3 MEMORY

What Is Memory? | Encoding | Storage | Retrieval and Forgetting

Twentieth-century playwright Tennessee Williams once commented that life is all memory except for that one present moment that goes by so quickly that you can hardly catch it going. But just what is memory?

memory The retention of information over time, which involves encoding, storage, and retrieval.

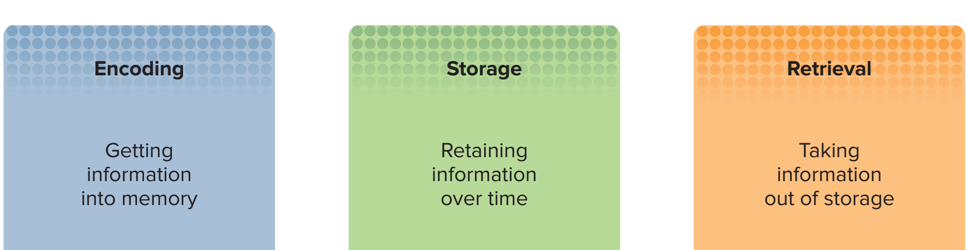
WHAT IS MEMORY?

Memory is the retention of information over time. Educational psychologists study how information is initially placed or encoded into memory, how it is retained or stored after being encoded, and how it is found or retrieved for a certain purpose later. Memory anchors the self in continuity. Without memory you would not be able to connect what happened to you yesterday with what is going on in your life today. Today, the emphasis not on how children add something to memory but rather to underscore how children actively construct their memory (Howe, 2015).

The main body of our discussion of memory will focus on encoding, storage, and retrieval. Thinking about memory in terms of these processes should help you to understand it better (see Figure 1). For memory to work, children have to take information in, store it or represent it, and then retrieve it for some purpose later.

FIGURE 1 PROCESSING INFORMATION IN MEMORY

As you read about the many aspects of memory in this chapter, think about the organization of memory in terms of these three main activities: encoding, storage, and retrieval.



As you learned earlier, *encoding* is the process by which information gets into memory. *Storage* is the retention of information over time. *Retrieval* means taking information out of storage. Let's now explore each of these three important memory activities in greater detail.

ENCODING

Attention is a key aspect of the encoding process (Schneider, 2015). By focusing their attention, as children listen to a teacher, do homework, write a paper, read a book, watch a movie, listen to music, or talk with a friend, they can encode the information into memory. In addition to attention, encoding consists of a number of processes: rehearsal, deep processing, elaboration, constructing images, and organization.

Rehearsal **Rehearsal** is the conscious repetition of information over time to increase the length of time information stays in memory. For example, when you make a date to meet your best friend for lunch, you are likely to repeat, or rehearse, the date and time: "OK—Wednesday at 1:30." Rehearsal works best when you need to encode and remember a list of items for a brief period of time. When you must retain information over long periods of time, as when you are studying for a test you won't take until next week, other strategies usually work better than rehearsal. Rehearsal does not work well for retaining information over the long term because it often involves just rote repetition of information without imparting any meaning to it. When you construct your memory in meaningful ways, you remember better. As we will see next, you also remember better when you process material deeply and elaborate it.

Deep Processing Following the discovery that rehearsal is not an efficient way to encode information for long-term memory, Fergus Craik and Robert Lockhart (1972) proposed that we can process information at a variety of levels. Their **levels of processing theory** states that the processing of memory occurs on a continuum from shallow to deep, with deeper processing producing better memory. Shallow processing means analyzing the sensory, or physical, features of a stimulus at a shallow level. This might involve detecting the lines, angles, and contours of a printed word's letters or a spoken word's frequency, duration, and loudness. At an intermediate level of processing, you recognize the stimulus and give it a label. For example, you identify a four-legged, barking object as a dog. Then, at the deepest level, you process information semantically, in terms of its meaning. For example, if a child sees the word *boat*, at the shallow level she might notice the shapes of the letters, at the intermediate level she might think of the characteristics of the word (for instance, that it rhymes with *coat*), and at the deepest level she might think about the last time she went fishing with her dad on a boat and the kind of boat it was. Researchers have found that individuals remember information better when they process it at a deep level (Abbassi & others, 2015; Soravia & others, 2016).

Elaboration Cognitive psychologists soon recognized, however, that there is more to good encoding than just depth of processing. They discovered that when individuals use elaboration in their encoding of information, their memory benefits (Ashcraft & Radvansky, 2016). **Elaboration** is the extensiveness of information processing involved in encoding. Thus, when you present the concept of democracy to students, they likely will remember it better if they come up with good examples of it. Thinking of examples is a good way to elaborate information. For instance, self-reference is an effective

rehearsal The conscious repetition of information over time to increase the length of time information stays in memory.

levels of processing theory The theory that processing of memory occurs on a continuum from shallow to deep, with deeper processing producing better memory.

elaboration The extensiveness of information processing involved in encoding.

way to elaborate information. If you are trying to get students to remember the concept of fairness, the more they can generate personal examples of inequities and equities they have personally experienced, the more likely they are to remember the concept.

