The surgery proved quite effective in decreasing the frequency and severity of the seizures. In fact, preliminary tests showed that H.M.'s IQ had risen slightly because he now could better concentrate on tasks. As time passed, doctors detected an unforeseen and devastating result of the surgery—H.M. had lost the ability to store new long-term memories. Although he could remember events that occurred before the operation, H.M. could no longer retain information about events occurring after the surgery. Amazingly, he could still read, carry on conversations, and solve problems. He could recall information he learned five to ten minutes beforehand, but H.M.'s brain could not transfer that short-term information into long-term memory.

Hypothesis: The case of H.M. sparked many theories about the functions of the hippocampus region of the brain. One theory proposed that the transfer of short-term memory into long-term memory was fixed in the hippocampus region. H.M.'s memories before the operation remained mostly intact, but after the operation, there was no hippocampus region to which to transfer new memories—new information had nowhere to go and so could not be recalled at a later time.

Method: Doctors tested H.M. by presenting him with information, distracting him momentarily, and then asking him to recall the information first discussed. H.M. was unable to learn sequences of digits beyond the usual short-term memory span of seven digits. Likewise, H.M. could not recognize the photographs of people shown and described to him just a short time earlier.

Interestingly, H.M. demonstrated that he could learn difficult motor skills such as solving puzzles. Although H.M. clearly demonstrated skill in completing these activities, he reported never to have learned the activities. This implied that H.M. could learn new motor abilities even though he could not retain new long-term memories.

Results: The most apparent source of H.M.'s problem was a disruption in transferring short-term memory to long-term memory. This indicated that the hippocampus region is not involved with storing long-term memory, because recollection of pre-surgery events was intact. Thus, the hippocampus region of the brain *may be* the component involved in this memory transferring process but *definitely is* a pathway through which this information travels.

H.M. lived the rest of his life with the frustration of not remembering the current year, his age, or where he lived. He was placed in the care of a nursing home and had to be accompanied by someone everywhere he wanted to go. He needed constant reminders of what he was doing. He could not remember anything following the year 1953—the year of his surgery. Sadly, H.M. was literally "frozen in time."

Analyzing the Case Study

1. What type of surgery did H.M. have? Why?
2. What problems did H.M. encounter following the surgery? Why?
3. **Critical Thinking** If a virus suddenly destroyed your hippocampus, what effect would it have on your performance in school?

SECTION 2

Retrieving Information

Reader's Guide

Main Idea

Stored memory can be retrieved by recognition, recall, and relearning.

Vocabulary

- recognition
- recall
- reconstructive processes
- confabulation
- schemas
- eidetic memory
- decay
- interference
- elaborative rehearsal
- mnemonic devices

Objectives

- Identify several memory retrieval processes.
- Explain the processes involved in forgetting.

Exploring Psychology

What a Memory!

Rajan Mahadevan stood before the packed house of the International Congress on Yoga and Meditation. He recited, from memory, the first 30,000 digits of pi, which is often rounded off to two decimal points, or 3.14. He did not err until the 31,812th digit. This feat took 3 hours and 44 minutes and earned him a place in the *Guinness Book of World Records*. . . .

Rajan can repeat a string of 60 numbers after a single hearing, while most of us can repeat an average of about seven random numbers. Rajan is one of only a half-dozen people in the world known to have such gargantuan memory powers.

Despite Rajan's unbelievable ability to memorize numbers, he seems to be worse than average at recalling faces, and he constantly forgets where he put his keys.

—adapted from *Introduction to Psychology* by Rod Plotnik, 2005

The example above illustrates the brain's tremendous capacity for storing and retrieving information. Stored information is useless unless it can be retrieved from memory. Once you have forgotten to send a card for your mother's birthday, for example, it is not very consoling to prove that you have the date filed away in your brain. We have all experienced the acute embarrassment of being unable to remember a close friend's name. There are few things in life more frustrating than having a word "on the tip of your tongue" and not being able to remember it.

The problem of memory is to store many thousands of items in such a way that you can find the one you need when you need it. The solution to retrieval is organization. Because human memory is extraordinarily efficient, it must be extremely well organized. Psychologists do not yet know how it is organized, but they are studying the processes of retrieval for clues.

