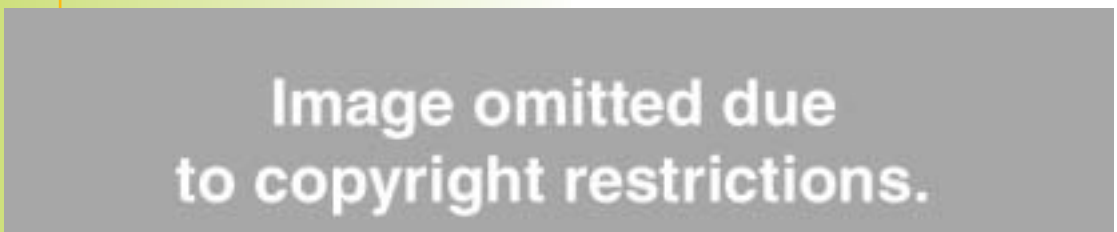
6 Memory



"No, no, not me. Not me!" cried Hen Van Nguyen in halting English. This unfortunate Vietnamese immigrant, on trial for murder, protested his innocence for two full days at the trial before it was discovered that he was not the real defendant. Before the trial, Nguyen had been charged with theft and was being held in a Georgia county jail. In the same jail was another Vietnamese man, who had been accused of stabbing to death the woman he lived with.

The jailer had mistakenly delivered the wrong man to the courtroom. Yet unbelievably, during the trial, two eyewitnesses identified Nguyen and swore that he had committed the murder. Even more astonishing, the defence attorney, who had met several times with his client to prepare his defence, sat with the wrong man in the courtroom and defended him for two days. The county sheriff remarked, "How the defence attorney did not know his client, I don't know" ("Wrong man," 1985).

In this case, the defence attorney, the sheriff, and the eyewitnesses were all members of a racial group different from Mr. Nguyen's.

In another case, however, even though the eyewitness was of the same race as the suspect, she picked the wrong man. Can someone be in two

Donald Thomson, psychologist

places at once? No! And this saved psychologist Donald Thomson.

One night, Thomson was a guest on an Australian talk show about eyewitness testimony. He was with other experts, including the chief of police. He argued that a good eyewitness must notice specific features of the face. He pointed to his important features (eyes, smile, and so on). A woman who was watching him on the show was, at that time, assaulted and raped. Later, when she regained consciousness, she identified Thomson as her assailant. Fortunately for Thomson, it was a live taping and he had witnesses to support his alibi.

This case is ironic in that Thomson studies the very phenomenon that led to his arrest.

Do these cases simply reflect the rare and unusual in human memory, or are memory errors common occurrences? This and many other questions you may have about memory will be answered in this chapter. We will describe three memory systems: sensory, short-term, and long-term. You will learn how much information each system holds, for how long, and in what form. You will discover why virtually everyone finds it harder to remember names than faces. Is memory like a video recorder, in which the sights and sounds we experience are captured intact and simply played back in exact detail? Or do we "reconstruct" the past when we remember, leaving out certain bits and pieces of events that actually happened and adding others that did not?

Would you like to improve your memory? You will learn some techniques that can help you study more effectively, and some mnemonic devices (memory strategies) that can be used in practical ways every day as memory aids. Now read on … and remember.

Remembering

Our memory is the storehouse for everything we know. It enables us to know who and where we are when we awaken each morning. Memory provides the continuity of life—the long thread to which are tied our joys and sorrows, our knowledge and skills, our triumphs and failures, and the people and places that form our lives.

Most current efforts to understand human memory have been conducted within a framework known as the *information-processing approach* (Klatzky, 1984). This approach makes use of modern computer science and related fields to provide models that help us understand the processes involved in memory.

The Three Processes in Memory: Encoding, Storage, and Retrieval

What three processes are involved in the act of remembering?

What must occur to enable us to remember a friend's name, a fact from history, or an incident from our past? The act of remembering requires the successful completion of three processes: encoding, storage, and retrieval. The first process, **encoding**, involves transforming information into a form that can be stored in memory. Sometimes we encode information automatically, without any effort; but often we must do something with the information to remember it. For example, if you met someone named Brian at a party, you might associate his name with

Bryan Adams or Brian Mulroney. Such simple associations can markedly improve your ability to recall names and other information. Carefully encoding information greatly increases the chances that you will remember it.

This sounds easier than it actually is. To ensure that we encode information appropriately we must focus our *attention*. At any given time, we are bombarded with all kinds of sensory information. Imagine yourself in your classroom, and recall how hard it is to focus on your instructor's voice when you can also hear overhead fans and papers rustling; or you are distracted by how hot you feel, how uncomfortable your chair is, or how hungry or thirsty you are. All of these events compete for our attention. Because we cannot absorb every piece of information in our environment, we have to *selectively attend* to some information and let the other information fade into the background. **Selective attention** is the tool that allows us to eliminate interference from the relevant information.

The second memory process, **storage**, involves keeping or maintaining information in memory. For encoded information to be stored, some physiological change in the brain must take place—a process called **consolidation**. Consolidation occurs automatically in normal circumstances. If a person loses consciousness for any reason, the process can be disrupted and a permanent memory will not form (Deutsch & Deutsch, 1966). That is why someone who has been in a serious car accident may awaken in a hospital and not remember what has happened.

The final process, **retrieval**, occurs when information stored in memory is brought to mind. Calling Brian by name the next time you meet him shows that you have retrieved his name from memory. To remember, we must perform all three of these processes—encode the information, store it, and then retrieve it. Memory failure can result from the failure of any one of the three processes (see Figure 6.1).

Similar steps are required in the information processing of computers. Information is encoded (entered in some form the computer is able to use), then stored on the hard drive or floppy disks, and later retrieved on the screen or through the printer. You would not be able to retrieve the material if you had failed to enter it, if a power failure occurred before you could save what you had entered, or if you forgot which disk or file contained the needed information. Of course, human memory is far more complex than even the most advanced computer systems, but computer processing provides a useful analogy to memory, provided we don't take it too literally.

The Three Memory Systems: The Long and the Short of It

How are memories stored? According to one widely accepted view, the Atkinson–Shiffrin model, there are three different, interacting memory systems: sensory, short-term, and long-term (Atkinson & Shiffrin, 1968; Broadbent, 1958; Shiffrin & Atkinson, 1969). Considerable research in the biology of memory lends support to the model (Squire et al., 1993). We will

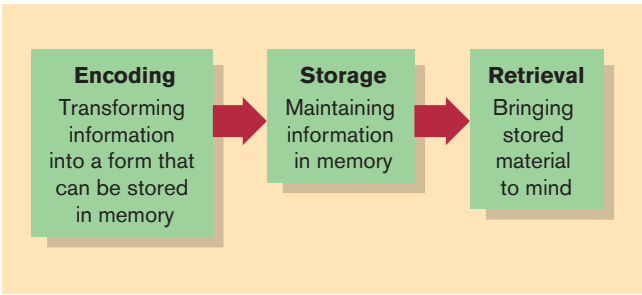


FIGURE 6.1

The Processes Required in Remembering **The act of remembering requires the successful completion of three processes: encoding, storage, and retrieval. Memory failure can result from the failure of any one of the three processes.**

encoding: Transforming information into a form that can be stored in short-term or long-term memory.

selective attention: Focusing on one piece of information while placing other information in the background.

storage: The act of maintaining information in memory.

consolidation: The presumed process, believed to involve the hippocampus, by which a permanent memory is formed.

retrieval: The act of bringing to mind material that has been stored in memory.

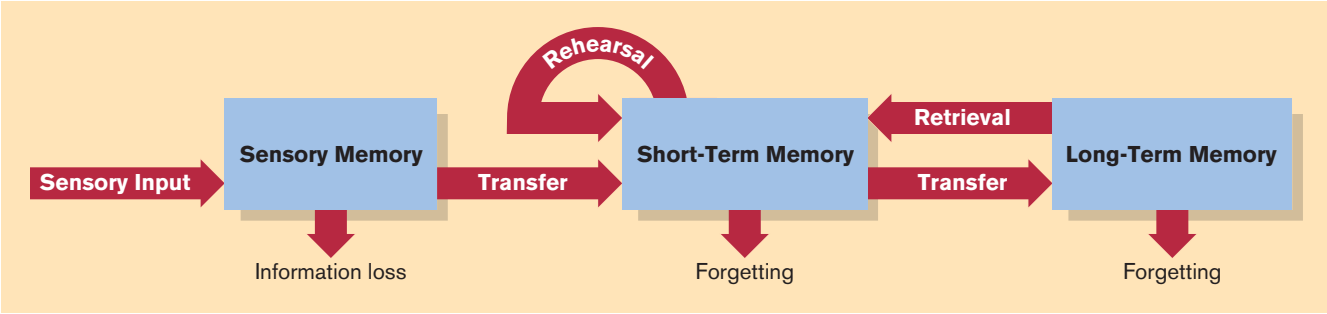


FIGURE 6.2

The Three Memory Systems **According to the Atkinson–Schiffrin model, there are three separate memory systems: sensory memory, short-term memory, and long-term memory.**

examine each of these three memory systems, which are shown in Figure 6.2.

Sensory Memory: Images and Echoes

What is sensory memory?

As information comes in through the senses, virtually everything we see, hear, feel, or otherwise sense is held in **sensory memory**, but only for the briefest period of time. Sensory memory normally holds visual images for a fraction of a second and holds sounds for about two seconds (Crowder, 1992).

Visual sensory memory lasts just long enough to keep whatever you are viewing from disappearing when you blink your eyes. You can demonstrate visual sensory memory for yourself by doing the *Try It!*

For a fraction of a second, glance at the three rows of letters and numbers shown below and then close your eyes. How many of the items can you recall?

X B D F
M P Z G
L C N H

Most people can correctly recall only four or five of the items when they are briefly presented. Does this indicate that visual sensory memory can hold only four or five items at a time? No. Researcher George Sperling (1960) knew that our visual sensory capacity should enable us to take in most or all of the 12 items at a single glance. Could it be that sensory memory is so short-lived that while we are reporting some items, others have already faded from sensory memory? Sperling thought of an ingenious method to test this notion. He briefly flashed 12 items like those above to his participants. Immediately upon turning the display off, he sounded a high, medium, or low tone that signalled the participants to report

Try It!

Testing Sensory Memory

To prove the existence of the visual sensory memory, move your forefinger back and forth rapidly in front of your face. You will see what appears to be the blurred images of many fingers. This occurs because your sensory memory briefly holds a trace of the various positions that your finger occupies as it moves.

Sensory memory holds a visual image, such as a lightning bolt, for a fraction of a second–just long enough for us to perceive a flow of movement.

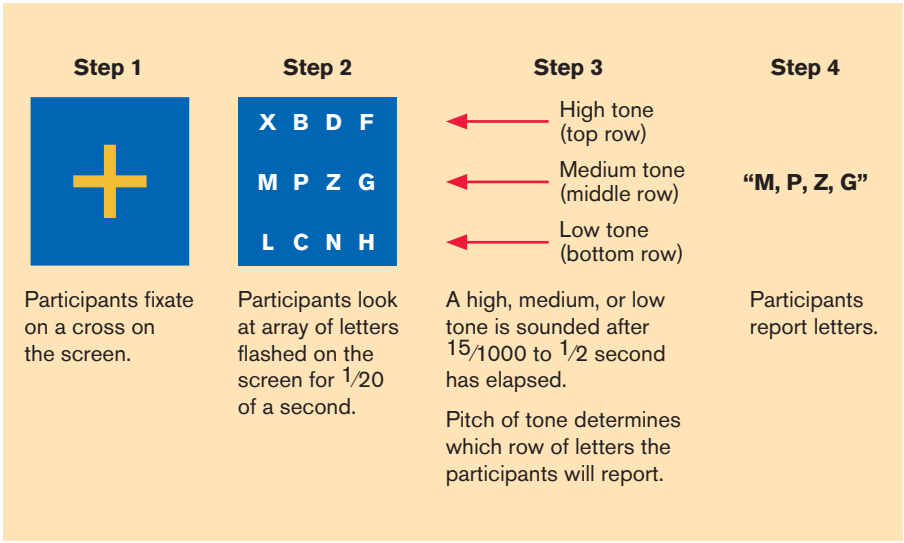


FIGURE 6.3
Sperling's Study of the Capacity of Sensory Memory **Sperling demonstrated that sensory memory holds more information than participants are able to report completely because the visual afterimage fades so quickly. Sperling proved that people could retain 12 items in sensory memory, but only long enough to report 4 items in the designated row. (Based on Sperling, 1960.)**

only the top, middle, or bottom row of items. Before they heard the tone, the participants had no way of knowing which row they would have to report. Sperling found that when the participants could view the letters for 0.0015 to 0.5 seconds, they could report correctly all the items in any row nearly 100 percent of the time. But the items fade from sensory memory so quickly that during the time it takes to report three or four of the items, the other eight or nine have already disappeared. Figure 6.3 shows the steps that were involved in Sperling's research study.

Sensory memory for sound is similar to that for vision. You have experienced auditory sensory memory when the last few words someone has spoken seem to echo briefly in your mind. Auditory sensory memory usually lasts about two seconds, compared with the fractions of a second for visual sensory memory (Klatzky, 1980).

We have seen that an abundance of information in raw, natural form can be stored briefly in sensory memory. This brief period is just long enough for us to begin to process the sensory stimuli and to select the most important information for further processing in the second memory system—short-term memory.

Short-Term Memory: Short Life, Small Capacity

What are the characteristics of short-term memory?

Whatever you are thinking about right now is in your **short-term memory** (STM). We use short-term memory when we carry on a conversation, solve a problem, or look up a telephone number and remember it just long enough to dial it.