The use of elaboration changes developmentally (McDonnell & others, 2016). Adolescents are more likely to use elaboration spontaneously than children are. Elementary school children can be taught to use elaboration strategies on a learning task, but they are less likely than adolescents to use the strategies on other learning tasks in the future. Nonetheless, verbal elaboration can be an effective memory strategy even with young elementary school children. In one study, the experimenter told second- and fifth-grade children to construct a meaningful sentence for a keyword (such as "The postman carried a letter in his cart" for the keyword *cart*) (Pressley, Levin, & McCormick, 1980). Both second- and fifth-grade children remembered the keywords better when they constructed a meaningful sentence containing the word than when the keyword and its definition were told to the child.

One reason elaboration works so well in encoding is that it adds to the distinctiveness of memory code (Hofmeister & Vasishth, 2014). To remember a piece of information, such as a name, an experience, or a fact about geography, students need to search for the code that contains this information among the mass of codes in their long-term memory. The search process is easier if the memory code is unique. The situation is not unlike searching for a friend at a crowded airport—if your friend is 6 feet 3 inches tall and has flaming red hair, it will be easier to find him in the crowd than if he has more common features. Also, as a student elaborates information, more information is stored. And as more information is stored, it becomes easier to differentiate the memory from others. For example, if a student witnesses another student being hit by a car that speeds away, the student's memory of the car will be far better if she deliberately encodes her observations that the car is a red 2005 Pontiac with tinted windows and spinners on the wheels than if she observes only that it is a red car.

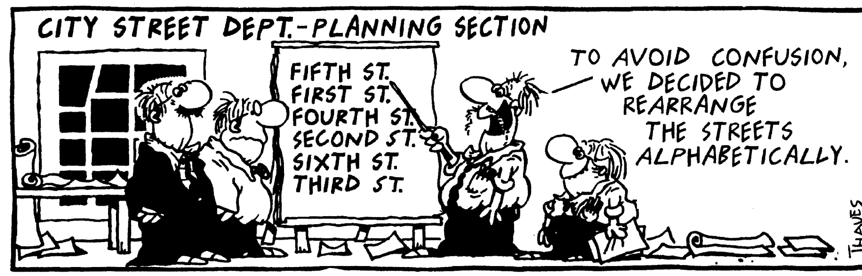
Constructing Images When we construct an image of something, we are elaborating the information. For example, how many windows are there in the apartment or house where your family has lived for a substantial part of your life? Few of us ever memorize this information, but you probably can come up with a good answer, especially if you reconstruct a mental image of each room.

Allan Paivio (1971, 1986, 2013) argues that memories are stored in one of two ways: as verbal codes or as image codes. For example, you can remember a picture by a label (*The Last Supper,* a verbal code) or by a mental image. Paivio says that the more detailed and distinctive the image code is, the better your memory of the information will be.

Researchers have found that encouraging children to use imagery to remember verbal information works better for older children than for younger children (Schneider, 2004). In one study, experimenters presented 20 sentences to first- through sixth-grade children to remember (such as "The angry bird shouted at the white dog" and "The policeman painted the circus tent on a windy day") (Pressley & others, 1987). Children were randomly assigned to an imagery condition (make a picture in your head for each sentence) and a control condition (children were told just to try hard). The imagery instructions improved memory more for the older children (grades 4 through 6) than for the younger children (grades 1 through 3). Researchers have found that young elementary school children can use imagery to remember pictures better than they can use it to remember verbal materials such as sentences (Schneider & Pressley, 1997).

Organization If students organize information when they are encoding it, their memory benefits (Schneider, 2015). To understand the importance of organization in encoding, complete the following exercise: Recall the 12 months of the year as quickly as you can. How long did it take you? What was the order of your recall? Your answers are probably a few seconds and in natural order (January, February, March, and so on). Now try to remember the months in alphabetical order. Did you make any errors? How long did it take you? There is a clear distinction between recalling the months in natural order and recalling alphabetically. This exercise is a good one to use with your students to help them understand the importance of organizing their memories in meaningful ways.

When you present information in an organized way, your students are more likely to remember it. This is especially true if you organize information hierarchically or outline it. Also, if you simply encourage students to organize information, they often will remember it better than if you give them no instructions about organizing (Mandler, 1980).



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Chunking is a beneficial organizational memory strategy that involves grouping, or "packing," information into "higher-order" units that can be remembered as single units. Chunking works by making large amounts of information more manageable and more meaningful. For example, consider this simple list of words: *hot, city, book, forget, tomorrow, smile.* Try to hold these in memory for a moment, and then write them down. If you recalled all six words, you succeeded in holding 30 letters in your memory. But it would have been much more difficult to try to remember those 30 letters. Chunking them into words made them meaningful.