RECOGNITION

Human memory is organized in such a way as to make recognition quite easy—people can say with great accuracy whether or not something is familiar to them. If someone asked you the name of your first-grade teacher, for example, you might not remember it. Chances are, however, that you would recognize the name if you heard it. Similarly, a multiple choice test may bring out knowledge that a student might not be able to show on an essay test. The ability to recognize suggests that much more information is stored in memory than one might think.

The process of **recognition** provides insight into how information is stored in memory. We can recognize the sound of a particular musical instrument (say, a piano) no matter what tune is being played on it. We can also recognize a tune no matter what instrument is playing it. This pattern of recognition indicates that a single item of information may be indexed under several headings so that it can be reached in many ways. A person's features, for instance, may be linked to a large number of categories. The more categories the features are filed in, the more easily they can be retrieved, and the more likely you are to recognize someone.

recognition: memory retrieval in which a person identifies an object, idea, or situation as one he or she has or has not experienced before

PSYCHOLOGY and You — Remembering Classmates

Few of us will ever forget our high school days, but how many of us will remember the names and faces of our high school classmates 10, 20, 30, and even 40 years after graduation? According to one study, apparently more of us will than you might think.

To find out just how long our long-term memory is, researchers showed nearly 400 high school graduates, ranging in age from 17 to 74, pictures from their high school yearbooks. Here are the surprising results:

- Thirty-five years after graduation, people could identify the faces of 9 out of 10 of their classmates. The size of the high school made no difference in their response.
- Fifteen years after graduation, participants could recall 90 percent of their classmates' names.
- Name recall began to fade to between 70 and 80 percent by the time people reached their late 30s.
- Women generally had better memories for names and faces than men.

Researchers explain these amazing results by looking at the way we collect this information in the first place. Our storehouse of names and faces is built over our four-year high school careers, and continual repetition helps cement this knowledge in our memories for decades (Bahrick, Bahrick, & Wittinger, 1974; Kolata, 1993).

RECALL

More remarkable than the ability to recognize information is the ability to recall it. **Recall** is the active reconstruction of information. Just think about the amount of recall involved in a simple conversation. Each person uses hundreds of words involving all kinds of information, even though each word and bit of information must be retrieved separately from the storehouse of memory.

recall: memory retrieval in which a person reconstructs previously learned material

More About...

Eyewitness Testimony

One situation in which recognition is extremely important is in the courtroom. It is very convincing to a judge or jury when an eyewitness points to someone in the room and says, "He's the one who did it."

Elizabeth Loftus (1974) has shown that even after it had been proven that the eyesight of a witness was too poor for her to have seen a robber's face from where she stood at the scene of a robbery, the jury was still swayed by her testimony. Lawyers cite many cases of people falsely accused by eyewitnesses whose testimonies later proved to be inaccurate.

A person's memory of an event can be distorted in the process of remembering it. Shocking events, such as those involving violence, can disrupt our ability to form a strong memory. Without a strong, clear memory of the event, the eyewitness is more likely to incorporate after-the-fact information into the recall. Jurors should remember that the eye is not a camera, and recall is not videotape.

Recall involves more than searching for and finding pieces of information, however. It involves a person's knowledge, attitudes, and expectations. The brain is not like a video recorder that plays back episodes intact. Remembering is an active process guided by experience, knowledge, and cues we receive from the environment. Recall is influenced by **reconstructive processes.** Our memories may be altered or distorted, depending on our experiences, attitudes, and inferences from other information. One type of mistake is called **confabulation,** which is when a person "remembers" information that was never stored in memory. If our reconstruction of an event is incomplete, we fill in the gaps by making up what is missing. Sometimes we may be wrong without realizing it.