Short-term memory does not hold sensory stimulus the way sensory memory does. Short-term memory usually codes information according to sound—that is, in acoustic form (Conrad, 1964). The letter *T* is coded as the sound "tee," not as the shape T. Short-term memory can also hold visual images, and store information in semantic form (i.e., according to meaning) (Shulman, 1972).

LINK IT!

www.ucs.mun.ca/~mathed/Stats/memory14.htm
Investigating short-term memory

www.alzheimer.ca
Alzheimer Society of Canada

THE CAPACITY OF SHORT-TERM MEMORY Unlike sensory memory, which can hold a vast amount of information briefly, short-term memory has a very limited

sensory memory: The memory system that holds information coming in through the senses for a period ranging from a fraction of a second to several seconds.

short-term memory: The second stage of memory, which holds about seven (a range of five to nine) items for less than 30 seconds without rehearsal; working memory; the mental workspace we use to keep in mind tasks we are thinking about at any given moment.

capacity—about seven (plus or minus two) different items or bits of information at one time (Miller, 1956). Test the capacity of your short-term memory in the *Try It!*

Try It!

Testing Short-Term Memory

Read aloud the digits in the first row (row "a" below) at a steady rate of about two per second. Then, from memory, write them down on a sheet of paper.

Repeat the process, row by row.

a. 3 8 7 1

b. 9 6 4 7 3

c. 1 8 3 0 5 2

d. 8 0 6 5 9 1 7

e. 5 2 9 7 3 1 2 5

f. 2 7 4 0 1 9 6 8 3

g. 3 9 1 6 5 8 4 5 1 7

How well did you do in *Try It*? You just learned that most people recall about seven items. This is just enough for phone numbers and postal codes. When short-term memory is filled to capacity, **displacement** can occur (Waugh & Norman, 1965). In displacement, each incoming item pushes out an existing item, which is then forgotten.

One way to overcome the limitation of seven or so bits of information is to use a technique that George A. Miller (1956) calls "chunking." Chunking means organizing or grouping separate bits of information into larger units, or chunks. A chunk is an easily identifiable unit such as a syllable, a word, an acronym, or a number (Cowan, 1988). For example, the numbers 5 2 9 7 3 1 2 5 could be chunked 52 97 31 25, leaving the short-term memory with the easier task of dealing with four chunks of information instead of eight separate bits. Complete the next *Try It*! and see if chunking works for you.

Try It!

Chunking

Read the following letters individually at the rate of about one per second and then see if you can repeat them.

N - H - L - C - B - C - P - E- I - V - C - R - R - C - M - P

Did you have difficulty? Probably, because there are 16 different letters. But now try this:

NHL CBC PEI VCR RCMP

Did you find that five chunks are easier to remember than 16 separate items?

Chunking is a very useful technique for increasing the capacity of short-term memory, but there are limits. Simon (1974) suggests that the larger the chunks, the fewer chunks we can remember.

THE DURATION OF SHORT-TERM MEMORY Items in short-term memory are lost very quickly, in less than 30 seconds, unless we repeat them over and over to ourselves, silently or out loud, to retain them. This process is known as **rehearsal**. We rehearse telephone numbers that we have looked up to keep them in short-term memory long enough to dial the number. But short-term memory is easily disrupted. It is so fragile, in fact, that an interruption or a distraction can cause information to be lost in just a few seconds.

Researchers have tried to determine how long short-term memory lasts if rehearsal is prevented. In a series of early studies, participants were briefly shown three consonants, such as H, G, and L, and were then asked to count backward by threes from a given number (738, 735, 732, and so on). After intervals lasting from 3 to 18 seconds, participants were instructed to stop their backward counting and recall the three letters (Brown, 1958; Peterson & Peterson, 1959). Following a delay of nine seconds, the participants could recall an average of only one of the three letters. After 18 seconds, there was practically no recall whatsoever. An 18-second distraction had completely erased the three letters from short-term memory.

SHORT-TERM MEMORY AS WORKING MEMORY Short-term memory is more than just a system that holds information received from sensory memory until we are able to store it in long-term memory. Allan Baddeley (1990, 1992, 1995) suggests that *working memory* is a more fitting term than *short-term memory*. More than just a temporary way station between sensory memory and long-term memory, working memory is a kind of mental workspace that temporarily holds incoming information from sensory memory or information retrieved from long-term memory in order to perform some conscious cognitive activity. "Without it you couldn't understand this sentence, add up a restaurant tab in your head, or find your way home. Working memory is an erasable mental blackboard that allows you to hold briefly in your mind and manipulate the information, whether it be words, menu prices, or a map of your surroundings" (Wickelgren, 1997, p. 1580).

Research shows that the prefrontal cortex is the primary area responsible for working memory (Courtney et al., 1997; Rao et al., 1997).

Long-Term Memory: As Long as a Lifetime

What is long-term memory, and what are its subsystems?

Some information from short-term memory makes its way into long-term memory. **Long-term memory** (LTM) is our vast storehouse of permanent or relatively permanent memories. There are no known limits to the storage capacity of long-term memory. Long-term memories last a long time, some of them for a lifetime.

When we talk about memory in everyday conversation, we are usually referring to long-term memory. Long-term memory holds all the knowledge we have accumulated, the skills we have acquired, and the memories of our past experiences. Although visual images, sounds, and odours can be stored in long-term memory, information in long-term memory is usually stored in semantic form.

But how does this vast store of information make its way from short-term memory into long-term memory? We seem to remember some information with ease, almost automatically, but other kinds of material require great effort. Sometimes, through mere repetition or rehearsal, we are able to transfer information into long-term memory. Your teachers may have used a drill to try to cement the multiplication tables in your long-term memory. This rote rehearsal, however, is not necessarily the best way to transfer information to long-term memory (Craik & Watkins, 1973). When you relate new information to the information already safely tucked away in long-term memory, you increase the chances that you will be able to retrieve the new information (Symons & Johnson, 1997; Willoughby et al., 2000). These skills would surely be useful in games such as that described in the *It Happened in Canada* box. Figure 6.4 summarizes the three memory systems.

IT HAPPENED IN CANADA

Trivial Pursuit

Where was the game Trivial Pursuit invented? If you guessed Canada, you were right. And if you were playing Trivial Pursuit, you might have earned a piece of the pie! If you like to play, try these questions:

1. Into how many languages has Trivial Pursuit been translated?
2. In how many countries can you buy the game?

As you can see, the game involves recalling facts from memory. Have you ever noticed that some categories are easier for you to answer than others? This has to do with the way that you store information and how valuable the information is to you when you learn it. Now try to answer the following question: What type of memory are you using when you play Trivial Pursuit?

The answers are 19 and 33.

displacement: The event that occurs when short-term memory is holding its maximum and each new item entering short-term memory pushes out an existing item.

rehearsal: The act of purposely repeating information to maintain it in short-term memory or to transfer it to long-term memory.

long-term memory: The relatively permanent memory system with a virtually unlimited capacity.

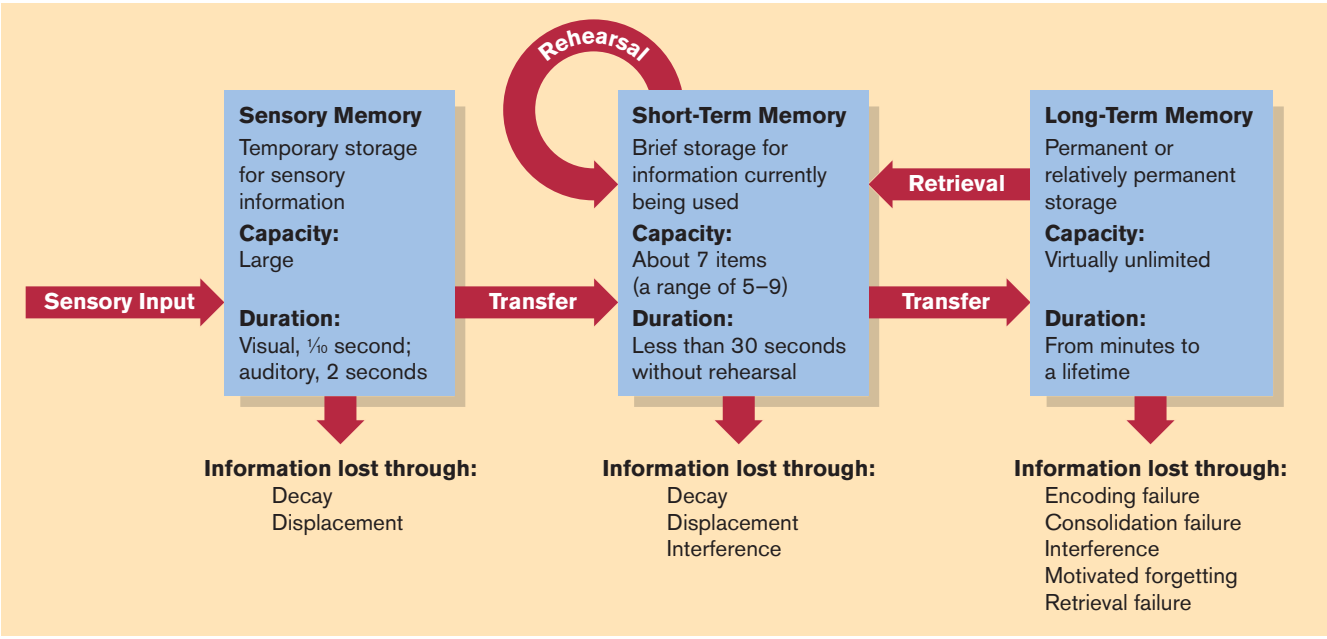


FIGURE 6.4
Characteristics of and Processes Involved in the Three Memory Systems

Declarative Memory and Non-Declarative Memory

A number of experts believe that there are two main subsystems within long-term memory—declarative memory and non-declarative memory.

Declarative memory (also called "explicit memory") stores facts and information. There are two types of declarative memory—episodic memory and semantic memory.

EPISODIC MEMORY **Episodic memory** is the subpart of declarative memory that contains the memory of events we have experienced personally (Wheeler et al., 1997). Endel Tulving (1985) at the University of Toronto describes it as something like a mental diary that records the episodes of our lives—the people we have known, the places we have seen, and the personal experiences we have had. According to Tulving,

> The episodic system stores and makes possible subsequent recovery of information about personal experiences from the past. It enables people to travel back in time, as it were, into their personal past, and to become consciously aware of having witnessed or participated in events and happenings at earlier times. (1989, p. 362)

SEMANTIC MEMORY **Semantic memory**, the second subpart of declarative memory, is our memory for general knowledge and is made up of objective facts and information. In other words, semantic memory is our mental dictionary or encyclopedia of stored knowledge such as the following:

> The three memory systems are sensory, short-term, and long-term memory.
>
> Dictionary is spelled d-i-c-t-i-o-n-a-r-y.
>
> 10 times 10 equals 100.

When you play Trivial Pursuit, you are calling on semantic memory almost exclusively to answer the questions. As a rule, the semantic facts you have stored are not personally referenced to time and place, as episodic memories are. You probably do not remember exactly where and when you learned to spell *dictionary* or to multiply 10 times 10.

Non-declarative memory (also called "implicit memory") consists of motor skills, habits, and simple classically conditioned responses (Squire et al., 1993). Motor skills are acquired through repetitive practice and include such things as eating with a fork, riding a bicycle, and driving a car. Although acquired

Declarative memory stores facts, information, and personal life events, such as a trip to a foreign country.
Non-declarative memory encompasses motor skills, such as dance movements, which–once learned–can be carried out with little or no conscious effort.

slowly, once learned, these skills become habit, are quite reliable, and can be remembered and carried out with little or no conscious effort. For example, you probably use the keyboard on a computer without consciously being able to name the keys in each row from left to right.

Figure 6.5 shows the subsystems of long-term memory.

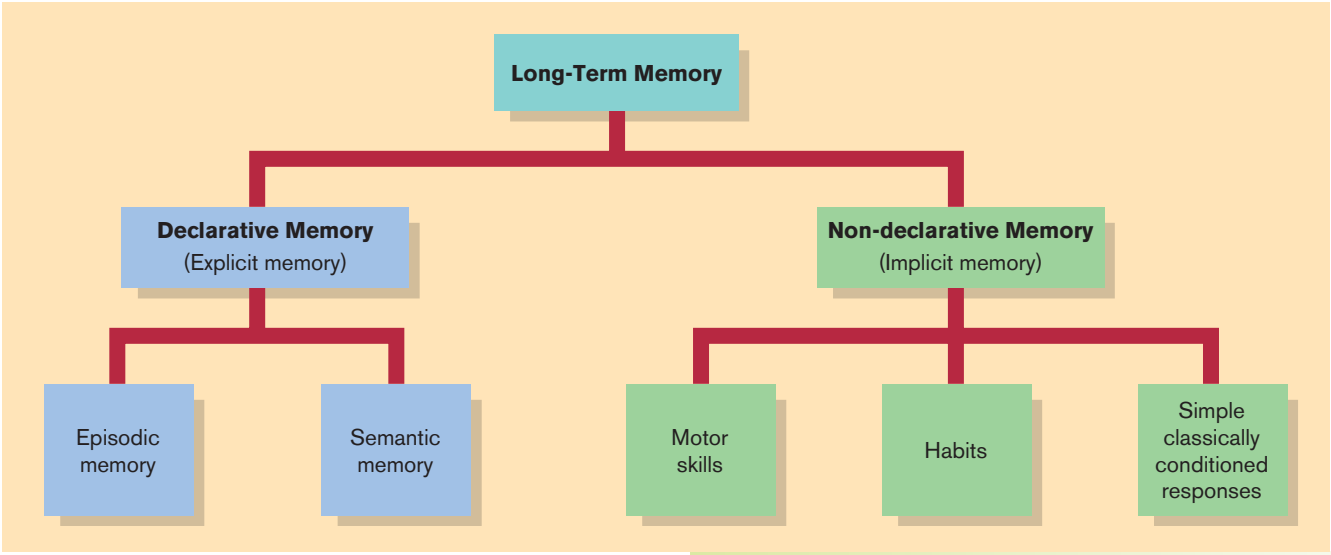


FIGURE 6.5

Subsystems of Long-Term Memory **Non-declarative memory consists of motor skills acquired through repetitive practice, habits, and simple classically conditioned responses. Declarative memory can be divided into two subparts–episodic memory, which stores memories of personally experienced events, and semantic memory, which stores facts and information.**

declarative memory: The subsystem within long-term memory that stores facts, information, and personal life experiences; also called explicit memory.

episodic memory (ep-ih-SOD-ik): The subpart of declarative memory that contains memories of personally experienced events.

semantic memory: The subpart of declarative memory that stores general knowledge; our mental encyclopedia or dictionary.

non-declarative memory: The subsystem within long-term memory that consists of skills acquired through repetitive practice, habits, and simple classically conditioned responses; also called implicit memory.