STORAGE

After children encode information, they need to retain, or store, the information. Children remember some information for less than a second, some for about half a minute, and other information for minutes, hours, years, even a lifetime. The three types of memory, which correspond to these different time frames, are *sensory memory* (which lasts a fraction of a second to several seconds); *short-term memory* (lasts about 30 seconds); and *long-term memory* (which lasts up to a lifetime).

DEVELOPMENT

Sensory Memory

Sensory memory holds information from the world in its original sensory form for only an instant, not much longer than the brief time a student is exposed to the visual, auditory, and other sensations.

Students have a sensory memory for sounds for up to several seconds, similar to a brief echo. However, their sensory memory for visual images lasts only for about one-fourth of a second. Because sensory information lasts for only a fleeting moment, an important task for the student is to attend to the sensory information that is important for learning quickly, before it fades.

Short-Term Memory

Short-term memory is a limited-capacity memory system in which information is retained for as long as 30 seconds, unless the information is rehearsed or otherwise processed further, in which case it can be retained longer. Compared with sensory memory, short-term memory is limited in capacity but relatively longer in duration. Its limited capacity intrigued George Miller (1956), who described this in a paper with a catchy title: "The Magical Number Seven, Plus or Minus Two." Miller pointed out that on many tasks, students are limited in how much information they can keep track of without external aids. Usually the limit is in the range of 7 +/– 2 items.

The most widely cited example of the 7 +/– 2 phenomenon involves **memory span,** the number of digits an individual can report back without error from a single presentation. How many digits individuals can report back depends on how old they are. In one study, memory span increased from two digits in 2-year-olds, to five digits in 7-year-olds, to six to seven digits in 12-year-olds (Dempster, 1981) (see Figure 2). Many college students can handle lists of eight or nine digits. Keep in mind that these are averages and that individuals differ. For example, many 7-year-olds have a memory span of fewer than six or seven digits; others have a memory span of eight or more digits.

Related to short-term memory, British psychologist Alan Baddeley (2000, 2007, 2012, 2013) proposed that **working memory** is a three-part system that temporarily holds information as people perform tasks. Working memory is a kind of mental

chunking Grouping, or "packing," information into "higher-order" units that can be remembered as single units.

sensory memory Memory that holds information from the world in its original form for only an instant.

short-term memory A limited-capacity memory system in which information is retained for as long as 30 seconds, unless the information is rehearsed, in which case it can be retained longer.

memory span The number of digits an individual can report back without error in a single presentation.

working memory A three-part system that holds information temporarily as a person performs a task. A kind of "mental workbench" that lets individuals manipulate, assemble, and construct information when they make decisions, solve problems, and comprehend written and spoken language.

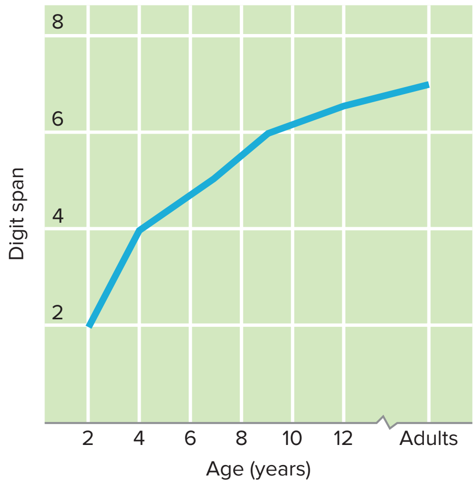

FIGURE 2 DEVELOPMENTAL CHANGES IN MEMORY SPAN

In one study, memory span increased from two digits at 2 years of age to five digits at 7 years of age (Dempster, 1981). By 12 years of age, memory span had increased on average another one and a half digits.