Occasionally our memories are reconstructed in terms of our **schemas.** These are conceptual frameworks we use to make sense of the world. They are sets of expectations about something that is based on our past experiences. Elizabeth Loftus and J.C. Palmer (1974) conducted a classic study on the roles that schemas play in memory reconstruction. Participants in this study watched a film of a two-car accident. They were then asked to fill out a questionnaire about the accident. One of the questions had four different versions. Some participants were asked, "About how fast were the two cars going when they *contacted* each other?" In the other versions of the questions, the words *hit, bumped,* or *smashed* were substituted for the word *contacted.* Participants given the question with the word *contacted* recalled a speed of 32 mph. Those given the word *hit* recalled a speed of 34 mph, those given the word *bumped* recalled 38 mph, and those given the word *smashed* recalled speeds of 41 mph. Therefore, the schemas people used—whether the cars contacted, hit, bumped, or smashed—affected the way they reconstructed the crash.

reconstructive processes: the alteration of a recalled memory that may be simplified, enriched, or distorted, depending on an individual's experiences, attitudes, or inferences

confabulation: the act of filling in memory gaps

schemas: conceptual frameworks a person uses to make sense of the world

eidetic memory: the ability to remember with great accuracy visual information on the basis of short-term exposure

About 5 percent of all children do not seem to reconstruct memories actively. They have an **eidetic memory,** a form of photographic memory shared by few adults. Children with eidetic memory can recall very specific details from a picture, a page, or a scene briefly viewed. Photographic memory in adults is extremely rare. It involves the ability to form sharp visual images after examining a picture or page for a short time and then recalling the entire image later.

State-Dependent Learning

Have you ever become upset at someone and while doing so remembered many past instances of when you were upset at the same person? This is an example of state-dependent learning. *State-dependent learning* occurs when you recall information easily when you are in the

same physiological or emotional state or setting as you were when you originally encoded the information. This is why some people advise you to study for a test in the same classroom or setting in which you will take the test. Being in a certain physiological or emotional state serves as a cue to help you more easily recall stored information.

RELEARNING

While recognition and recall are measures of declarative memory, relearning is a measure of both declarative and procedural memory. Suppose you learned a poem as a child but have not rehearsed it in years. If you can relearn the poem with fewer recitations than someone with ability similar to yours, you are benefiting from your childhood learning.

FORGETTING

Everyone experiences a failure of memory from time to time. You are sure you have seen that person before but cannot remember exactly where. You have the word on the tip of your tongue, but. . . . When information that once entered long-term memory is unable to be retrieved, it is said to be forgotten. Forgetting may involve decay, interference, or repression.

Some inputs may fade away, or **decay,** over time. Items quickly decay in sensory storage and short-term memory, as indicated earlier. It is not certain, however, whether long-term memories can ever decay. We know that a blow to the head or electrical stimulation of certain parts of the

decay: fading away of memory over time

Profiles In Psychology

Elizabeth Loftus

1944–

"One of the things that we know about memory for very upsetting experiences, traumatic experiences, is that the memory does not work like a videotape recorder."

The work of Elizabeth Loftus has been in the forefront of a raging debate over memory. Loftus has spent much of her life gathering evidence that memory is extremely fragile and not always accurate. She has shown that eyewitness testimony is often unreliable and that false memories can be triggered merely by suggestion. The manner in which a person builds memories can be altered by information acquired after the original experience.

Her work is controversial because it raises doubts about the validity of repressed memories of repeated trauma, such as that of childhood abuse. Loftus has testified in hundreds of court cases, including the case of George Franklin. Franklin was sent to jail in 1990 for first-degree murder after his daughter Eileen recalled, 20 years later, that her father had killed her friend in 1969. Eileen had recounted the details of the murder to the police in amazing detail. Eileen's memory of the event, though, changed—matching media descriptions of it. Loftus noted that memory changes over time, and as more time passes, our memories become more distorted. Loftus believes that there exists a very real possibility that Eileen unconsciously created the memory as a result of guilt, anger, fear, and desperation connected to the childhood abuse she suffered at the hands of her father.

Figure 10.7 Memory Failure

You may experience memory failure because of decay, interference, or repression. ***What is decay?***

brain can cause loss of memory. The memories lost, however, are the most recent ones; older memories seem to remain. The fact that apparently forgotten information can be recovered through meditation, hypnosis, or brain stimulation suggests that at least some memories never decay. Rather, interference or repression causes people to lose track of them.