The Levels-of-Processing Model: Another View of Memory

Not all psychologists support the notion of three memory systems. University of Toronto researchers Craik and Lockhart (1972) proposed instead a **levels-of-processing model** (see also Lockhart & Craik, 1990). They suggest that whether we remember an item for a few seconds or a lifetime depends on how deeply we process the information. With the shallowest levels of processing, we are merely aware of the incoming sensory information. Deeper processing takes place only when we do something more with the information—when we form a relationship, make an association, or attach meaning to a sensory impression.

Craik and Tulving (1975) tested the levels-of-processing model. They had students answer *yes* or *no* to questions asked about words just before the words were flashed to them for 0.2 seconds. The students had to process the words *visually* (was the word in capital letters?), *acoustically* (does the word rhyme with another particular word?), and *semantically* (does the word make sense when used in a particular sentence?). Read the material in the next *Try It!*

The test required shallow processing for the first question, deeper processing for the second question, and the deepest processing for the third question. Later the students were unexpectedly given a retention test to see whether deeper levels of processing would facilitate memory. The deeper the level of processing, the higher the accuracy rate of memory. However, this conclusion would be equally valid for the three-system model. Now, test their conclusions yourself. Without looking back, name the three words you read in *Try It!* Were any easier to remember?

Brain-imaging studies with fMRI have revealed that semantic (deeper) encoding causes greater activity in the prefrontal cortex (Gabrieli et al., 1996).

Remember It!

Basic Memory Processes

1. Transforming information into a form that can be stored in memory is called _____; bringing the material that has been stored to mind is called _____.

   a. encoding; decoding
   b. consolidation; retrieval
   c. consolidation; decoding
   d. encoding; retrieval

2. Match the memory system with the best description of its capacity and the duration of time it holds information.

   ____ 1) sensory memory
   ____ 2) short-term memory
   ____ 3) long-term memory

   a. virtually unlimited capacity; long duration
   b. large capacity; short duration
   c. very limited capacity; short duration

3. Match the example with the appropriate memory system.

   ____ 1) semantic memory
   ____ 2) episodic memory
   ____ 3) non-declarative memory
   ____ 4) working memory

   a. playing tennis
   b. remembering your high school graduation
   c. deciding what you will do tomorrow
   d. naming the premiers of the provinces.

4. Which subsystem of long-term memory does not require conscious awareness?

   a. episodic memory
   b. semantic memory
   c. non-declarative memory
   d. declarative memory

Answers: 1. d 2. 1) b 2) c 3) a 3. 1) d 2) b 3) a 4) d 4. c

Try It!

Testing the Levels-of-Processing Model

Answer *yes* or *no* to each of the following questions:

1. Is the word *LARK* in capital letters?
2. Does the word *speech* rhyme with *sleet*?
3. Would the word *park* make sense in this sentence?

   The woman passed a _____ on her way to work.

Now continue reading.

Measuring Memory

Three Methods of Measuring Memory

What are three methods of measuring retention?

Psychologists have used three main methods of measuring memory: recall, recognition, and the relearning method.

Recall

Recall tasks are usually the most difficult. In **recall** we must produce the required information by searching our memory without the help of **retrieval cues**. Remembering someone's name, recalling items on a shopping list, memorizing a speech or a poem word for word, and remembering appointments are all recall tasks. Essays and fill-in-the-blank questions require recall. Try to answer the following question:

> The three processes involved in memory are _____, _____, and _____.

In recalling, we must remember information "cold." Recall tasks are a little easier if cues are provided to jog our memory. Such cues might consist of the first letters of the required words for fill-in-the-blank questions. If you did not recall the three terms in the first question, try again with cued recall:

> The three processes involved in memory are e_____, s_____, and r_____.

Sometimes serial recall is required—that is, information must be recalled in a specific order. This is the way you learned the alphabet, memorized poems, and learned any tasks that had to be carried out in a certain sequence.

Recognition

Recognition is exactly what the name implies: we simply recognize something as familiar—a face, a name, a taste, a melody. Some multiple-choice, matching, and true/false questions are examples of recognition test items. Consider a version of the question that was posed before:

> Which of the following is *not* one of the processes involved in memory?
>
> a. encoding b. assimilation
> c. storage d. retrieval

Was this recognition question easier than the recall version? The main difference between recall and recognition is that a recognition task does not require you to supply the information but only to recognize it when you see it. The correct answer is included along with the other items in a recognition question.

The Relearning Method

There is yet another way to measure memory that is even more sensitive than recognition. With the **relearning method** (the savings method), retention is expressed as the percentage of time saved when material is relearned compared with the time required

levels-of-processing model: A single-memory-system model in which retention depends on how deeply information is processed.

recall: A measure of retention that requires one to remember material with few or no retrieval cues, as in an essay test.

retrieval cue: Any stimulus or bit of information that aids in the retrieval of particular information from long-term memory.

recognition: A measure of retention that requires one to identify material as familiar, or as having been encountered before.

relearning method: Measuring retention in terms of the percentage of time or learning trials saved in relearning material compared with the time required to learn it originally; also called the *savings method*.

to learn the material originally. Suppose it took you 40 minutes to memorize a list of words, and one month later you were tested, using recall or recognition, to see how many of the words you remembered. If you could not recall or recognize a single word, would this mean that you had absolutely no memory of anything on the test? Or could it mean that the recall and the recognition methods of testing were not sensitive enough to pick up what little information you may have stored? How could we measure what is left of this former learning? Using the relearning method, we could time how long it would take you to relearn the list of words. If it took 20 minutes to relearn the list, this would represent a 50 percent savings over the original learning time of 40 minutes. The percentage of time saved—the **savings score**—reflects how much material remains in long-term memory.

Often parents wonder if the time they spend reading to their young children or exposing them to good music has any lasting influence. Do some traces of such early exposure remain? Many years ago, H.E. Burtt (1932) carried out a unique relearning experiment on his son Benjamin to study this question.

Every day Burtt read to his son three passages from Sophocles's *Oedipus Tyrannus* in the original Greek. He would repeat the same three passages for three months and then read three new passages for the next three months. This procedure continued from the time Benjamin was 15 months until he was three years old. Nothing more was done for five years until the boy reached the age of eight. Then Burtt tested Benjamin by having him memorize some of the passages read to him originally and some similar passages that he had never heard before. It took Benjamin 27 percent fewer trials to memorize the original passages. This 27 percent savings score suggests that a considerable amount of information remained in his memory for an extended period of time—information that could not have been detected through recall or recognition tests. The study also suggests that even information we do not understand can be stored in memory. Between 15 months and three years of age, young Benjamin did not speak or understand Greek, yet much of the information remained in his memory for years.

Students demonstrate this each semester when they study for comprehensive final exams. Relearning material for the final exams takes less time than it took to learn the material originally.

Hermann Ebbinghaus and the First Experimental Studies on Learning and Memory

What was Ebbinghaus's major contribution to psychology?

Hermann Ebbinghaus (1850–1909) conducted the first experimental studies on learning and memory. Ebbinghaus realized that some materials are easier than others to understand and remember. To study memory objectively, he was faced with the task of selecting materials that would all be equally difficult to memorize. To accomplish this, he originated the use of **nonsense syllables**, which are consonant-vowel-consonant combinations that are not actual words. Examples are LEJ, XIZ, LUK, and ZOH. The use of nonsense syllables largely accomplished Ebbinghaus's goal. But did you notice that some of the syllables sound more like actual words than others and would, therefore, be easier to remember?

Ebbinghaus conducted his famous studies on memory using 2300 nonsense syllables as his material and using himself as his only subject. He carried out all his experiments in the same surroundings at about the same time of day, and he kept away all possible distractions. Ebbinghaus's method was to learn lists of nonsense syllables, repeating them over and over at a constant rate of 2.5 syllables per second, marking time with a metronome or the ticking of a watch. He repeated a list until he could recall it twice without error, a point that he called *mastery*.

Ebbinghaus recorded the amount of time or the number of learning trials it took to memorize his lists to mastery. Then, after different periods of time had passed and forgetting had occurred, he recorded the amount of time or the number of trials he needed to relearn the same list to mastery. Ebbinghaus compared the time or the trials required for relearning with those of the original learning and then computed the percentage of time saved, or *savings score*. For him, the percentage of savings represented the percentage of the original learning that remained in memory.

Ebbinghaus's famous curve of forgetting, shown in Figure 6.6, consists of savings scores at various time intervals after the original learning. What does the curve of forgetting show about how rapidly this type of material is forgotten? Forgetting begins very quickly and then gradually tapers off. Ebbinghaus found that

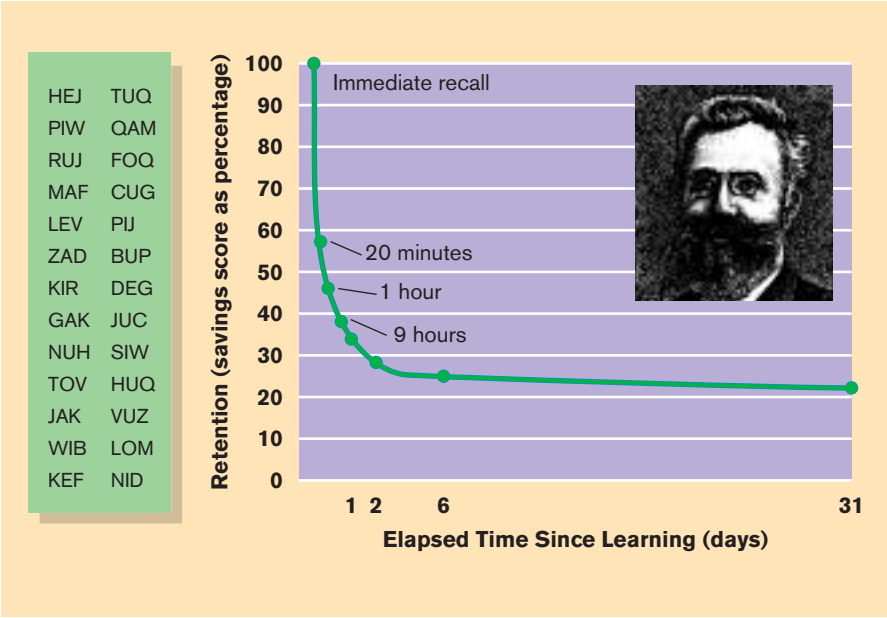


FIGURE 6.6

Ebbinghaus's Curve of Forgetting

After memorizing lists of nonsense syllables similar to those on the left of the figure, Ebbinghaus measured his retention after varying intervals of time using the relearning method. Forgetting was most rapid at first, as shown by his retention of only 58 percent after 20 minutes and 44 percent after 1 hour. Then the rate of forgetting tapered off, with a retention of 34 percent after 1 day, 25 percent after 6 days, and 21 percent after 31 days. (Data from Ebbinghaus, 1913.)

if he retained information as long as a day or two, very little more would be forgotten even a month later. But remember, this curve of forgetting applies to nonsense syllables. The forgetting of meaningful, carefully encoded, deeply processed, or frequently rehearsed material usually occurs more slowly.

What Ebbinghaus learned about the rate of forgetting is relevant for all of us. Do you, like most students, cram before a big exam? If so, don't assume that everything you memorize on Monday can be held intact until Tuesday. Because a significant amount of forgetting can occur within the first 24 hours, it is wise to spend at least some time reviewing the material on the day of the test. The less meaningful the material is to you, the more forgetting you can expect and the more necessary a review will be.

Forgetting

Patient: Doctor, you've got to help me. I'm sure I'm losing my memory. I hear something one minute and forget it the next. I don't know what to do!

Doctor: When did you first notice this?

Patient: Notice what?

Most of us think of forgetting as a problem to be overcome, but forgetting is not all bad. Wouldn't it be depressing if you were condemned to remember in stark detail all the bad things that ever happened to you? Forgetting clearly has its advantages.

The Causes of Forgetting

What are six causes of forgetting?

There are many reasons why we fail to remember. Among them are encoding failure, consolidation failure, decay, interference, motivated forgetting, and retrieval failure.

Encoding Failure

There is a distinction between forgetting and not being able to remember. Forgetting is "the inability to recall something now that could be recalled on an earlier occasion" (Tulving, 1974, p. 74). But often when we say we cannot remember, we have not actually forgotten. Our inability to remember may be a result of **encoding failure**—the information never entered our long-term memory in the first place. Of

savings score: The percentage of time or learning trials saved in relearning material over the amount of time or number of learning trials taken in the original learning.

nonsense syllable: A consonant-vowel-consonant combination that does not spell a word; used to control for the meaningfulness of the material.

encoding failure: Forgetting resulting from material never having been put into long-term memory.

Remember It!