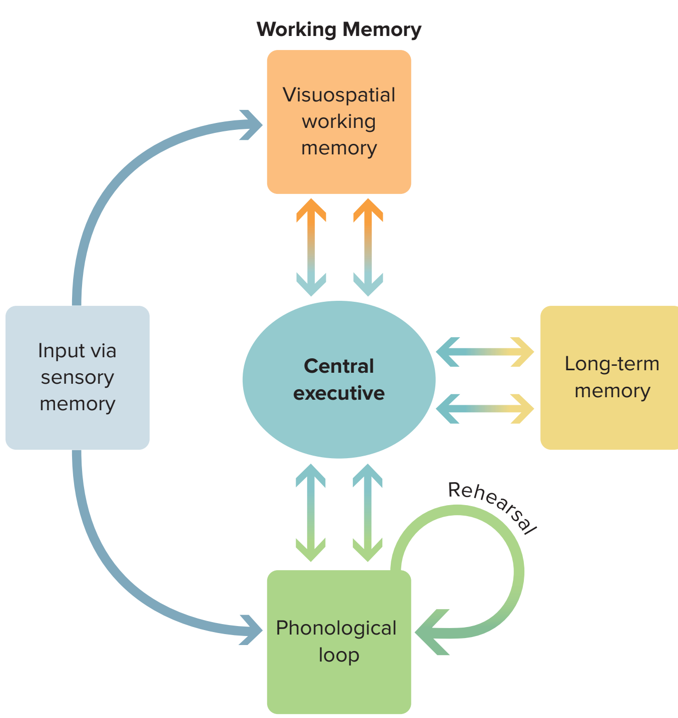

FIGURE 3 BADDELEY'S WORKING MEMORY MODEL

In Baddeley's working memory model, working memory consists of three main components: the phonological loop, visuospatial working memory, and the central executive. The phonological loop and visuospatial working memory serve as assistants, helping the central executive do its work. Input from sensory memory goes to the phonological loop, where information about speech is stored and rehearsal takes place, and to visuospatial working memory, where visual and spatial information, including imagery, is stored. Working memory is a limited-capacity system, and information is stored there for only a brief time. Working memory interacts with long-term memory, drawing information from long-term memory and transmitting information to long-term memory for longer storage.

"workbench" where information is manipulated and assembled to help us make decisions, solve problems, and comprehend written and spoken language. Notice that working memory is not like a passive storehouse with shelves to store information until it moves to long-term memory. Rather, it is a very active memory system (Logie & Cowan, 2015).

Figure 3 shows Baddeley's view of working memory and its three components: phonological loop, visuospatial working memory, and central executive. Think of them as an executive (central executive) with two assistants (phonological loop and visuospatial working memory) to help do your work.

- The *phonological loop* is specialized to briefly store speech-based information about the sounds of language. The phonological loop contains two separate components: an acoustic code, which decays in a few seconds, and rehearsal, which allows individuals to repeat the words in the phonological store.
- *Visuospatial working memory* stores visual and spatial information, including visual imagery. Like the phonological loop, visuospatial working memory has a limited capacity. The phonological loop and visuospatial working memory function independently. You could rehearse numbers in the phonological loop while making spatial arrangements of letters in visuospatial working memory.
- The *central executive* integrates information not only from the phonological loop and visuospatial working memory but also from long-term memory. In Baddeley's view, the central executive plays important roles in attention, planning, and organizing behavior. The central executive acts much like a supervisor who determines which information and issues deserve attention and which should be ignored. It also selects which strategies to use to process information and solve problems. As with the other two components of working memory—the phonological loop and visuospatial working memory—the central executive has a limited capacity.

Working memory develops gradually. Even by 8 years of age, children can only hold in memory half the items that adults can remember (Kharitonova, Winter, & Sheridan, 2015). Working memory is linked to many aspects of children's development (Bigorra & others, 2016; Gerst & others, 2016). For example, children who have better working memory are more advanced in reading comprehension, math skills, and problem solving than their counterparts with less effective working memory (Swanson, 2016).

The following recent studies reflect the strength of working memory to improve children's performance in these areas:

- Verbal working memory played a key role in 7- to 11-year-old children's ability to follow instructions over extended periods of activity (Jaroslawska & others, 2016).
- Children with better working memory had higher academic achievement in math fluency, calculation, reading fluency, and passage comprehension (Blankenship & others, 2015).
- Children's verbal working memory was linked to these aspects of language acquisition in both first- and second-language learners: morphology, syntax, and grammar (Verhagen & Leseman, 2016). However, their verbal working memory was not related to vocabulary development.
- A working memory training program (CogMed) implemented when students were in the fourth grade was linked to higher achievement in math and reading two years later in the sixth grade than a control group of children who

- received education as usual (Soderqvist & Bergman, 2015). To learn more about the CogMed working memory training program for children and how it can be used in classrooms, go to www.cogmed.com/educators
- A working memory training program improved the arithmetic problem-solving skills of 8- to 10-year-olds (Cornoldi & others, 2015).
- A working memory training program improved the listening comprehension skills of first-grade children (Peng & Fuchs, 2016).

Is the working memory of adolescents better than the working memory of children? One study found that it was (Swanson, 1999). Investigators examined the performance of children and adolescents on both verbal and visuospatial working memory tasks. Working memory increased substantially from 8 through 24 years of age no matter what the task. Thus, the adolescent years are likely to be an important developmental period for improvement in working memory.

Long-Term Memory **Long-term memory** is a type of memory that holds enormous amounts of information for a long period of time in a relatively permanent fashion. A typical human's long-term memory capacity is staggering, and the efficiency with which individuals can retrieve information is impressive. It often takes only a moment to search through this vast storehouse to find the information we want. Think about your own long-term memory. Who wrote the Gettysburg Address? Who was your first-grade teacher? You can answer thousands of such questions instantly. Of course, not all information is retrieved so easily from long-term memory.