Interference refers to a memory being blocked or erased by previous or subsequent memories. This blocking is of two kinds: proactive and retroactive. In *proactive interference* an earlier memory blocks you from remembering later information. In *retroactive interference* a later memory or new information blocks you from remembering information learned earlier. Suppose you move to a new home. You now have to remember a new address and phone number. At first you may have trouble remembering them because the memory of your old address and phone number gets in the way (proactive interference). Later, you know the new information but have trouble remembering the old data (retroactive interference). It is important to note that proactive interference does not lead to retroactive interference; the two are separate concepts.

interference: blockage of a memory by previous or subsequent memories or loss of a retrieval cue

It may be that interference actually does erase some memories permanently. In other cases the old data have not been lost. The information is in your memory somewhere, if only you could find it. According to Sigmund Freud, sometimes blocking is no accident. A person may subconsciously block memories of an embarrassing or frightening experience. This kind of forgetting is called *repression.* The material still exists in the person's memory, but it has been made inaccessible because it is so disturbing.

Did You Know?

Flashbulb Memories Ask your friends where they were on September 11, 2001, when they found out that terrorists had attacked New York's World Trade Center. They will most likely remember in vivid detail. This ability is called "flashbulb memory." This type of memory usually involves events that are shocking or emotional. Scientists have concluded that flashbulb memories involve special kinds of encoding that occur when events are extreme and/or personal.

Amnesia

Some people also forget information due to amnesia. *Amnesia* is a loss of memory that may occur after a blow to the head or as a result of brain damage. Amnesia may also be the result of drug use or severe psychological stress.

Infant amnesia is the relative lack of early declarative memories. For example, why is it that we do not seem to remember much from when we were 2 or 3 years old? Although some children do form lasting memories, most memories from early childhood seem to fade away.

Psychologists have proposed several theories to explain infant amnesia. Freud thought that infant

memories are repressed because of the emotional traumas of infancy. Others believe that because infants do not yet understand language, their memories are nonverbal, whereas later memories are verbal (once language is learned). Still others claim that the hippocampus may not be mature enough in infancy to spark memories or that infants have not yet developed a sense of self to experience memories.

IMPROVING MEMORY

Techniques for improving memory are based on efficient organization of the things you learn and on chunking information into easily handled packages.

Meaningfulness and Association

As we discussed earlier, using repetition, or maintenance rehearsal, can help you remember for a short period of time. In this method, words are merely repeated with no attempt to find meaning. A more efficient way of remembering new information involves **elaborative rehearsal.** In this method, you relate the new information to what you already know. The more meaningful something is, the easier it will be to remember. For example, you would be more likely to remember the six letters DFIRNE if they were arranged to form the word FRIEND.

Similarly, you remember things more vividly if you associate them with things already stored in memory or with a strong emotional experience. The more categories a memory is indexed under, the more accessible it is. If an input is analyzed and indexed under many categories, each association can serve as a trigger for the memory. If you associate the new information with strong sensory experiences and a variety of other memories, any of these stimuli can trigger the memory. The more senses and experiences you use when trying to memorize something, the more likely it is that you will be able to retrieve it—a key to improving memory.

For similar reasons, a good way to protect a memory from interference is to overlearn it—to keep on rehearsing it even after you think you know it well. Another way to prevent interference while learning new material is to avoid studying similar material together. Instead of studying history right after political science, study biology in between. Still another method is to space out your learning. Trying to absorb large amounts of information at one sitting results in a great deal of interference. It is far more effective to study a little at a time—called *distributed practice.*

In addition, how you originally learn or remember something influences how readily you recall that information later. If a bit of information is associated with a highly emotional event or if you learned this bit of

elaborative rehearsal: the linking of new information to material that is already known

Quick Lab

Can you improve your memory?

At one time or another we have all had to memorize items—a list of facts, telephone numbers, or a dialogue in a play. Are there ways to improve these memorization tasks?