Measures of Retention

1. Which of the following methods is the most sensitive way of measuring retention and can detect learning where other methods cannot?
   a. recall
   b. recognition
   c. relearning
   d. retrieval
2. Who invented the nonsense syllable, conceived the relearning method for testing retention, and plotted the curve of forgetting?
   a. George Sperling
   b. H. E. Burtt
   c. Frederick Bartlett
   d. Hermann Ebbinghaus
3. The curve of forgetting shows that memory loss
   a. occurs most rapidly at first and then levels off to a slow decline.
   b. begins to occur about 3 to 4 hours after learning.
   c. occurs at a fairly steady rate over a month's time.
   d. occurs slowly at first and increases steadily over a month's time.
4. Match all examples with the corresponding method of measuring retention.

   ____ 1) recognition
   ____ 2) relearning
   ____ 3) recall

   a. identifying a suspect in a lineup
   b. answering a fill-in-the-blank question on a test
   c. having to study less for a comprehensive final exam than for the sum of the previous exams
   d. answering questions on this Remember It!

Answers: 1. c 2. d 3. a 4. 1) a, d 2) c 3) b

the many things we encounter every day, it is sometimes surprising how little we actually encode. Can you recall accurately, or even recognize, something you have seen thousands of times before? Do the *Try It!* to find out.

Try It!

Check Your Recall

On a separate sheet of paper, draw a sketch of a one-cent coin from memory using recall. In your drawing, show the direction the Queen's image is facing and the location of the date, and include all the words on the "heads" side of the cent.

Once your drawing is complete, check the accuracy of your recall by comparing your drawing to a real coin. How accurate were you?

In your lifetime you have seen thousands of pennies, but unless you are a coin collector, you probably have not encoded the details of a penny. If you did poorly on the *Try It!*, you have plenty of company. Nickerson and Adams (1979) reported that few people can reproduce a penny from recall. In fact, only a handful of subjects could even recognize a drawing of a real penny when it was presented along with incorrect drawings.

In preparing for tests, do you usually assume a passive role? Do you merely read and reread your textbook and notes and assume that this process will eventually result in learning? If you don't test yourself, you may find that you have been the unwitting victim of encoding failure.

Consolidation Failure

Consolidation is the process by which encoded information is stored in memory. When a disruption in the consolidation process occurs, a permanent memory usually does not form. **Consolidation failure** can result from anything that causes a person to lose consciousness—a car accident, a blow to the head, a grand mal seizure, or an electroconvulsive shock treatment given for severe depression. Memory loss of the experiences that occurred shortly before the loss of consciousness is called **retrograde amnesia** (Lynch & Yarnell, 1973; Stern, 1981).

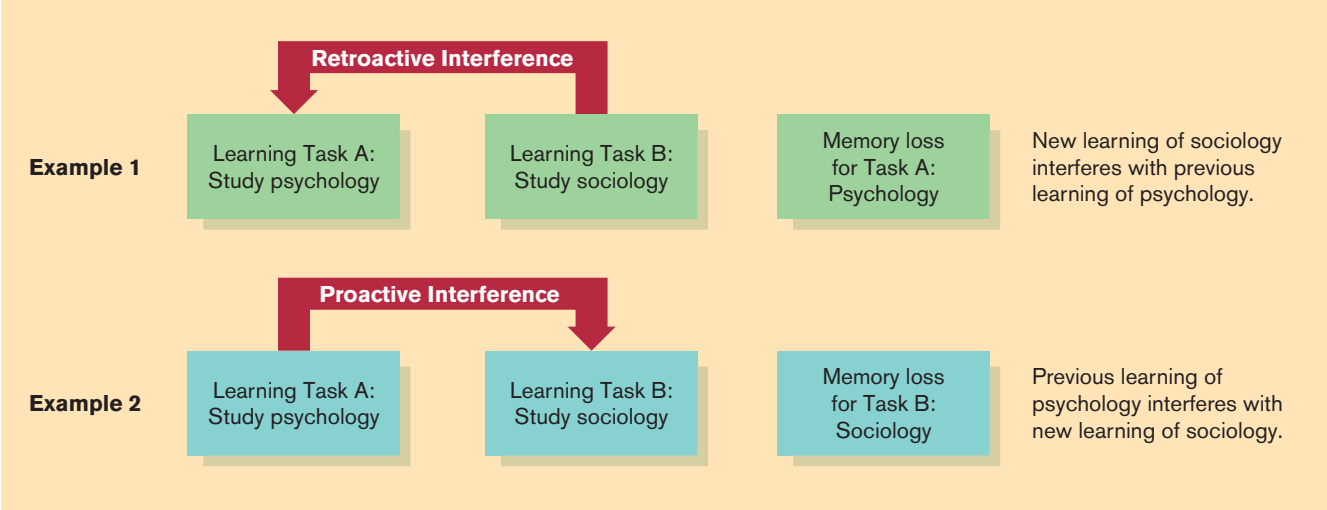


FIGURE 6.7

Retroactive and Proactive Interference **In Example 1, retroactive interference occurs when new learning hinders the ability to recall information learned previously. In Example 2, proactive interference occurs when prior learning hinders new learning.**

Decay

Decay theory, probably the oldest theory of forgetting, assumes that memories, if not used, fade with time and ultimately disappear entirely. The term *decay* implies a physiological change in the neural trace that recorded the experience. According to this theory, the neural trace may decay or fade within seconds or days, or over a much longer period of time.

Today most psychologists accept the notion of decay, or fading of the memory trace, as a cause of forgetting in sensory and short-term memory but not in long-term memory. If there were a gradual, inevitable decay of the memory trace in long-term memory, Harry Bahrick and colleagues (1975) would not have found that after 35 years, people recognized 90 percent of their high school classmates' names and photographs—the same percentage as for recent graduates.

Interference

What is interference, and how can it be minimized?

A major cause of forgetting, and one that affects us every day, is **interference**. Interference refers to those times when new information or information you have already learned interferes with what you are now learning or trying to recall (see Figure 6.7). There are two forms of interference: proactive and retroactive (Underwood, 1964).

PROACTIVE INTERFERENCE Laura's romance with her new boyfriend, Todd, got off to a bad start when she accidentally called him Dave, her former boyfriend's name. How many cheques written early in January do you suppose have the wrong year? Such mistakes happen frequently, and the reason for that is proactive interference. Proactive interference occurs when information or experiences already stored in long-term memory hinder our ability to remember newer information (Underwood, 1957). When you buy a new car, it may take a while to feel comfortable with the new arrangement of the dashboard. Your memory of the old car's dashboard may at first interfere with your driving. This type of proactive interference is called *negative transfer*. One explanation for interference is that old and new responses are competing with each other (Bower et al., 1994).

consolidation failure: Any disruption in the consolidation process that prevents a permanent memory from forming.

retrograde amnesia (RET-ro-grade): A loss of memory for events occurring during a period of time preceding a brain trauma that caused a loss of consciousness.

decay theory: A theory of forgetting that holds that the memory trace, if not used, disappears with the passage of time.

interference: The cause of memory loss that occurs when information or associations stored either before or after a given memory hinder our ability to remember it.

RETROACTIVE INTERFERENCE New learning or experience that interferes with our ability to remember information previously stored is called "retroactive interference." The more similar the new learning or experience is to the previous learning, the more interference there is. You may be surprised to learn that of all the activities we engage in, sleep interferes with previous learning the least.

What can you do to lessen the effects of retroactive interference on memory?

- When possible, study before going to sleep.
- If you can't study before going to sleep, at least review at that time the material you need to remember.
- Try not to study similar subjects back-to-back. Better yet, after studying one subject, take a short break before beginning the next subject.
- Schedule your classes so that courses with similar subject matter do not follow each other.

We have discussed ways to avoid forgetting. But there are times when we may need to avoid remembering—when we *want* to forget.

Motivated Forgetting: Don't Remind Me

Victims of assault and survivors of disasters (natural or human) may be haunted by their experiences for years. They are motivated to forget. However, even people who have not suffered any trauma use **motivated forgetting** to protect themselves from experiences that are painful, frightening, or otherwise unpleasant.

With one form of motivated forgetting, *suppression,* a person makes a conscious, active attempt to put a painful or disturbing memory out of mind, but the person is still aware that the painful event occurred. With another type of motivated forgetting, **repression**, unpleasant memories are literally removed from consciousness, and the person is no longer aware that the unpleasant event ever occurred (Freud, 1922). People who have **amnesia** (memory loss) that is not due to loss of consciousness or brain damage have actually repressed the events they no longer remember. To deal with unpleasant memories, more people probably use motivated forgetting than any other method. Humans, it seems, have a natural tendency to forget the unpleasant circumstances of life and to remember the pleasant ones (Linton, 1979; Matlin, 1989; Meltzer, 1930).

Retrieval Failure: Misplaced Memories

How many times have these experiences happened to you? You are with a friend when you meet an acquaintance, but you can't introduce the two because you cannot recall the name of your acquaintance. Or while taking a test, you can't remember the answer to a question that you are sure you know. Often we are certain that we know something, but we are not able to retrieve the information when we need it. This type of forgetting is called "retrieval failure" (Shiffrin, 1970).

Tulving (1974) asserts that much of what we call "forgetting" is really our inability to locate the information we seek. The information is in our long-term memory, but we cannot retrieve it. Tulving found that participants could recall a large number of items they seemed to have forgotten if he provided retrieval cues to jog their memory. For example, odours often provide potent reminders of experiences from the past, and they can serve as retrieval cues for information learned when certain odours were present (Schab, 1990).

A common retrieval failure experience is known as the "tip-of-the-tongue" (TOT) phenomenon (Brown & McNeil, 1966). Surely you sometimes try to recall a name, a word, or some other bit of information, fully aware that you know the item almost as well as your own name. You can almost recall the word or name, and perhaps even know the number of syllables and the beginning or ending letter of the word. It is on the tip of your tongue, but it just won't quite come out.

Prospective Forgetting: Forgetting to Remember

Do you have trouble remembering appointments? Do you forget to mail birthday cards on time, pick up your clothes at the cleaners, pay your bills, or water your plants? If you do, you are not alone. In a study of everyday forgetting, Terry (1988) had 50 people keep a diary of the instances of forgetting that occurred each day. Of the 751 recorded instances of forgetting, most did not involve forgetting names, facts, or other information already known. Rather, they involved prospective memory—remembering to carry out an action in the future.

Remember It!

Forgetting

1. Match the example with the appropriate cause of forgetting.
   ____ 1) encoding failure
   ____ 2) consolidation failure
   ____ 3) retrieval failure
   ____ 4) repression
   ____ 5) interference
2. To minimize interference, it is best to follow learning with
   a. rest.
   b. recreation.
   c. sleep.
   d. unrelated study.
3. According to the text, the major cause of forgetting is interference. (true/false)

a. failing to remember the answer on a test until after you turn the test in
b. forgetting a humiliating experience from childhood
c. not being able to describe the back of a five-dollar bill
d. calling a friend by another's name
e. waking up in the hospital and not remembering you had an automobile accident

Answers: 1. 1) c 2) e 3) a 4) b 5) d 2. c 3. true

The Nature of Remembering and Forgetting

Memory as a Permanent Record: The Video Recorder Analogy

For hundreds of years, people have speculated about the nature of memory. Aristotle suggested that the senses imprint memories in the brain like signet rings stamping impressions in wax. Freud believed that all memories are permanently preserved, with some lying deep in the unconscious. Wilder Penfield (1969), a Canadian neurosurgeon, asserted that experiences leave a "permanent imprint on the brain … as though a tape recorder had been receiving it all" (p. 165). What would lead him to such a conclusion?

Penfield (1975) performed more than 1100 operations on patients with epilepsy. He found that when parts of the temporal lobes were stimulated with an electrical probe, a small number of patients (3.5 percent) reported flashback experiences, as though they were actually reliving parts of their past. After reviewing Penfield's findings, other researchers offered different explanations for his patients' responses. Neisser (1967) suggested that the experiences patients reported were "comparable to the content of dreams," rather than the recall of actual experiences (p. 169).

Memory as a Reconstruction: Partly Fact and Partly Fiction

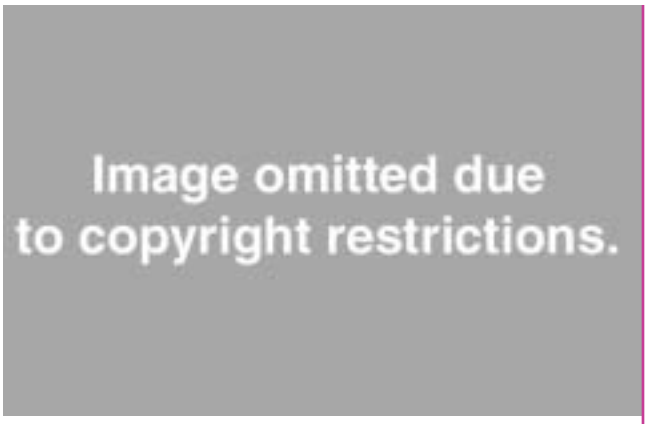
What is meant by the statement "Memory is reconstructive in nature"?

Other than Penfield's work, there is no research to suggest that memory works like a video recorder, capturing every part of an experience exactly as it happens. Normally, what we recall is not an exact replica of an event (Schachter et al., 1998). Rather, it is a **reconstruction**—a piecing together of a few highlights, using information that may or may not be accurate (Loftus & Loftus, 1980). Even for

motivated forgetting: Forgetting through suppression or repression in order to protect oneself from material that is too painful, anxiety- or guilt-producing, or otherwise unpleasant.

repression: Removing from one's consciousness disturbing, guilt-provoking, or otherwise unpleasant memories so that one is no longer aware that a painful event occurred.

amnesia: A partial or complete loss of memory resulting from brain trauma or psychological trauma.



When people recall an event, such as a car accident, they are actually reconstructing it from memory by piecing together bits of information that may or may not be totally accurate.

those of us with the most accurate memories, recall is partly truth and partly fiction (Conway et al., 1996). We supply what we *think* are facts to flesh out or complete those fragments of our experiences that we do recall accurately. This was the finding of another pioneer in memory research, Sir Frederick Bartlett.