A Model of the Three Memory Stores This three-stage concept of memory we have been describing was developed by Richard Atkinson and Richard Shiffrin (1968). According to the **Atkinson-Shiffrin model,** memory involves a sequence of sensory memory, short-term memory, and long-term memory stages (see Figure 4). As we have seen, much information makes it no further than the sensory memories of sounds and sights. This information is retained only for a brief instant. However, some information, especially that to which we pay attention, is transferred to short-term memory, where it can be retained for about 30 seconds (or longer with the aid of rehearsal). Atkinson and Shiffrin claimed that the longer information is retained in short-term memory through the use of rehearsal, the greater its chance is of getting into long-term memory. Notice in Figure 4 that information in long-term memory also can be retrieved back into short-term memory.

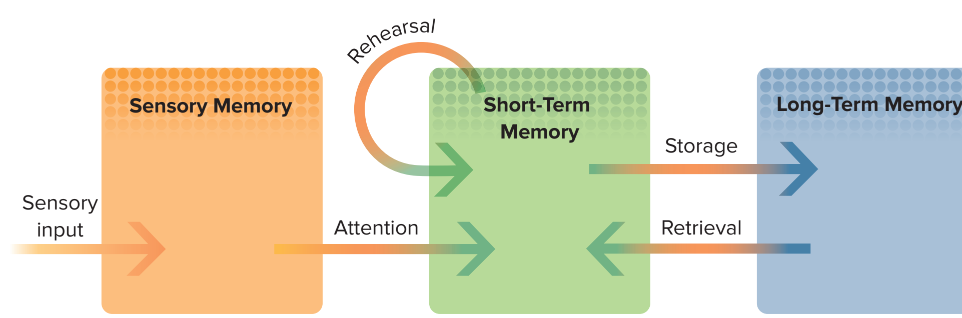

FIGURE 4 ATKINSON AND SHIFFRIN'S MODEL OF MEMORY

In this model, sensory input goes into sensory memory. Through the process of attention, information moves into short-term memory, where it remains for 30 seconds or less, unless it is rehearsed. When the information goes into long-term memory storage, it can be retrieved throughout a person's lifetime.

Some contemporary experts on memory believe that the Atkinson-Shiffrin model is too simple (Bartlett, 2015). They argue that memory doesn't always work in a neatly packaged three-stage sequence, as Atkinson and Shiffrin proposed. For example, these contemporary experts stress that *working memory* uses long-term memory's contents in more flexible ways than simply retrieving information from it. Despite these problems, the model is useful in providing an overview of some components of memory.

Long-Term Memory's Contents Just as different types of memory can be distinguished by how long they last, memory can be differentiated on the basis of its contents. For long-term memory, many contemporary psychologists accept the hierarchy of contents described in Figure 5 (Bartlett, 2015). In this hierarchy, long-term memory is divided into the subtypes of declarative and procedural memory. Declarative memory is subdivided into episodic memory and semantic memory.

long-term memory A type of memory that holds enormous amounts of information for a long period of time in a relatively permanent fashion.

Atkinson-Shiffrin model A model of memory that involves a sequence of three stages: sensory memory, short-term memory, and long-term memory.

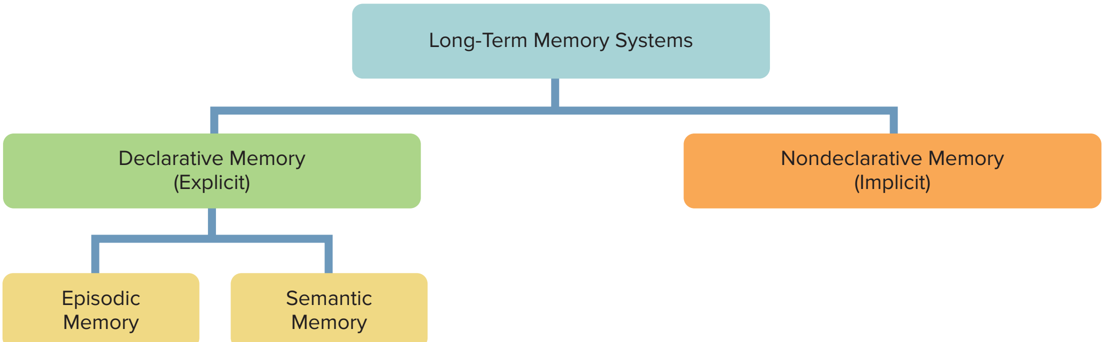

FIGURE 5 CLASSIFICATION OF LONG-TERM MEMORY'S CONTENTS

Declarative and Procedural Memory **Declarative memory** is the conscious recollection of information, such as specific facts or events that can be verbally communicated. Declarative memory has been called "knowing that" and more recently has been labeled "explicit memory." Demonstrations of students' declarative memory could include recounting an event they have witnessed or describing a basic principle of math. However, students do not need to be talking in order to use declarative memory. If students simply sit and reflect on an experience, their declarative memory is involved.