Procedure

1. Give several friends and classmates the following list of numbers to memorize: 6, 9, 8, 11, 10, 13, 12, 15, 14, 17, 16, etc.
2. Tell some people to simply memorize the number sequence.
3. Tell others that there is an organizational principle behind the number sequence (which they are to discover) and to memorize the numbers with the aid of this principle. (The principle here is "plus 3, minus 1.")

Analysis

1. Which group was better at remembering the number sequence? Why do you think this is so? Write a brief analysis.

See the Skills Handbook, page 622, for an explanation of designing an experiment.

Psychology and You

On the Tip of Your Tongue

Have you ever tried to remember something but could not quite do so, saying, "I know it; it's on the tip of my tongue"? What you experienced is called the tip-of-the-tongue phenomenon. Later, in a different situation, the information you were looking for earlier comes to you. Why does this happen? In certain cases, maybe you encoded the information in your memory with insufficient retrieval cues and just cannot find an association to retrieve the memory. In other cases, the information may be blocked through interference. When you think about other things, the information pops back into your memory.

information in the absence of interference, you will more easily recall that information because of the strength of that memory.

Mnemonic Devices

Techniques for using associations to memorize information are called **mnemonic devices.** The ancient Greeks memorized speeches by mentally walking around their homes or neighborhoods and associating each line of a speech with a different spot—called the Method of Loci. Once they made the associations, they could recall the speech by mentally retracing their steps and picking up each line. The rhyme we use to recall the number of days in each month ("Thirty days has September") is a mnemonic device. In the phrase "Every Good Boy Does Fine," the first letters of the words are the same as the names of the musical notes on the lines of a staff (E, G, B, D, and F).

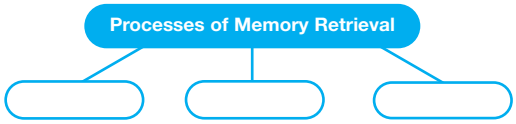
mnemonic devices: techniques for using associations to memorize and retrieve information

Another useful mnemonic device is to form mental pictures. Suppose you have trouble remembering the authors and titles of books or which artists belong to which schools of painting. To plant the fact in your mind that John Updike wrote *Rabbit, Run,* you might picture a RABBIT RUNning UP a DIKE. To remember that Picasso was a Cubist, picture someone attacking a giant CUBE with a PICKAX, which sounds like Picasso (Lorayne & Lucas, 1974). Mnemonic devices are not magical. Indeed, they involve extra work—making up words, stories, and so on. The very effort of trying to do this, however, may help you remember things.

Reading Check What are some common mnemonic devices?

SECTION 2 Assessment

1. **Review the Vocabulary** What is the difference between proactive and retroactive interference? Between maintenance and elaborative rehearsal?
2. **Visualize the Main Idea** In a graphic organizer similar to the one below, explain the three processes of memory retrieval.



3. **Recall Information** What is state-dependent learning? How does it relate to studying and taking exams?
4. **Think Critically** What types of test questions do you prefer: those that require recall, such as essay questions, or those that require recognition, such as multiple choice questions? Why?
5. **Application Activity** Provide an example of a mnemonic device that helped you learn or remember something.

CHAPTER 10

Summary and Vocabulary

Memory is a complex mental process that allows us to recognize friends and family as well as to do things such as drive, speak a language, and play an instrument. Psychologists have sought to understand memory and to find ways to improve it.

Section 1 Taking in and Storing Information

Main Idea: There are three processes involved in memory: encoding, storage, and retrieval.

- During encoding, you use your senses to encode and establish a memory.
- Storage is the process by which information is maintained over a period of time.
- Retrieval occurs when information is brought to mind from storage.
- According to one theory, there are three types of memory—sensory, short-term, and long-term—each with a different purpose and time span.
- Although psychologists agree that some physiological changes occur in the brain when something is stored in long-term memory, they are only beginning to identify how and where memories are stored.

Section 2 Retrieving Information

Main Idea: Stored memory can be retrieved by recognition, recall, and relearning.

- Human memory is organized in such a way as to make recognition quite easy.
- Recall involves a person's knowledge, attitudes, and expectations.
- Recall seems to result from the reconstruction of the features of a memory from which the required information is extracted.
- People's memories are sometimes reconstructed in terms of their schemas.
- State-dependent learning aids recall only if you are in the same physiological or emotional state as you were when you originally encoded the information.
- Forgetting can be the result of decay, interference, or repression.
- Memory can be improved through meaningfulness, association, lack of interference, and degree of original learning.