Sir Frederick Bartlett

What is Bartlett's contribution to our understanding of memory?

Sir Frederick Bartlett (1886–1969) studied memory using rich and meaningful material learned and remembered under more life-like conditions. Bartlett (1932) gave participants stories to read and drawings to study. Then at varying time intervals he had them reproduce the original material. Accurate reports were rare. His participants seemed to reconstruct rather than actually remember the material they had learned. They recreated the stories, making them shorter and more consistent with their own individual points of view. They rationalized puzzling features of the stories to fit their own expectations; and they often changed details and substituted more familiar objects or events. Bartlett also found that errors in memory increased with time and that his participants were not aware that they had partly remembered and partly invented. Ironically, the parts his participants had created were often the very parts that they most adamantly claimed to have remembered.

Bartlett concluded that we systematically distort the facts and the circumstances of our experiences and that we do not simply remember new experiences as isolated events. Rather, information already stored in long-term memory exerts a strong influence on how we remember new information and experiences.

Schemas and Memory

What are schemas, and how do they affect memory?

Bartlett suggested that the inaccuracies in the participants' memories reflected **schemas**—integrated frameworks of knowledge and assumptions about people, objects, and events. Schemas help us process large amounts of material by providing us with means to incorporate new information and experience. They also provide association cues that can help us with retrieval. For example, you probably have a schema for fast-food restaurants. You typically order at a counter, pay immediately, wait for your food, carry your food to a table, and put your tray away when you're finished. We are often made aware of our schemas when they are violated. For example, if you went into a restaurant that you expected to serve fast food, you would be surprised if someone gave you a menu and tried to seat you.

Once formed, our schemas influence what we notice and how we encode and recall information. When we encounter new information or have a new experience related to an existing schema, we try to make it "fit" that schema. To this end, we may have to distort some aspects of the information and ignore or forget other aspects. Some of the distorting and ignoring occurs as the material is being encoded; more can occur when we try to remember or reconstruct the original experience (Brewer & Nakamura, 1984).

Distortion in Memory

When we reconstruct our memories, we do not purposely try to distort the actual experience—unless, of course, we are lying. But all of us tend to omit some facts that actually occurred and to supply other details from our own imaginations. Distortion occurs when we alter the memory of an event or of our experience so that it fits our beliefs, expectations, logic, or prejudices.

The tendency toward systematic distortion of actual events has been demonstrated many times. Try your own demonstration of distortion in memory in *Try It!*

Try It!

Testing Memory Distortion

Read this list of words aloud at a rate of about one word per second. Then close your book and write all the words you can remember.

bed	rest	awake	tired
dream	wake	snooze	doze
nap	yawn	snore	slumber

Now check your list. Did you "remember" the word *sleep*? Many people do, even though it is not one of the words on the list (Deese, 1959).

Try It! shows that we are very likely to alter or distort what we see or hear to make it fit with what we believe *should* be true. Since all the words on the list are related to sleep, it seems logical that *sleep* should be one of the words. In a a recent study that used word lists similar to the one in the *Try It!* box, Roediger and McDermott (1995) found that 40 to 55 percent of the participants "remembered" the very word that was not on the list.

Our tendency to distort makes the world more understandable and lets us organize our experiences into our existing systems of beliefs and expectations. This tendency is, however, also frequently responsible for gross inaccuracies in what we remember. We tend to distort memories in a positive way. Bahrick and others (1996) found that 89 percent of college students accurately remembered the A's they earned in high school, but only 29 percent accurately recalled the D's. Some of the most dramatic examples of systematic distortion are found in eyewitness testimony.

Eyewitness Testimony: Is It Accurate?

When people say, "I ought to know—I saw it with my own eyes," we are likely to accept their statement almost without question. After all, seeing is believing. Or is it?

Studies on the accuracy of human memory suggest that eyewitness testimony is highly subject to error and should always be viewed with caution (Brigham et al., 1982; Loftus, 1993a). Nevertheless, eyewitness testimony does play a vital role in our justice system. Says Loftus (1984), "We can't afford to exclude it. Sometimes, as in cases of rape, it is the only evidence available, and it is often correct" (p. 24). In fact, researchers at the University of British Columbia argue that eyewitness testimony may not be as problematic as others suggest. Yuille and Tollestrup (1992) believe that in most crime incidents, the victim is involved and "invested" (unlike participants in laboratory research). Hence, their memories tend to be more accurate.

Fortunately, there are ways in which eyewitness mistakes can be minimized. Eyewitnesses to crimes typically identify suspects from a lineup. The composition of the lineup is important. Other subjects in a lineup must resemble the suspect in age, body build, and certainly in race. Even then, if the lineup does not contain the guilty party, eyewitnesses may identify the person who most resembles the perpetrator (Gonzalez et al., 1993). Eyewitnesses are less likely to identify the culprit incorrectly and just as likely to make a correct identification if a sequential lineup is used—that is, if the members of the lineup are viewed one after the other, rather than simultaneously (Loftus, 1993a). Some police officers and researchers prefer a "showup" to a lineup. In a showup, one suspect is presented and the witness indicates whether that person is or is not the perpetrator. There are fewer misidentifications with a showup, but also more failures in making positive identifications (Gonzalez et al., 1993; Wells, 1993). However, Yarmey and his colleagues (1996) at the University of Guelph caution that lineups may provide greater accuracy than showups when the time interval between the occurrence and identification is lengthened.

In the case of children, fast "elimination lineups" seem to be most effective. In a Canadian study (Pozzulo & Lindsay, 1999), children were most accurate when asked to eliminate lineup members until only one suspect was left. Then, the children were told about the consequences of incorrectly identifying

reconstruction: A memory that is not an exact replica of an event but has been pieced together from a few highlights, with the use of information that may or may not be accurate.

schemas: The integrated frameworks of knowledge and assumptions we have about people, objects, and events, which affect how we encode and recall information.

an innocent person as a criminal. This procedure enhanced children's performance to the level of adults.

Regardless of age, the race of the individual is also a critical concern because eyewitnesses are more likely to identify the wrong person if the person's race is different from their own. According to Egeth (1993), misidentifications are about 15 percent higher in cross-race than in same-race identifications.

Questioning witnesses after a crime also can influence what they later remember. Because leading questions can substantially change a witness's memory of an event, it is critical that interviewers ask neutral questions (Leichtman & Ceci, 1995). Misleading information supplied after the event can result in erroneous recollections of the actual event, a phenomenon known as the *misinformation effect* (Loftus, 1997). Furthermore, after eyewitnesses have repeatedly recalled information, whether accurate or inaccurate, they become even more confident when they testify in court because the information is so easily retrieved (Shaw, 1996).

Witnessing a crime is highly stressful. How does stress affect eyewitness accuracy? Research suggests that eyewitnesses do tend to remember the central, critical details of the event even though their arousal is high. It is the memory of *peripheral* details that suffers as a result of high arousal (Burke et al., 1992; Christianson, 1992).

Hypnosis for Eyewitnesses

Does hypnosis improve the memory of eyewitnesses?

Research suggests that under controlled laboratory conditions, people do not show improved memory under hypnosis (Buckhout et al., 1981). Hypnotized subjects supply more information and are more confident of their recollections, but they supply more *inaccurate* information as well (Dywan & Bowers, 1983; Nogrady et al., 1985). Because subjects are much more confident of their memories after hypnosis, they become very convincing witnesses. Some critics of hypnosis are against using it as an aid for eyewitness testimony, but they believe that it can be a valuable investigative tool for police.

Recovering Repressed Memories: A Controversy

Since the late 1980s, thousands of people, most of them adult women under the age of 50, have come forward claiming to have been sexually abused as children. Given the fact that childhood sexual abuse is widespread and underreported, the growing number of claims of sexual abuse, including incest, should not be surprising. But many of these new claims are controversial in that the accusers maintain that they had repressed all memory of the abuse until they underwent therapy or read a self-help book for survivors of childhood sexual abuse. Is it likely that people could endure repeated episodes of childhood sexual abuse for years, selectively repress all memories of their abuse, and then recover the repressed memories as adults? On this issue, psychologists are divided.

Critics of repressed memory therapy are especially skeptical of recovered memories of events that occurred in the first few years of life. According to Loftus (1994), "Not a single piece of empirical work in human memory provides support for the idea that adults have concrete episodic memories of events from the first years of their lives" (p. 443). In fact, most people have few if any memories from the second and third year of life, in part because the hippocampus, which is vital in the formation of declarative memories, is not fully developed; nor, according to Squire and colleagues (1993), are the areas of the cortex where memories are stored. Furthermore, children are still limited in their language ability during these years and therefore do not store memories in the categories that would be accessible to them later in life. This relative inability of older children and adults to recall events from the first few years of life is referred to as **infantile amnesia**.

In contrast, Connie Kristiansen (1994), at Carleton University, argues that the question is not whether repressed memory occurs but how often it occurs. Even those who contest the existence of repressed memories (e.g., Loftus, 1993b) report finding them in some people. In her recent research, Kristiansen reports that false memory syndrome is not occurring in "epidemic proportions" (Hovdestad & Kristiansen, 1996). In fact, only 3.9 to 13.6 percent of individuals with recovered memories satisfy the criteria for diagnosis. Kristiansen also suggests that "repressed" memory might be better called "dissociated" memory to reflect the trauma that would lead a person to dissociate himself or herself from an event.

We have seen that conscious memory, even at its best, is a mixture of accurate recall and fragments of our own imagination. And at best, factual recall is

not a faithful, point-by-point, detail-by-detail rendering of what actually occurred. There is strong evidence that the memory of an event is not like a photograph or recording that sits awaiting retrieval and is capable of being recalled intact. Rather, memory, like other brain functions, is fluid, plastic, and malleable. Like a living thing, it grows and changes over the years.

LINK IT!

www.brown.edu/Departments/Taubman_Center/Recovmem/Archive.html
Recovered Memory Project

www.jimhopper.com/memory
Recovered memories of sexual abuse: scientific research & scholarly resources

www.csicop.org/si/9503/memory.html
Committee for the Scientific Investigation of Claims of the Paranormal (CSICOP), Skeptical Inquirer, "Remembering Dangerously"

www.fmsfonline.org
Website of the False Memory Syndrome Foundation

www.kspope.com/memory.shtml
Memory, Abuse, and Science

www.vix.com/pb/men/falsereport/child.html#recover
False allegations of child molestation and abuse

Unusual Memory Phenomena

Flashbulb Memories: Extremely Vivid Memories

Most of you remember New Year's Eve for the coming of the year 2000, and many of you may have unusually vivid memories of exactly when and where you were when the final countdown occurred. This type of extremely vivid memory is called a **flashbulb memory** (Bohannon, 1988; Brown & Kulik, 1977). Brown and Kulik suggest that a flashbulb memory is formed when an individual learns of an event that is highly shocking and emotional. You may have a flashbulb memory of the time you received the news of the death or serious injury of a close family member or a friend.

Reisberg and colleagues (1988) suggest that the vividness of a memory is related to the strength of

A flashbulb memory is formed when a person learns of an event that is shocking and highly emotional, such as the death of Princess Diana in 1997. Where were you when you first heard the news of the car accident?

the emotion we feel rather than to the element of surprise or whether the emotion is positive or negative. Other researchers remind us that a memory remains vivid because the person has probably talked about the circumstance with others or thought about it on many occasions.

Pillemer (1990) argues that flashbulb memories do not constitute a different type of memory altogether. Rather, he suggests that all memories vary on the dimensions of emotion, importance, and rehearsal (how often people think or talk about the event after-

infantile amnesia: The relative inability of older children and adults to recall events from the first few years of life.

flashbulb memory: An extremely vivid memory of the conditions surrounding one's first hearing of the news of a surprising, shocking, or highly emotional event.

ward). Since flashbulb memories rank high in all three dimensions, they should be the most accurate of any memories. But are they infallible? Hardly.

Several studies suggest that flashbulb memories may not be as accurate as people believe them to be. Neisser and Harsch (1992) questioned first-year university students about the Challenger disaster the following morning. When the same students were questioned again three years later, one-third gave accounts that differed markedly from those they gave initially, even though they were extremely confident of their recollections.

Eidetic Imagery: Almost Like "Photographic Memory"

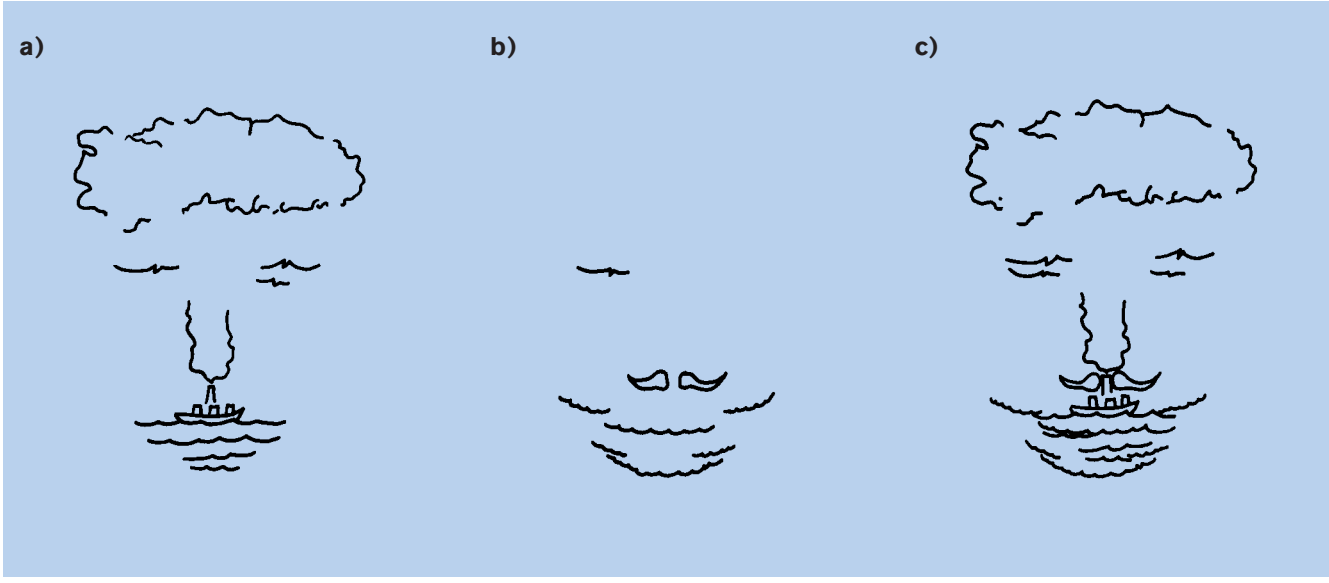
Have you ever wished you had a photographic memory? Perhaps you have heard of someone who is able to read a page in a book and recall it word for word. More than likely, this person has developed such an enviable memory by learning and applying principles of memory improvement. Psychologists doubt that there are more than a few rare cases of truly photographic memory, which captures all the details of any experience and retains them perfectly. But some studies do show that about 5 percent of children apparently have something akin to photographic memory, which psychologists call "eidetic imagery" (Haber, 1980). **Eidetic imagery** is the ability to retain the image of a visual stimulus, such as a picture, for several minutes after it has been removed from view and to use this retained image to answer questions about the visual stimulus (see Figure 6.8).