Procedural memory is nondeclarative knowledge in the form of skills and cognitive operations. Procedural memory cannot be consciously recollected, at least not in the form of specific events or facts. This makes procedural memory difficult, if not impossible, to communicate verbally. Procedural memory is sometimes called "knowing how," and it also has been described as "implicit memory." When students apply their abilities to perform a dance, ride a bicycle, or type on a computer keyboard, their procedural memory is at work. It also is at work when they speak grammatically correct sentences without having to think about how to do it.

declarative memory The conscious recollection of information, such as specific facts or events that can be verbally communicated.

procedural memory Nondeclarative knowledge in the form of skills and cognitive operations. Procedural memory cannot be consciously recollected, at least not in the form of specific events or facts.

episodic memory The retention of information about the where and when of life's happenings.

semantic memory An individual's general knowledge about the world, independent of the individual's identity with the past.

network theories Theories that describe how information in memory is organized and connected; they emphasize nodes in the memory network.

Episodic and Semantic Memory Cognitive psychologist Endel Tulving (2000) distinguishes between two subtypes of declarative memory: episodic and semantic. **Episodic memory** is the retention of information about the where and when of life's happenings. Students' memories of the first day of school, whom they had lunch with, or the guest who came to talk with their class last week are all episodic.

Semantic memory is a student's general knowledge about the world. It includes the following:

- Knowledge of the sort learned in school (such as knowledge of geometry)
- Knowledge in different fields of expertise (such as knowledge of chess, for a skilled 15-year-old chess player)
- "Everyday" knowledge about meanings of words, famous people, important places, and common things (such as what the word *pertinacious* means or who Nelson Mandela is)

Semantic memory is independent of the person's identity with the past. For example, students might access a fact—such as "Lima is the capital of Peru"—and not have the foggiest idea when and where they learned it. Figure 6 compares the characteristics of episodic and semantic memory.

Characteristic	Episodic Memory	Semantic Memory
Units	Events, episodes	Facts, ideas, concepts
Organization	Time	Concepts
Emotion	More important	Less important
Retrieval process	Deliberate (effortful)	Automatic
Retrieval report	"I remember"	"I know"
Education	Irrelevant	Relevant
Intelligence	Irrelevant	Relevant
Legal testimony	Admissible in court	Inadmissible in court

FIGURE 6 SOME DIFFERENCES BETWEEN EPISODIC & SEMANTIC MEMORY

These characteristics have been proposed as the main ways to differentiate episodic from semantic memory.

Representing Information in Memory

How do students represent information in their memory? Three main theories have addressed this question: network, schema, and fuzzy trace.

Network Theories **Network theories** describe how information in memory is organized and connected. They emphasize nodes in the memory network. The nodes stand for labels or concepts. Consider the concept "bird." One of the earliest network theories described memory representation as hierarchically arranged, with more-concrete concepts ("canary," for example) nestled under more abstract concepts (such as "bird"). However, it soon became clear that such hierarchical networks are too neat to accurately portray how memory representation really works. For example, students take longer to answer the question "Is an ostrich a bird?" than to answer the question "Is a canary a bird?" Thus, today memory researchers envision the memory network as more irregular and distorted (Ashcraft & Radvansky, 2016). A typical bird, such as a canary, is closer to the node, or center, of the category "bird" than is the atypical ostrich.

Schema Theories Long-term memory has been compared with a library of books. The idea is that our memory stores information just as a library stores books. In this analogy, the way students retrieve information is said to be similar to the process they use to locate and check out a book. The process of retrieving information from long-term memory, however, is not as precise as the library analogy suggests. When we search through our long-term memory storehouse, we don't always find the exact "book" we want, or we might find the "book" we want but discover that only "several pages" are intact—we have to reconstruct the rest.

Schema theories state that when we reconstruct information, we fit it into information that already exists in our mind. A **schema** is information—concepts, knowledge, information about events—that already exists in a person's mind. Unlike network theories, which assume that retrieval involves specific facts, schema theory claims that long-term memory searches are not very exact. We often don't find precisely what we want, and we have to reconstruct the rest. Often when asked to retrieve information, we fill in the gaps between our fragmented memories with a variety of accuracies and inaccuracies.

We have schemas for all sorts of information (Gluck, Mercado, & Myers, 2016). If you tell virtually any story to your class and then ask the students to write down what the story was about, you likely will get many different versions. That is, your students won't remember every detail of the story you told and will reconstruct the story with their own particular stamp on it. Suppose you tell your class a story about two men and two women who were involved in a train crash in France. One student might reconstruct the story by saying the characters died in a plane crash, another might describe three men and three women, another might say the crash was in Germany, and so on. The reconstruction and distortion of memory is nowhere more apparent than in the memories given by courtroom witnesses. In criminal court trials, the variations in people's memories of what happened underscores how we reconstruct the past rather than take an exact photograph of it.