Chapter Vocabulary

memory (p. 274)
encoding (p. 274)
storage (p. 274)
retrieval (p. 274)
sensory memory (p. 274)
short-term memory (p. 276)
maintenance rehearsal (p. 276)
chunking (p. 277)
semantic memory (p. 279)
episodic memory (p. 279)
declarative memory (p. 279)
procedural memory (p. 279)
recognition (p. 283)
recall (p. 283)
reconstructive processes (p. 284)
confabulation (p. 284)
schemas (p. 284)
eidetic memory (p. 284)
decay (p. 285)
interference (p. 286)
elaborative rehearsal (p. 287)
mnemonic devices (p. 288)

CHAPTER 10 Assessment

PSYCHOLOGY Online

Self-Check Quiz
Visit the *Understanding Psychology* Web site at glencoe.com and click on **Chapter 10—Self-Check Quizzes** to prepare for the Chapter Test.

Reviewing Vocabulary

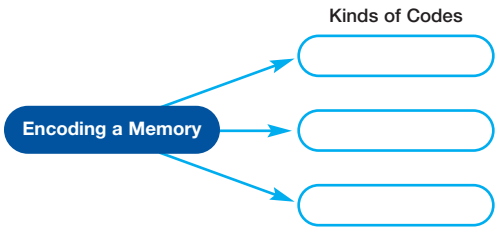
Choose the letter of the correct term or concept below to complete the sentence.

a. memory
b. storage
c. short-term memory
d. episodic memory
e. procedural memory
f. recall
g. confabulation
h. schemas
i. eidetic memory
j. elaborative rehearsal

1. _____ is the second memory process during which information is maintained passively over a sometimes extended period of time.
2. When you relate new information to what you already know you are practicing _____.
3. _____ is a mistake in memory during which a person recalls information that was never stored in memory.
4. The skills you develop when you learn how to swim become part of your _____.
5. The active reconstruction of information is called _____.
6. _____ are conceptual frameworks we use to make sense of the world.
7. _____ is the input, storage, and retrieval of what has been learned or experienced.
8. The things you have in your conscious mind at any one moment are held in your _____.
9. When you remember what you did on your vacation, you are experiencing _____.
10. A small percentage of children have a(n) _____, or photographic memory.

Recalling Facts

1. Using a graphic organizer similar to the one below, identify and describe the codes used to encode a memory.



2. List two strategies for expanding the limits of short-term memory.
3. Describe the primacy-recency effect.
4. What are the two types of interference that block memory?
5. Describe five methods you can use to improve your memory.

Critical Thinking

1. **Evaluating Information** Explain what methods you use to memorize items such as lists or phone numbers. Which method do you find most effective? Why?
2. **Analyzing Information** How would having a photographic memory make your life different?
3. **Synthesizing Information** Try to remember what you did on your last birthday. As you probe your memory, verbalize the mental steps you are going through. What processes do you use to remember?
4. **Making Inferences** As a juror, what concerns might you have when hearing eyewitness testimony? Why?
5. **Applying Concepts** Why is it important for teachers to make learning meaningful to their students?

CHAPTER 10 Assessment

Psychology Projects

1. **Taking in and Storing Information** Research the latest findings about the workings of the brain in terms of memory. Share your findings in a written report. You might include diagrams in your report.
2. **Retrieving Information** Research the use of repressed memories in recent child abuse cases. Report the results of the cases and the effects of repressed memories on the outcomes.
3. **Approaches to Memory** Use this textbook and other sources to research several psychological approaches to memory, such as psychoanalytic, behavioral, humanistic, or cognitive. Summarize your findings in a chart.
4. **Recall** Pick several events that should produce flashbulb memories. Interview 10 people about their memories of the events, and identify similarities and differences in their remembrances.