Children with eidetic imagery generally have no better long-term memory than children without it, and virtually all children who have eidetic imagery lose it before adulthood. One exception, however, is Elizabeth, a highly intelligent teacher and a skilled artist. Elizabeth can project on her canvas an exact duplicate of a remembered scene with all its rich detail. Even more remarkable is her ability to retain visual images other than scenes and pictures. "Years after having read a poem in a foreign language, she can fetch back an image of the printed page and copy the poem from the bottom line to the top line as fast as she can write" (Stromeyer, 1970, p. 77).

Some impressive memory abilities develop through cultural needs, as the *World of Psychology* box illustrates.

FIGURE 6.8

Test for Eidetic Imagery **Researchers test children for eidetic imagery by having them stare for 30 seconds at a picture like the one in (a). A few minutes later, the drawing in (b) is shown to the children, who are asked to report what they see. Those with eidetic imagery usually maintain that they see a face and describe the composite sketch in (c). The face can be perceived only if the participant retains the image of the first picture and fuses it with the middle drawing. (From Haber, 1980.)**



WORLD OF PSYCHOLOGY

Memory and Culture

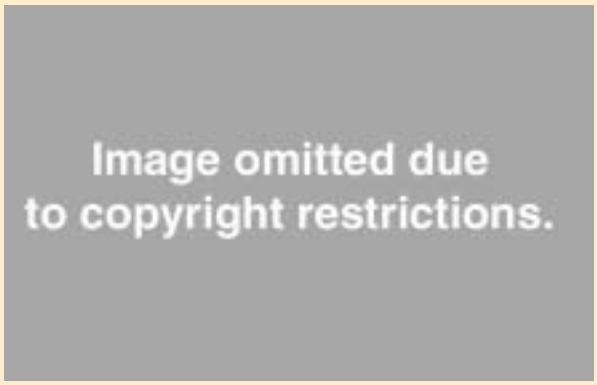
Sir Frederick Bartlett believed that memory operates within a social or cultural context and cannot be understood as a pure process. He stated that "both the manner and matter of recall are often predominantly determined by social influences" (1932, p. 244).

In studying memory in a cultural context, Bartlett described the amazing ability of the Swazi people of Africa to remember the slight differences in individual characteristics of their cattle. One Swazi herdsman, Bartlett said, could remember details of every head of cattle bought the year before by the owner of the herd. Such a feat is less surprising when we consider that the key component of traditional Swazi culture consists of the herds of cattle the people depend upon for their living. Do the Swazi people have super powers of memory? Bartlett performed experiments comparing young Swazi men with young European men of comparable ages. Asked to recall a message consisting of 25 words, the young Swazis had no better recall ability than the young Europeans.

Among many peoples of Africa, tribal history is preserved orally. For this reason, an oracle, or specialist, must be able to encode, store, and retrieve huge volumes of historical data (D'Azevedo, 1982). In New Guinea, elders of the Iatmul people are said to have committed to memory the lines of descent for the various clans of their people stretching back generation upon generation (Bateson, 1982). The unerring memory of the elders for the kinship patterns of generations of their people are used to resolve disputed property claims (Mistry & Rogoff, 1994).

Barbara Rogoff, an expert in cultural psychology, maintains that such phenomenal, prodigious memory feats are best explained and understood in the cultural context in which they occur (Rogoff & Mistry, 1985). The tribal elders perform their impressive memory feats because doing so is an integral and critically important part of the culture in which they live. Most likely, their ability to remember lists of nonsense syllables would be no better than your own.

In summary, memory is not a pure process that exists apart from cultural context, social influences, or our individual interests. We remember what we are interested in, what we think about, and the daily transactions that occur in our cultural and social world.



Remember It!

The Nature of Remembering and Forgetting

1. What early memory researcher found that, rather than accurately recalling information detail by detail, people often reconstruct and systematically distort facts to make them more consistent with past experiences?
   a. Hermann Ebbinghaus
   b. Frederick Bartlett
   c. Wilder Penfield
   d. William James
2. Which of the following is *not* true of schemas?
   a. Schemas are the integrated frameworks of knowledge assumptions we have about people, objects, and events.
   b. Schemas affect the way we encode information.
   c. Schemas affect the way we retrieve information.
   d. When we use schemas, our memories are accurate.
3. As a rule, people's memories are more accurate under hypnosis. (true/false)
4. The ability to retain a visual image several minutes after it has been removed is called
   a. photographic memory.
   b. flashbulb memory.
   c. eidetic imagery.
   d. sensory memory.

Answers: 1. b 2. d 3. false 4. c

eidetic imagery (eye-DET-ik): The ability to retain the image of a visual stimulus several minutes after it has been removed from view.

Factors Influencing Retrieval

Researchers in psychology have identified several factors that influence memory. We can control some of these factors, but not all of them.

The Serial Position Effect: To Be Remembered, Be First or Last but Not in the Middle

What is the serial position effect?

If you were introduced to a dozen people at a party, you would most likely recall the names of the first few people you met and the last one or two, but forget most of the names in the middle. A number of studies have revealed the **serial position effect**—the finding that for information learned in sequence, recall is better for items at the beginning and the end than for items in the middle of the sequence.

Information at the beginning of a sequence has a fairly high probability of being recalled because there has been time to rehearse it and encode it into long-term memory. This is called the **primacy effect**. Information at the end of a sequence has an even higher probability of being recalled because it is still in short-term memory and being rehearsed and encoded at the time you need to remember it. This is known as the **recency effect**. The poorer recall of information in the middle of a sequence occurs because that information is no longer in short-term memory and has not yet been placed in long-term memory. The serial position effect lends strong support to the notion of separate systems for short-term and long-term memory (Glanzer & Cunitz, 1966; Postman & Phillips, 1965).

Primacy and recency effects can also have an impact on information stored for longer periods of time (Roediger, 1991). For example, children learning the alphabet are likely to remember the first and last several letters of the alphabet better than many of the letters in the middle.

Environmental Context and Memory

How does environmental context affect memory?

Have you ever stood in your living room and thought of something you needed from your bedroom, only to forget what it was when you went there? Did the item come to mind when you returned to the living room? Some research has revealed that we tend to recall information better when we are in the same location—the same environmental context—as when the information was originally encoded.

Tulving and Thompson (1973) suggest that many elements of the physical setting in which we learn information are encoded along with the information and become part of the memory trace. If part or all of the original context is reinstated, it may serve as a retrieval cue. Then the information previously learned in that context may come to mind. This is known as the *encoding specificity hypothesis.*

Godden and Baddeley (1975) conducted one of the early studies of context and memory with members of a university scuba diving club. Students memorized a list of words when they were either 10 feet under water or on land. They were later tested for recall of the words in the same or in a different environment. The results of the study suggest that recall of information is strongly influenced by environmental context (see Figure 6.9). Words learned under water were best recalled under water, and words learned on land were best recalled on land. In fact, when the scuba divers learned and recalled the words in the same context, their scores were 47 percent higher than when the two contexts were different.

Godden and Baddeley (1980) found that changes in context did not affect the outcome when they measured memory using recognition rather than recall. Why? The original context seems to provide retrieval cues that make recall easier. In a recognition task, people have only to recognize the information as being familiar, so there is less need for the extra retrieval cues that the original context provides (Eich, 1980).

Going from 10 feet under water to dry land is a rather drastic change in context. Some researchers find the same effects in more subtle context changes, such as going from one room to another.

Odours can also supply powerful and enduring retrieval cues for memory. Experimental participants who experienced a pleasant odour during learning and again when tested five days later had greater recall than those who did not experience the odour during both learning and recall (Morgan, 1996).

Not all studies have found that memory is enhanced when students learn and are tested in the same environment (Fernandez & Glenberg, 1985;

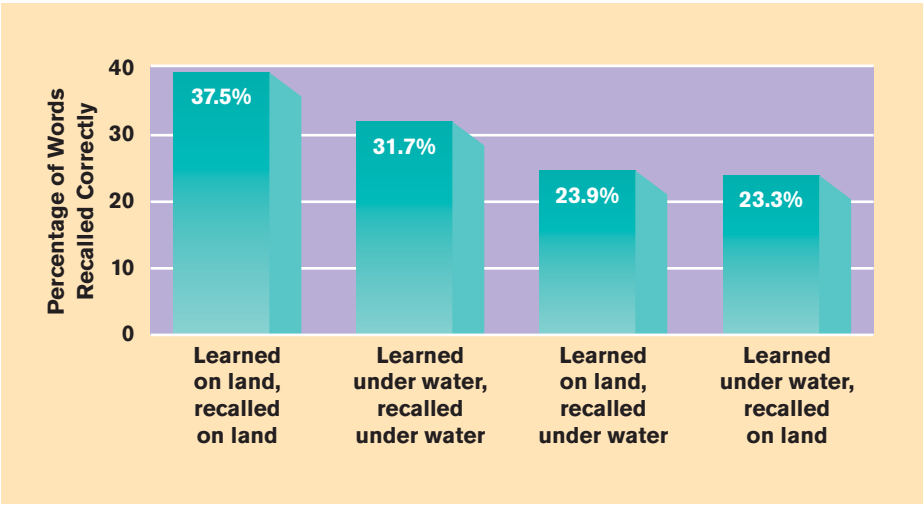


FIGURE 6.9
Context-Dependent Memory
Godden and Baddeley showed the strong influence of environmental context on recall. Scuba divers who memorized a list of words, either on land or under water, had significantly better recall in the same physical context in which the learning had taken place. (Data from Godden & Baddeley, 1975.)

Saufley et al., 1985). How can the discrepancy be explained? McDaniel and colleagues (1989) reasoned that the more completely and carefully people encode material to be remembered, the less dependent they are on reinstating the original context or environment. But we have already learned that people do not always carefully encode information and events to be remembered. Consequently, authorities investigating crimes often bring eyewitnesses back to the crime scene or ask them to visualize it to help them recall more details of the crime.

The State-Dependent Memory Effect

What is the state-dependent memory effect?

Does our internal state (e.g., happy or sad mood, intoxicated or sober) influence our memory? Yes it does. We tend to recall information better if we are in the same internal state as when the information was encoded. Psychologists call this the **state-dependent memory effect**.

Alcohol, Other Drugs, and Memory

Some studies have shown a state-dependent memory effect for alcohol and drugs such as marijuana, amphetamines, and barbiturates (Eich, 1980). People learned (encoded) material while sober or intoxicated, and later were tested in either the sober or the intoxicated state. Recall was found to be best when the subjects were in the same state for both learning and testing (Weingartner et al., 1976). As in other studies, the state-dependent memory effect was evident for recall but not for recognition. Research by Bruce and colleagues (1999) suggests that alcohol affects memory by intensifying the processes of interference.

Mood and Memory

Researchers have not been able to reliably demonstrate that recall is best if participants are in the same mood (happy or sad) when they encode or learn material as when they try to recall it. However, some evidence does suggest that pleasant experiences are more likely to be recalled when people are in a happy mood, and negative experiences when people are in a negative mood (Bower, 1992; Eich et al., 1994; Teasdale & Fogarty, 1979). Adults who are clinically depressed tend to recall more negative life experiences (Clark & Teasdale, 1982) and are likely to recall their parents as unloving and rejecting (Lewinsohn & Rosenbaum, 1987). But as depression lifts, the tendency toward negative recall reverses itself (Lloyd & Lishman, 1975).

serial position effect: The tendency to recall the beginning and ending items on a list better than the middle items.

primacy effect: The tendency to recall the first items on a list more readily than the middle items.

recency effect: The tendency to recall the last items on a list more readily than those in the middle of the list.

state-dependent memory effect: The tendency to recall information better if one is in the same pharmacological or psychological (mood) state as when the information was encoded.

Stress, Anxiety, and Memory: Relax and Remember

Have you ever watched a quiz show on television, convinced that you could have easily won the prize? Would your memory work as well under the stress of TV cameras, lights, and millions of people watching as it does in the privacy and comfort of your own home? Psychologists who study stress and memory say that either too much or too little stress and emotional arousal can hinder memory performance (Loftus, 1980).

Biology and Memory

We have learned a great deal about how we remember and why we forget. And we know that our vast store of information must exist physically somewhere in the brain. But where?