In sum, schema theory accurately predicts that people don't always coldly store and retrieve bits of data in a computer-like fashion. The mind can distort an event as it encodes and stores impressions of reality.

A **script** is a schema for an event. Scripts often have information about physical features, people, and typical occurrences. This kind of information is helpful when teachers and students need to figure out what is happening around them. In a script for an art activity, students likely will remember that you will instruct them on what to draw, that they are supposed to put on smocks over their clothes, that they must get the art paper and paints from the cupboard, that they are to clean the brushes when they are finished, and so on. For example, a student who comes in late to the art activity likely knows much of what to do because he has an art activity script.

Fuzzy Trace Theory Another variation of how individuals reconstruct their memories is **fuzzy trace theory,** which states that when individuals encode information it creates two types of memory representations: (1) a *verbatim memory trace*, which consists of precise details; and (2) a *fuzzy trace*, or gist, which is the central idea of the information (Brainerd & others, 2006, 2015; Brainerd & Reyna, 2014). For example, consider a child who is presented with information about a pet store that has 10 birds, 6 cats, 8 dogs, and 7 rabbits. Then the child is asked two different types of questions: (1) verbatim questions, such as "How many cats are in the pet store, 6 or 8?" and (2) gist questions, such as "Are there more cats or more dogs in the pet store?" Researchers have found that preschool children tend to remember verbatim information better than gist

schema theories Theories that when we construct information, we fit it into information that already exists in our mind.

schema Information—concepts, knowledge, information about events—that already exists in a person's mind.

script A schema for an event.

fuzzy trace theory States that memory is best understood by considering two types of memory representations: (1) verbatim memory trace and (2) fuzzy trace, or gist. In this theory, older children's better memory is attributed to the fuzzy traces created by extracting the gist of information.

information, but elementary-school-aged children are more likely to remember gist information (Brainerd & Reyna, 2014). Thus, in fuzzy trace theory, the increased use of gist information by elementary-school-aged children accounts for their improved memory, because fuzzy traces are less likely to be forgotten than verbatim traces.

RETRIEVAL AND FORGETTING

After students have encoded information and then represented it in memory, they might be able to retrieve some of it but might also forget some of it. What factors influence whether students can retrieve information?

Retrieval When we retrieve something from our mental "data bank," we search our store of memory to find the relevant information. Just as with encoding, this search can be automatic or it can require effort. For example, if you ask your students what month it is, the answer will immediately spring to their lips. That is, the retrieval will be automatic. But if you ask your students to name the guest speaker who came to the class two months earlier, the retrieval process likely will require more effort.

An item's position on a list also affects how easy or difficult it will be to remember it. In the **serial position effect,** recall is better for items at the beginning and end of a list than for items in the middle. Suppose that when you give a student directions about where to go to get tutoring help, you say, "Left on Mockingbird, right on Central, left on Balboa, left on Sandstone, and right on Parkside." The student likely will remember "Left on Mockingbird" and "Right on Parkside" better than "Left on Balboa." The *primacy effect* is that items at the beginning of a list tend to be remembered. The *recency effect* is that items at the end of the list also tend to be remembered.

serial position effect The principle that recall is better for items at the beginning and the end of a list than for items in the middle.

encoding specificity principle The principle that associations formed at the time of encoding or learning tend to be effective retrieval cues.

Figure 7 shows a typical serial position effect with a slightly stronger recency effect than primacy effect. The serial position effect applies not only to lists but also to events. If you spread out a history lesson over a week and then ask students about it the following Monday, they likely will have the best memory for what you told them on Friday of last week and the worst memory for what you told them on Wednesday of last week.

Another factor that affects retrieval is the nature of the cues people use to prompt their memory (Schneider, 2015; van Lamsweerde, Beck, & Johnson, 2016). Students can learn to create effective cues. For example, if a student has a "block" about remembering the name of the guest who came to class two months ago, she might go through the alphabet, generating names with each letter. If she manages to stumble across the right name, she likely will recognize it.

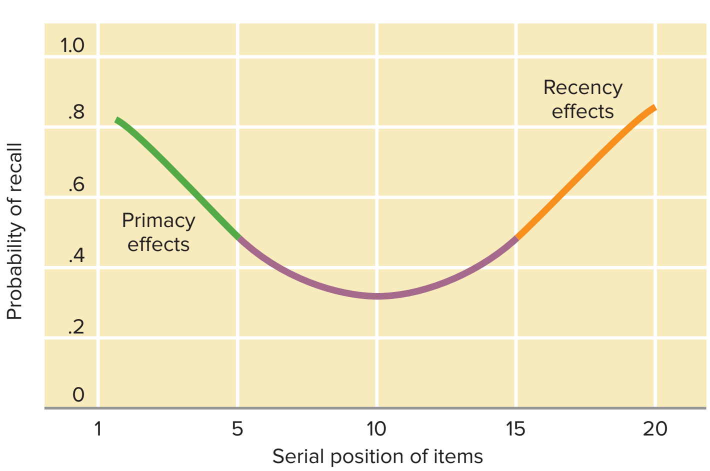

FIGURE 7 THE SERIAL POSITION EFFECT

When a person is asked to memorize a list of words, the words memorized last usually are recalled best, those at the beginning next best, and those in the middle least efficiently.