Technology Activity

Search the Internet for Web sites that provide information to help you improve your memory. Several sites provide tips and techniques to help you remember a variety of facts, such as mathematical formulas. Explore and evaluate these sites, try out several tips for yourself, and then report your findings to the class.

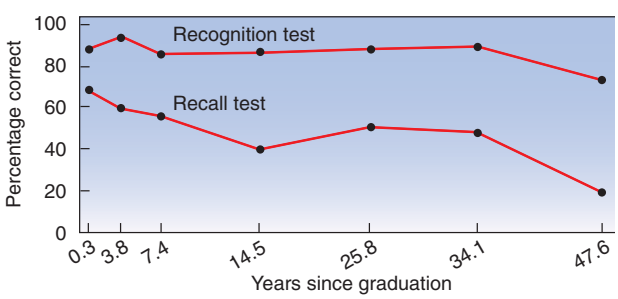
Psychology Journal

Reread the journal entry you wrote about your earliest memory. Write an analysis explaining why you think this is your first memory and why it continues to stay in your mind. Explain whether any confabulation might be involved in this memory. Were other people involved? Is their recall of the memory consistent with the way you remember it? Explain.

Building Skills

Interpreting a Graph The graph below shows the results of an experiment in which the ability to remember names and faces of classmates by high school graduates was tested. In a recognition test, participants were asked to match yearbook pictures of classmates with their names. In a recall test, participants were shown yearbook pictures and asked to simply recall the names. Review the graph below, then answer the questions that follow.

Recognition and Recall Tests



Source: Bahrick, Bahrick, & Wittinger, 1974.

Practice and **assess** key social studies skills with **Glencoe Skillbuilder Interactive Workbook CD-ROM, Level 2.**

1. Which group of participants was most able to recall the names of their classmates?
2. What percentage of participants recalled the names of their classmates 34 years after graduation? 47 years after graduation?
3. How did retrieving information using recall change over a period of 50 years?
4. What effect does time have on retrieving information when recall is used? When recognition is used?
5. When you remember past events and people, how accurate do you think your memory is? Explain.

See the Skills Handbook, page 628, for an explanation of interpreting graphs.

Readings In Psychology

In 1953, doctors performed brain surgery on a man named Henry, also known as H.M. The doctors hoped to alleviate Henry's severe epileptic seizures by removing his hippocampus, where they believed the seizures originated. Although the surgery relieved Henry's seizures, he suffered severe memory problems. For years after the operation he cited the year as 1953 and could not encode new long-term memories, even though his existing long-term memories remained intact. Philip F. Hilts chronicled Henry's story in *Memory's Ghost*, published in 1995.

Reader's Dictionary

M.I.T.: Massachusetts Institute of Technology

hippocampus: a curved structure within the temporal lobe of the brain involved in transforming many kinds of short-term memories into permanent storage

MEMORY'S GHOST

BY PHILIP F. HILTS

We were out in the sun once, Henry in his wheelchair and I beside him, waiting for the taxi to take us for his brain scan. It was the usual changeable, disturbing weather of a Boston spring, but just now, it was bright and warm. "Great day!" I said. "And sunny!" As I said it, a shadow crossed the walk, and the sun dived into a cloud. Henry laughed. "Well, just as soon as you say it, it isn't!"

Across the street was a construction site. We watched at length; the crane—it must have been ten stories tall—swung out over the deep hole and back up to its bank, a huge bucket of gray muck gliding down. "I bet they are glad they don't have to haul that all the way up," said Henry. I glanced up the street for the taxi, and quickly Henry's gaze followed. He wasn't sure why we were looking there, and he studied me. My head was turning back to the construction, and Henry's gaze settled there again, too. He watches and listens for clues, for the implications of a question, for hints at what the subject is, how he should feel, and how he should answer. How else could he be more than like a dog, waiting expectantly at the door? I imagine him walking, always a little uncertain, but compelled to press ahead while around him is a blank fog. "And I moved forward," said poet W.S. Merwin, "because you must live forward, which is away from whatever it was that you had, though you think when you have it that it will stay with you forever."