Brain Damage: A Clue to Memory Formation

Modern researchers are finding some specific locations in the brain that house and mediate functions and processes in memory. One important source of information comes from people who have suffered memory loss as a result of damage to specific brain areas. One such person is H.M., who has had a major influence on present-day knowledge of human memory. Much of what we know about H.M. was recorded by Canadian researcher Brenda Milner.

The Case of H.M.

What has the study of H.M. revealed about the role of the hippocampus in memory?

H.M. suffered from such severe epilepsy that, out of desperation, he agreed to a radical surgical procedure. The surgeon removed the site responsible for his seizures, the medial portions of both temporal lobes—the amygdala and the *hippocampal region,* which includes the hippocampus itself and the underlying cortical areas. It was 1953, and H.M. was 27 years old.

After his surgery, H.M. remained intelligent and psychologically stable, and his seizures were drastically reduced. But unfortunately, the tissue cut from H.M.'s brain housed more than the site of his seizures. It also contained his ability to form new, conscious, long-term memories. Though his short-term memory is still as good as ever and he easily remembers the events of his life stored well before the operation, H.M. suffers from **anterograde amnesia.** He has not been able to remember a single event that has

Remember It!

Factors That Influence Memory

1. When children learn the alphabet, they often are better at learning and recalling the first few (a, b, c, d) and last few (x, y, z) letters of the alphabet, before learning the letters in between. This is called the
   a. primacy effect.
   b. recency effect.
   c. serial position effect.
   d. state-dependent memory effect.
2. Recall is about as good when people visualize the context in which learning occurred as it is when recall and learning occur in the same context. (true/false)
3. Scores on recognition tests (either multiple-choice or true/false) will be higher if testing and learning take place in the same physical environment. (true/false)
4. The fact that drugs such as alcohol and marijuana can interfere with recall if the participant is under the influence of drugs during learning but not during retrieval can best be explained on the basis of
   a. the consistency effect.
   b. state-dependent memory.
   c. context-dependent memory.
   d. consolidation failure.
5. Compared with non-depressed people, depressed people tend to have
   a. more sad memories.
   b. fewer memories.
   c. more pleasant memories.
   d. memories about the same in emotional content.

Answers: 1. c 2. true 3. false 4. b 5. a

occurred since the surgery over 40 years ago. Though H.M. turned 74 in the year 2000, as far as his conscious long-term memory is concerned, it is still 1953 and he is still 27 years old.

Surgery affected only H.M.'s declarative, long-term memory—his ability to store facts, personal experiences, and names, faces, telephone numbers, and the like. Researchers were surprised to discover that he could still form non-declarative memories—that is, he could still acquire skills through repetitive practice, although he could not remember having done so. For example, since the surgery, H.M. has learned to play tennis and improve his game, but he has no memory of having played. (Adapted from Milner, 1966, 1970; Milner et al., 1968.)

H.M.'s case was one of the first indications that the hippocampal region is involved in the formation of long-term memories. Other patients who, like H.M., have suffered similar brain damage exhibit the same types of memory loss (Squire, 1992). The most recent research indicates that the hippocampus is critically important in forming episodic memories (Eichenbaum, 1997; Gluck & Myers, 1997). Semantic memory, however, depends not on the hippocampus itself, but on the other parts of the hippocampal region underlying it (Vargha-Khadem et al., 1997).

Other research suggests that the hippocampus is needed for only a limited time after learning (Kim & Fanselow, 1992). The hippocampus plays a continuing role during the process of reorganization and consolidation through which memories are finally stored in other areas of the cortex. At that point, the memory can be recalled without the involvement of the hippocampus (Frackowiak, 1994; Squire & Zola-Morgan, 1991).

The Case of K.C.

To support the distinction between semantic and episodic memory, Tulving cites the case of K.C., a Toronto resident who sustained a severe head injury from a motorcycle accident (1989; Tulving et al., 1988). K.C. suffered massive damage to his left frontal lobe and other parts of the brain as well.

K.C.'s case is remarkable in that he cannot remember, in the sense of bringing back to conscious awareness, a single thing that he has ever done or experienced. He cannot remember himself experiencing situations and participating in life's events. This total absence of personal recollections makes K.C.'s case unique; no other reports exist of amnesiac patients who have been incapable of recollecting *any* personal happenings. (Tulving, 1989, p. 362)

Although his episodic memory was erased, K.C.'s semantic memory was largely spared. His storehouse of knowledge from fields such as geography, history, politics, and music is still large, enabling him to answer questions about many topics. Tulving concludes that episodic memory depends upon the functioning of parts of the frontal lobe. Studies using PET scans have confirmed that, in addition to the hippocampus, the left prefrontal lobe plays a role in encoding episodic memories, while the right prefrontal lobe is involved in their retrieval (Nyberg et al., 1996, 1996b).

We have described how researchers have been able to identify some of the brain structures that play a part in memory. But what processes within these structures make new memories?

Neuronal Changes in Memory: Brain Work

Some researchers are exploring memory more minutely, by studying the actions of single neurons. Others are studying collections of neurons and their synapses, and the neurotransmitters whose chemical action begins the process of recording and storing a memory. The first close look at the nature of memory in single neurons was provided by Eric Kandel and his colleagues, who traced the effects of learning and memory in the sea snail *Aplysia* (Dale & Kandel, 1990; Dash et al., 1990). Using tiny electrodes implanted in several single neurons in the sea snail, Kandel and his fellow researchers have been able to map neural circuits that are formed and maintained as the animal learns and remembers. Furthermore, they have discovered the different types of protein synthesis that facilitate short-term and long-term memory (Kandel et al., 1987; Sweatt & Kandel, 1989)

anterograde amnesia: The inability to form long-term memories of events occurring after brain surgery or a brain injury, although memories formed before the trauma are usually intact.

But the studies of learning and memory in *Aplysia* reflect only simple classical conditioning, which is a type of non-declarative memory. Other researchers are studying mammals and report that physical changes occur in the neurons and synapses in brain regions involved in declarative memory.

Long-Term Potentiation: Prolonged Action at the Synapses

What is long-term potentiation, and why is it important?

As far back as 1949, Canadian psychologist Donald O. Hebb argued that the necessary neural ingredients for learning and memory must involve the enhancement of transmission at the synapses. Hebb (1949) proposed that some process must operate at the synapse to initiate and maintain the continuous and simultaneous interaction of the presynaptic (sending) neurons and the postsynaptic (receiving) neurons. Such a process, he asserted, would strengthen the synaptic connection.

Today the most widely studied model for learning and memory at the level of the neurons is **long-term potentiation**, or LTP (Cotman & Lynch, 1989; Stein et al., 1993). LTP meets the requirements of the mechanism Hebb described (Fischbach, 1992). To *potentiate* means to make potent or to strengthen. LTP is a long-lasting increase in the efficiency of neural transmission at the synapses (Schuman & Madison, 1994). LTP has become the leading model for the facilitation of some types of long-term memory in mammals because it can last for days and even weeks (Bliss & Lomo, 1973; Nguyen et al., 1994). LTP is important because it may be the basis for learning and memory at the level of the neurons.

LTP does not take place unless *both* the presynaptic and postsynaptic neurons are activated at the same time by intense high-frequency stimulation. Also, the postsynaptic neuron must be depolarized (ready to fire) when stimulation arrives, or LTP will not occur. Increased neural activity at very fast frequencies (20–70 cycles per second) occurs at the synapses when learning and memory tasks are performed (Miltner et al., 1999) LTP is a common occurrence in the hippocampus, which, as you have learned, is essential in the formation of declarative memories. Much of the research on LTP has been conducted in various areas of the hippocampus (Eichenbaum & Otto, 1993).

If the types of changes in synapses produced by LTP are the same neural changes that take place in learning, then blocking or interfering with LTP should likewise interfere with learning. And it does. It appears that LTP is also involved in structural change in the neurons, as Hebb envisioned (Pinel, 1993).

Research in the biology of memory is exceedingly complex, and scientists are only beginning to provide compelling answers about the neurochemical nature of learning and memory.

Hormones and Memory

How do memories of threatening situations compare with ordinary memories?

The strongest and most lasting memories are usually those fuelled by emotion. Research by Cahill and colleagues (1995) suggests that there may be two pathways for forming memories—one for ordinary information and another for memories that are fired by emotion. When a person is emotionally aroused, the adrenal glands release the hormones adrenalin (epinephrine) and noradrenalin (norepinephrine) into the bloodstream. Long known to be involved in the "fight or flight response," these hormones enable humans to survive, and they also imprint powerful and enduring memories of the circumstances surrounding threatening situations.

Such emotionally laden memories activate the amygdala (known to play a central role in emotion) and other parts of the memory system (Gabrieli, 1998). Emotional memories are lasting memories, and this may be the most important factor in explaining the intensity and durability of flashbulb memories.

Other hormones may have important effects on memory. Estrogen, the female sex hormone, appears to improve learning and memory, not only in healthy women but in patients with Alzheimer's disease as well. Estrogen appears to exert this effect by helping to build and maintain synapses between neurons in brain areas known to be involved in memory, such as the hippocampal region (Woolley et al., 1997).

Improving Memory

Study Habits That Aid Memory

What are four study habits that can aid memory?

There are no magic formulas for improving your memory. Remembering is a skill and, like any other skill, requires knowledge and practice. In this section we will show you several study habits and techniques that can improve your memory.

Organization: Everything in Its Place

A telephone directory would be of little use to you if the names and phone numbers were listed in random order. In a similar way, you are giving your memory a task it probably will not accept if you try to remember large amounts of information in a haphazard fashion. Organizing material to be learned is a tremendous aid to memory. You can prove this for yourself by completing *Try It!*

We tend to retrieve information from long-term memory according to the way we have organized it for storage. Almost anyone can name the months of the year in about 12 seconds, but how long would it take to recall them in alphabetical order? The same 12 items, all well known, are much harder to retrieve in alphabetical order because they are not organized that way in memory. When you study, it is helpful to organize items in some meaningful way (in alphabetical order, or according to categories, historical sequence, size, or shape) to make retrieval easier.

Overlearning: Reviewing Again, and Again, and Again

What is overlearning, and why is it important?

Do you still remember the words to songs that were popular when you were in high school? Can you recite many of the nursery rhymes you learned as a child even though you haven't heard them in years? You probably can because of **overlearning**.

Let us say that you wanted to memorize a list of words, and you studied until you could recite the words once without error. Would this amount of study or practice be sufficient? Many studies suggest that we remember material better and longer if we overlearn it—that is, if we practise or study beyond the minimum needed to barely learn it (Ebbinghaus, 1885/1964). A pioneering study in overlearning by Krueger (1929) showed very substantial long-term gains for participants engaged in 50 and 100 percent overlearning. Furthermore, overlearning makes material more resistant to interference. It is perhaps your best insurance against stress-related forgetting.

The next time you study for a test, don't stop studying as soon as you think you know the material. Spend another hour or so going over it, and you will be surprised at how much more you will remember.

Spaced Versus Massed Practice: A Little at a Time Beats All at Once

We have all tried cramming for examinations, but spacing study over several different sessions generally is more effective than **massed practice**—learn-

long-term potentiation: A long-lasting increase in the efficiency of neural transmission at the synapses.

overlearning: Practising or studying material beyond the point where it can be repeated once without error.

massed practice: One long learning practice session as opposed to spacing the learning in shorter practice sessions over an extended period.

Try It!

Organizing Information to Aid Memory

Have a pencil and a sheet of paper handy. Read the following list of items out loud and then write down as many as you can remember.

peas	ice cream	fish	perfume	bananas
toilet paper	onions	apples	cookies	ham
carrots	shaving cream	pie	grapes	chicken

If you organize this list, the items are much easier to remember. Now read each category heading and the items listed beneath it. Write down as many items as you can remember.

Desserts	Fruits	Vegetables	Meat	Toilet Articles
pie	bananas	carrots	chicken	perfume
ice cream	apples	onions	fish	shaving cream
cookies	grapes	peas	ham	toilet paper

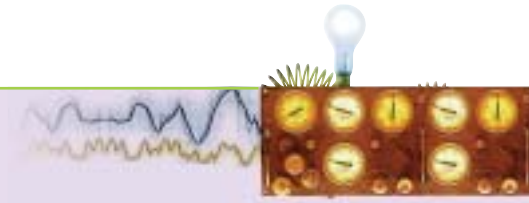
ing in one long practice session without rest periods (Bahrick & Phelps, 1987; Glover & Corkill, 1987). The spacing effect applies to learning motor skills as well as to learning facts and information. All music students can tell you that it is better to practise for half an hour each day, every day, than to practise for many hours in a row once a week.

You will remember more with less total study time if you space your study over several sessions. Long periods of memorizing make material particularly subject to interference and often result in fatigue and lowered concentration. Moreover, when you space your practice, you probably create a new memory that may be stored in a different place, and this increases your chances of recalling it.

Active Learning Versus Rereading: Active Learning Wins

Many students simply read and reread their textbook and notes when they study for an exam. Research over many years shows that you will recall more if you increase the amount of active learning in your study. For example, it is better to read a page or a few paragraphs and then practise recalling what you have just read. Even better, you should ask yourself questions as you read (Wood et al., 1990; Willoughby et al. 2000).

The *Apply It!* box offers a useful technique to help you remember certain material.



Apply It!

Improving Memory with Mnemonic Devices

We all use external aids to remember things. Writing notes, making lists, writing on a calendar, or keeping an appointment book is often more reliable and accurate than trusting our own memory. What if you need information at unpredictable times, when you do not have external aids handy?

Several *mnemonics*, or memory devices, have been developed over the years to aid memory. The mnemonic techniques we explore here are rhyme, the first-letter technique, and the keyword method (see Pressley et al., 1998; Wood et al., 1995).