Another consideration in understanding retrieval is the **encoding specificity principle,** which says that associations formed at the time of encoding or learning tend to be effective retrieval cues. For example, imagine that a 13-year-old child has encoded this information about Mother Teresa: She was born in Albania, lived most of her life in India, became a Roman Catholic nun, was saddened by seeing people sick and dying in Calcutta's streets, and won a Nobel Prize for her humanitarian efforts to help the poor and suffering. Later, when the child tries to remember details about Mother Teresa, she can use words such as *Nobel Prize, Calcutta,* and *humanitarian* as retrieval cues. The concept of encoding specificity is compatible with our earlier discussion of elaboration: The more elaboration children use in encoding information, the better their memory of the information will be. Encoding specificity and elaboration reveal how interdependent encoding and retrieval are.

Yet another aspect of retrieval is the nature of the retrieval task itself. *Recall* is a memory task in which individuals must retrieve previously learned information, as students must do for fill-in-the-blank or essay questions. *Recognition* is a memory task in which individuals only have to identify ("recognize") learned information, as is often the case on multiple-choice tests. Many students prefer multiple-choice items because they provide good retrieval cues, which fill-in-the-blank and essay items don't do.

Forgetting One form of forgetting involves the cues we just discussed. **Cue-dependent forgetting** is retrieval failure caused by a lack of effective retrieval cues. The notion of cue-dependent forgetting can explain why a student might fail to retrieve a needed fact for an exam even when he is sure he "knows" the information. For example, if you are studying for a test in this course and are asked a question about a distinction between recall and recognition in retrieval, you likely will remember the distinction better if you possess the cues "fill-in-the-blank" and "multiple-choice," respectively.

The principle of cue-dependent forgetting is consistent with **interference theory,** which states that we forget not because we actually lose memories from storage but rather because other information gets in the way of what we are trying to remember. For a student who studies for a biology test, then studies for a history test, and then takes the biology test, the information about history will interfere with remembering the information about biology. Thus, interference theory implies that, if you have more than one test to study for, you should study last what you are going to be tested on next. That is, the student taking the biology test would have benefited from studying history first and studying biology afterward. This strategy also fits with the recency effect we described earlier.

Another source of forgetting is memory decay. According to **decay theory,** new learning involves the creation of a neurochemical "memory trace," which will eventually disintegrate. Thus, decay theory suggests that the passage of time is responsible for forgetting.

Memories decay at different speeds. Some memories are vivid and last for long periods of time, especially when they have emotional ties. We can often remember these "flashbulb" memories with considerable accuracy and vivid imagery. For example, consider a car accident you were in or witnessed, the night of your high school graduation, an early romantic experience, and where you were when you heard about the destruction of the World Trade Center towers. Chances are, you will be able to retrieve this information many years after the event occurred.

I recently asked teachers how they help their students improve their memory skills. Following are their responses.

EARLY CHILDHOOD Repetition often helps preschoolers remember. For example, as a weekly theme, we focus on a letter of the week. Children are asked to write the same letter throughout the week. They also hear stories related to just that one letter and are asked to bring in something for "show and tell" that starts with the letter being highlighted that week.

—MISSY DANGLER, *Suburban Hills School*

ELEMENTARY SCHOOL: GRADES K–5 One strategy that works well with my students is to play the game *Jeopardy!* and use categories like math, grammar, science, social studies, and famous stories. The game keeps them excited and focused on the topics. Students receive bonus points for correct answers, which they can trade in for certain classroom privileges.

—CRAIG JENSEN, *Cooper Mountain Elementary School*

MIDDLE SCHOOL: GRADES 6–8 I use self-tests to help my seventh-graders improve their memory. Based on notes taken in class, students create their own quizzes and tests. Questions are on one side of the paper, answers on the other. When they study, they are seeing the questions, not the answers. This approach not only helps them remember, but also helps eliminate test anxiety for many students because they know what the test looks like before they get to class.

—MARK FODNESS, *Bemidji Middle School*

cue-dependent forgetting Retrieval failure caused by a lack of effective retrieval cues.

interference theory The theory that we forget not because we actually lose memories from storage but because other information gets in the way of what we are trying to remember.

decay theory The theory that new learning involves the creation of a neurochemical "memory trace," which will eventually disintegrate. Thus, decay theory suggests that the passage of time is responsible for forgetting.