I recall one of my visits to Henry. As he talked with Dr. Corkin, who had come to get him for tests, I observed in silence. When she approached, he looked up, blank at first. I could almost put words to passing expressions on his face: Ah, a face that seems familiar. To talk to me? Yes—she takes up my eyes.

"How are you, Henry?"

He groped a little, feeling just behind him for something. "Fine, I guess," he said, and smiled a little. Again he watched, expectantly.

"Do you know what we're going to do today?"

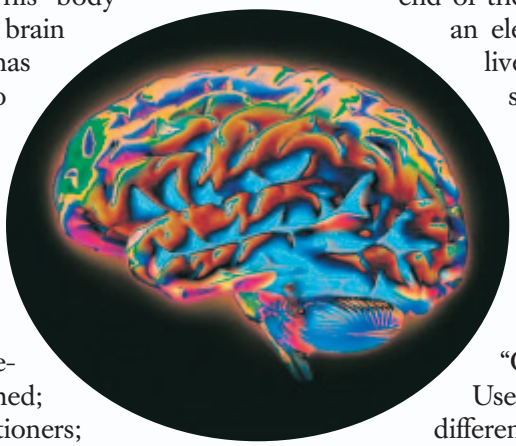
I felt him turn metaphorically to search for an answer. Then he shrugged. "I don't remember."

But then she handed him his walker. He can grasp it, flip out the legs, set it just ahead of himself, and lean up into it.

"Why do you use a walker, Henry, do you know?"

A brief look into the fog. Nothing there. He looked down. "Well, it's my legs," he said. He quickly realized the humor in this too-obvious reply, and grinned.

Down the hall, he turned left, heading for the experiment room. How did his body know to go that way? Part of his brain has learned, though the other has not. The one that is supposed to keep track of what has been learned is missing.



At the plain gray table in the experiment room, Dr. Corkin asked, "Do you know where you are, Henry?"

Again, he looked out into a fog. But here! There is something! "Well, at M.I.T.!" He beamed; he gathered a scrap for his questioners; he always likes to please. It has taken decades of travel to M.I.T. and frequent talk of the place for him to know that if he's being tested, this must be M.I.T.

Finally, as we stood out in the sun, the taxi arrived to take us across the Charles River. We bundled the awkward wheelchair in the trunk, him in the back seat, and we took the taxi over to Brigham and Women's Hospital where the magnetic resonance scanner awaited him. It is more than a device, it is the size of a room, and it is not pressed against the patient like an X-ray scope, but surrounds the patient as he is inserted *within* the machine.

Henry was a bit dubious about this, especially as he had to remove all metal objects from his person. That meant his belt, and he was shy removing it in front of the women researchers in the room. He was more chagrined after he removed it and everyone could see that there was a paper clip holding his trousers together.

I sat in the room with him, while everyone else retreated to another room, behind a large observation window. They spoke to Henry by microphone, trying to reassure him by tone of voice while they were in fact being distant and cold. And that noise! It was like being in a closet with a jackhammer operating in slow motion.

From all this crudeness issued, on the other end of the computing systems and wires, an elegant, flickering color image. A live image of his brain, slice by slice, as the imager moved backward through his brain taking images one plane at a time. When the imager reached Henry's temporal lobes and the place where his middle brain should be, the researcher at the panel let out a low gasp. "Oh! That's beautiful!" he said. Used to peering at subtle shading differences denoting massive tumors, he was now confronted with a huge black hole in the center of the brain, the first thing of its kind he had ever seen.

The series of images lead to measurements, recalculations, new guesses. There is, Dr. Corkin has discovered, a little more of the hippocampus present than was thought. But the other bits of middle brain linked to it, the parahippocampal gyrus, the entorhinal cortex, and the perirhinal cortex are all destroyed: they must be an important part of the "hippocampal" system of memory consolidation.

The pictures from within the dome of Henry's skull are a bit startling. Of course, we could have guessed what they might look like. But it is not the same to guess as to see the lovely textured images of the brain and then the black, ragged edges where tissue has been sucked out.

Analyzing the Reading

1. What types of things does Henry seem unable to recall?
2. Why does the researcher seem excited by Henry's brain scan?
3. **Critical Thinking** Why does the author compare Henry to a dog?