Rhyme

Many of us use rhymes to help us remember material. Perhaps as a child you learned the alphabet by using a rhyming song:

A - B - C - D
E - F - G
H - I - J - K
L - M - N - O - P

You may repeat the verse "Thirty days hath September" when you try to recall the number of days in each month, or the saying "*i* before *e* except after *c*" when you are trying to spell a word. Rhymes are useful because they ensure that information is recalled in the proper sequence. Otherwise there is no rhyme.

The First-Letter Technique

Another useful technique is to take the first letter of each item to be remembered and form a word, a phrase, or a sentence with those letters (Matlin, 1989). For example, if you had to memorize the seven colours of the visible spectrum in their proper order, you could use the first letter of each colour to form the name Roy G. Biv. Three chunks are easier to remember than seven different ones.

Red Orange Yellow Green
Blue Indigo Violet

As a child taking music lessons, you may have learned the saying "*E*very *g*ood *b*aby *d*oes *f*ine" to remember the lines of the treble clef, and *F A C E* to remember the spaces.

The Method of Loci: "In the First Place"

The *method of loci* is a mnemonic device that you can use to remember things in a specific order. The word *loci* is the plural of *locus*, which is Latin for "location" or "place."

To use the method of loci, select any familiar location—your home, for example—and simply associate the items to be remembered with places there. You begin by picturing the first locus, for example, your driveway; the second locus, your garage; the third locus, the walk leading to your front door; and the fourth locus, perhaps the front hall closet. You progress through your house from room to room in an orderly fashion. Then you visualize the first item or idea you want to remember in its place on the driveway, the second item in your garage, the third at your front door, and so on until you have associated each word, idea, or item you want to remember with a

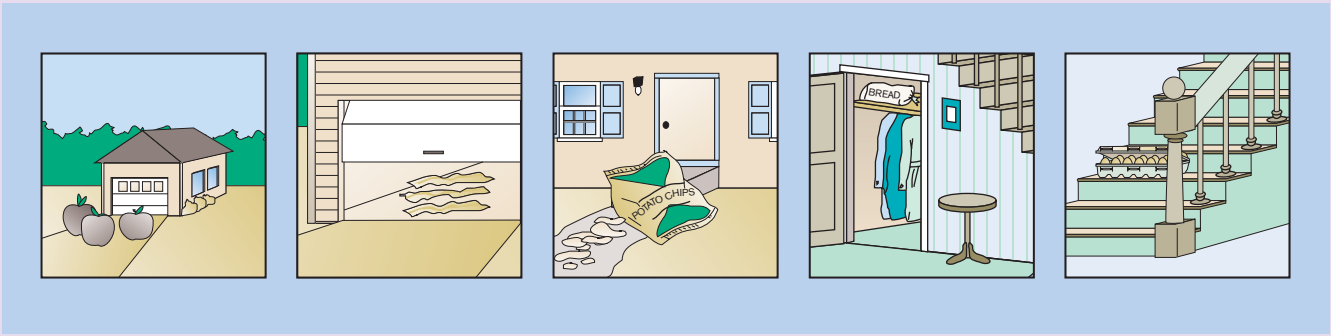


FIGURE 6.10

The Method of Loci **Begin by thinking of locations, perhaps in your home, that are in a sequence. Then visualize one of the items to be remembered in each location.**

specific place. You will probably find it helpful to conjure up exaggerated images of the items that you place at each location, as the examples in Figure 6.10 illustrate.

When you want to recall the items, take an imaginary walk starting at the first place, and the first idea will pop into your mind. When you think of the second place, the second idea will come to mind, and so on through all the places you visualize. The use of loci as a memory aid may be the origin of the phrase "in the first place."

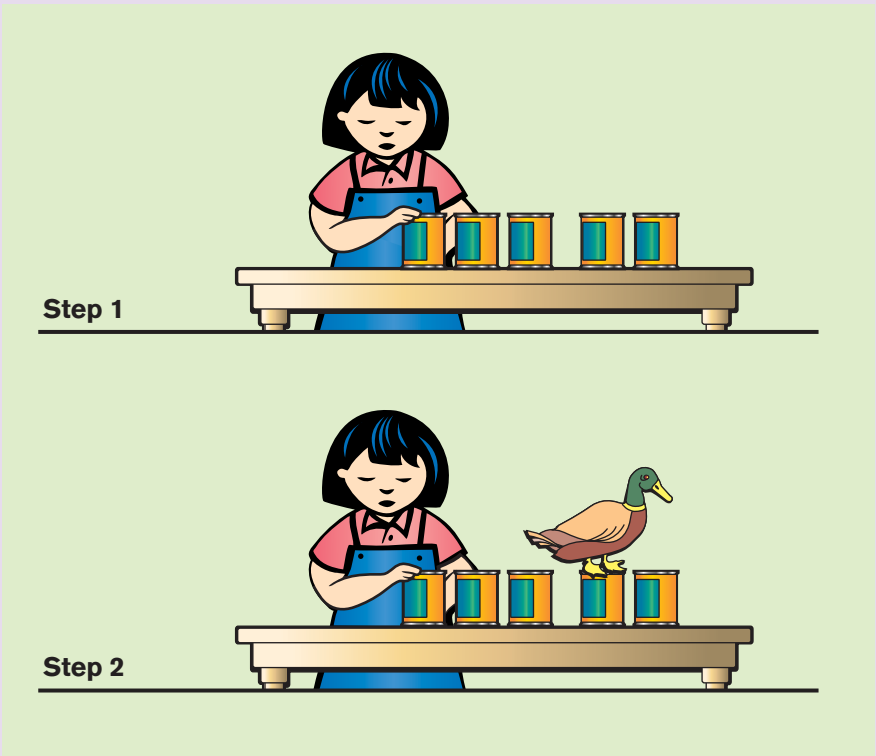
The Keyword Method

The keyword method is used primarily to assist in vocabulary and second-language learning. It has three steps, as illustrated in Figure 6.11. In Step 1, you take the new or foreign word that you have to remember and look for a familiar homonym (a word that sounds alike). For example, as an English speaker, I want to learn the French word for *duck* (*canard*). One homonym might be *canner*. This is a good homonym because it is easy to make a mental picture of someone making a can. In Step 2, you construct an image of the homonym and the meaning of the word (canard = duck). The image would be of a duck sitting in a can. Vivid images work better, so my duck is flapping his wings in the can. In Step 3, you try to remember. When you see the word "canard," you think of the homonym (canner) and ask yourself, "Who in my picture was in the can?" The answer is "duck." If, on the other hand, you are asked for a translation for the word "duck," you try to imagine what the duck was doing. This gives you "canner," which acts as a cue for the word "canard."

Extensive work was done on the keyword method and foreign language learning by Michael Pressley at the University of Western Ontario.

FIGURE 6.11

The Keyword Method **Here are the two steps for the keyword strategy. In Step 1, you picture something that sounds like the word you have to learn, such as "canner" for "canard." In Step 2, you make an interactive image with the sound-alike picture and a picture of the real word you have to learn ("duck in a can" for "canard").**



The Biology of Memory and Ways to Improve Memory

Remember It!

1. The hippocampus is the brain structure involved in the formation of permanent memories of
   a. motor skills.
   b. facts and personal experiences.
   c. motor skills, facts, and personal experiences.
   d. motor skills and personal experiences.
2. What is the term for the long-lasting increase in the efficiency of neural transmission at the synapses that may be the basis for learning and memory at the level of the neurons?
   a. long-term potentiation
   b. synaptic facilitation
   c. synaptic potentiation
   d. presynaptic potentiation
3. When studying for an exam, it is best to spend
   a. more time reciting than rereading.
   b. more time rereading than reciting.
   c. equal time rereading and reciting.
   d. all of the time reciting rather than rereading.
4. Being able to recite a number of nursery rhymes from childhood is probably due mainly to
   a. spaced practice.
   b. organization.
   c. mnemonics.
   d. overlearning.

Answers: 1. b 2. a 3. d 4. d

KEY TERMS

amnesia, p. 192
anterograde amnesia, p. 202
consolidation, p. 179
consolidation failure, p. 190
decay theory, p. 191
declarative memory, p. 184
displacement, p. 182
eidetic imagery, p. 198
encoding, p. 178
encoding failure, p. 189
episodic memory, p. 184
flashbulb memory, p. 197
infantile amnesia, p. 196
interference, p. 191
levels-of-processing model, p. 186
long-term memory, p. 183
long-term potentiation, p. 204
massed practice, p. 206
motivated forgetting, p. 192
non-declarative memory, p. 184
nonsense syllable, p. 188
overlearning, p. 205
primacy effect, p. 200
recall, p. 187
recency effect, p. 200
recognition, p. 187
reconstruction, p. 194
rehearsal, p. 182
relearning method, p. 187
repression, p. 192
retrieval, p. 179
retrieval cue, p. 187
retrograde amnesia, p. 190
savings score, p. 188
schemas, p. 194
selective attention, p. 179
semantic memory, p. 184
sensory memory, p. 180
serial position effect, p. 200
short-term memory, p. 181
state-dependent memory effect, p. 201
storage, p. 179

THINKING CRITICALLY

Evaluation

Some studies cited in this chapter involved only one or a few participants.

a. Select two of these studies and discuss the possible problems in drawing conclusions on the basis of studies using so few participants.
b. Suggest several possible explanations for the researchers' findings other than those proposed by the researchers.
c. In your view, should such studies even be mentioned in a textbook? Why or why not?

Point/Counterpoint

Using what you have learned in this chapter on memory, prepare an argument citing cases and specific examples to support each of these positions:

a. Long-term memory is a permanent record of our experiences.
b. Long-term memory is not necessarily a permanent record of our experiences.

Psychology in Your Life

Drawing upon your knowledge, formulate a plan that you can put into operation to help improve your memory and avoid the pitfalls that cause forgetting.

SUMMARY & REVIEW

Remembering

What three processes are involved in the act of remembering?

Three processes involved in remembering are (1) encoding–transforming information into a form that can be stored in memory; (2) storage–maintaining information in memory; and (3) retrieval–bringing stored material to mind.

What is sensory memory?

Sensory memory holds information coming in through the senses for up to several seconds, just long enough for us to begin to process the information and send some on to short-term memory.

What are the characteristics of short-term memory?

Short-term (working) memory holds about seven unrelated items of information for less than 30 seconds without rehearsal. Short-term memory also acts as our mental workspace while we carry out any mental activity.

What is long-term memory, and what are its subsystems?

Long-term memory is the permanent or relatively permanent memory system with a virtually unlimited capacity. Its subsystems are (1) declarative memory, which holds facts and information (semantic memory) and personal life experiences (episodic memory); and (2) non-declarative memory, which consists of motor skills acquired through repetitive practice, habits, and simple classically conditioned responses.

Measuring Memory

What are three methods of measuring retention?

Three methods of measuring retention are (1) recall, whereby information must be supplied with few or no retrieval cues; (2) recognition, whereby information must simply be recognized as having been encountered before; and (3) the relearning method, which measures retention in terms of time saved in relearning material compared with the time required to learn it originally.

What was Ebbinghaus's major contribution to psychology?

Hermann Ebbinghaus conducted the first experimental studies of learning and memory. He invented the nonsense syllable, conceived the relearning method as a test of memory, and plotted the curve of forgetting.

Forgetting

What are six causes of forgetting?

Six causes of forgetting are encoding failure, consolidation failure, decay, interference, motivated forgetting, and retrieval failure.

What is interference, and how can it be minimized?

Interference occurs when information or associations stored either before or after a given memory hinder our ability to remember it. To minimize interference, follow a learning activity with sleep, and arrange learning so that similar subjects are not studied back to back.

The Nature of Remembering and Forgetting

What is meant by the statement "Memory is reconstructive in nature"?

Our memory does not work like a video recorder. We reconstruct memories, piecing them together from a few highlights and using information that may or may not be accurate.

What is Bartlett's contribution to our understanding of memory?

Sir Frederick Bartlett found that people do not recall facts and experiences detail by detail. Rather, they systematically reconstruct and distort them to fit information already stored in memory.

What are schemas, and how do they affect memory?

Schemas are the integrated frameworks of knowledge and assumptions we have about people, objects, and events; schemas affect how we encode and recall information.

What conditions reduce the reliability of eyewitness testimony?

The reliability of eyewitness testimony is reduced when witnesses view a photograph of the suspect before viewing the lineup, when members of a lineup are viewed at the same time rather than one by one, when the perpetrator is of a different race from that of the eyewitness, when a weapon has been used in the crime, and when leading questions are asked to elicit information.

Does hypnosis improve the memory of eyewitnesses?

Hypnotized subjects supply more information and are more confident of their recollections, but they supply more inaccurate information as well.

Factors Influencing Retrieval

What is the serial position effect?

The serial position effect is the tendency, when a person is recalling a list of items, to remember the items at the beginning of the list (primacy effect) and the items at the end of the list (recency effect) better than items in the middle.

How does environmental context affect memory?

People tend to recall material more easily if they are in the same physical location during recall as during the original learning.

What is the state-dependent memory effect?

The state-dependent memory effect is our tendency to recall information better if we are in the same pharmacological or psychological state as when the information was learned.

Biology and Memory

What has the study of H.M. revealed about the role of the hippocampus in memory?

The case of H.M. reveals that the hippocampus is essential in forming declarative memories but not in forming non-declarative memories.

What is long-term potentiation, and why is it important?

Long-term potentiation (LTP) is a long-lasting increase in the efficiency of neural transmission at the synapses. LTP is important because it may be the basis for learning and memory at the level of the neurons.

How do memories of threatening situations compare with ordinary memories?

Memories of threatening situations tend to be more powerful and enduring than ordinary memories.

Improving Memory

What are four study habits that can aid memory?

Four study habits that can aid memory are organization, overlearning, the use of spaced rather than massed practice, and the use of a higher percentage of time reciting than rereading material.

What is overlearning, and why is it important?

Overlearning means practising or studying material beyond the point where it can be repeated once without error. Material that is overlearned is remembered better and longer, and it is more resistant to interference and stress-related forgetting.