6

CHAPTER OUTLINE AND LEARNING OBJECTIVES

What Is Memory?

LO 1 Define memory.

LO 2 Describe the processes of encoding, storage, and retrieval.

Stages of Memory

LO 3 Identify the stages of memory described by the information-processing model.

LO 4 Describe sensory memory.

LO 5 Summarize short-term memory.

LO 6 Give examples of how we can use chunking to expand our short-term memory.

LO 7 Describe working memory and its relationship to short-term memory.

LO 8 Describe long-term memory.

Retrieval and Forgetting

LO 9 Illustrate how encoding specificity relates to retrieval cues.

LO 10 Identify some of the reasons why we forget.

LO 11 Explain how the malleability of memory influences the recall of events.

LO 12 Describe the meaning of rich false memories.

The Biology of Memory

LO 13 Compare and contrast anterograde and retrograde amnesia.

LO 14 Identify the brain structures involved in memory.

LO 15 Describe long-term potentiation and its relationship to memory.

Monica Rodriguez/Getty Images.

Memory

What Is Memory?

MEMORY BREAKDOWN: THE CASE OF CLIVE WEARING Monday, March 25, 1985: Deborah Wearing awoke in a sweat-soaked bed. Her husband, Clive, had been up all night perspiring, vomiting, and with a high fever. He said that he had a "constant, terrible" headache, like a "band" of pain tightening around his head (Wearing, 2005, p. 27). The symptoms worsened over the next few days, but the two doctors caring for Clive reassured Deborah that it was just a bad case of the flu. By Wednesday, Clive had spent three nights awake with the pain. Confused and disoriented, he turned to Deborah and said, "Er, er, darling. . . . I can't . . . think of your name" (p. 31).

The doctor arrived a couple of hours later, reassured Deborah that her husband's confusion was merely the result of sleep deprivation, and

Ros Drinkwater/Alamy

The Conductor
In 1985 conductor Clive Wearing (pictured here with his wife, Deborah) developed a brain infection—viral encephalitis—that nearly took his life. Clive recovered physically, but his memory was never the same.

member recount what their partner had said. Four and 8 months later, the researchers checked in with the couples to see whether the problems they had discussed had diminished to some degree (Baker et al., 2020).

Here's what the study revealed: Talking about problems led to **better outcomes** when partners had a solid working memory capacity, or the "ability to actively maintain information during ongoing processing and despite distractions" (Baker et al., 2020, p. 580). Presumably, a good working memory capacity enabled them to focus on one another's statements, even while dealing with their own thoughts, emotions, and distractions in the environment. This likely helped them create long-term memories of the conversation and therefore make behavioral changes to allay the problem (Baker et al., 2020).

How can these findings help you? Talk about relationship problems when you have the ability to focus your attention on the issue, not when you are tired, distracted, or drinking alcohol (Hambrick & Katsumata, 2020). Make a point to listen, truly listen, to what your partner is saying so that information can be transferred into your long-term memory.

Research CONNECTIONS

In **Chapter 1,** we discussed negative correlations, or inverse links between variables. Here we see that the severity of problems was reduced when partners had higher working memory capacities. But correlation does not prove causation; perhaps there is a third factor, such as good verbal skills or the ability to pay attention, influencing both variables.

Now that we have established the importance of working memory, let's take a closer look at how it functions. Working memory has four components: the phonological loop, visuospatial sketchpad, central executive, and episodic buffer (Baddeley, 2002; Baddeley & Hitch, 2019; FIGURE **6.6**).

PHONOLOGICAL LOOP The *phonological loop* is responsible for working with verbal information for brief periods of time; when exposed to verbal stimuli, we "hear" an immediate corollary in our mind. This component of working memory is what we use when reading our textbook or trying to remember what a friend told us yesterday.

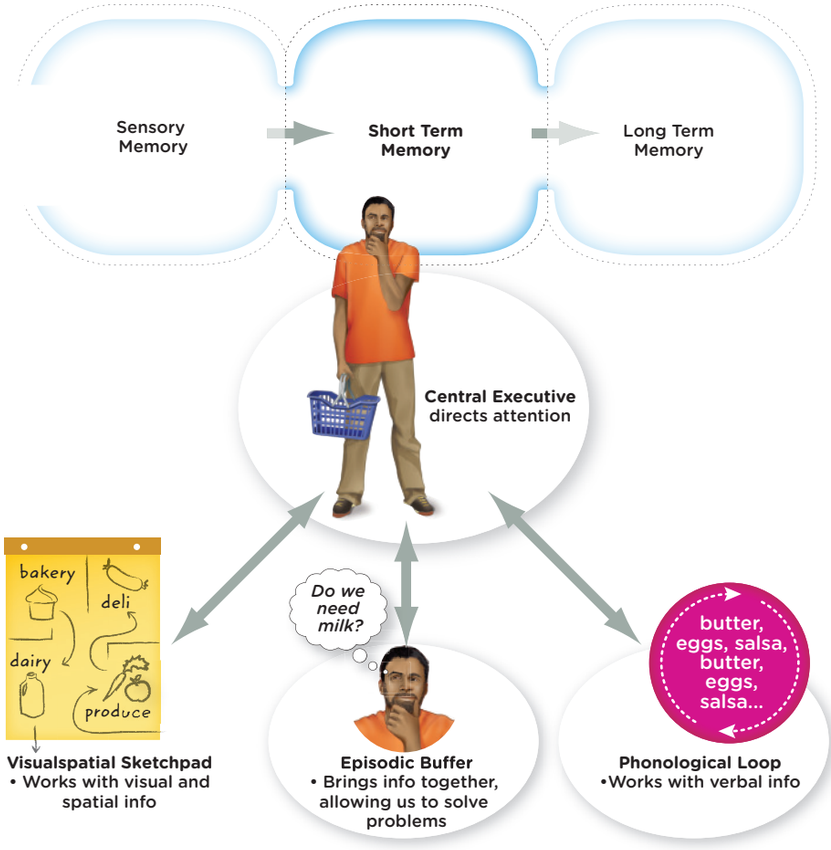


FIGURE 6.6
Working Memory
Working memory represents the active processing occurring in short-term memory. Overseeing the big picture is the central executive, which directs attention and integrates processing among three subsystems: the phonological loop, visuospatial sketchpad, and episodic buffer. To see how this model works, imagine you have stopped by the supermarket to pick up groceries. You rehearse the shopping list with your phonological loop, produce a mental layout of the store with your visuospatial sketchpad, and use the episodic buffer to access long-term memories and determine whether you need any additional items. Tying together all these activities is the central executive.

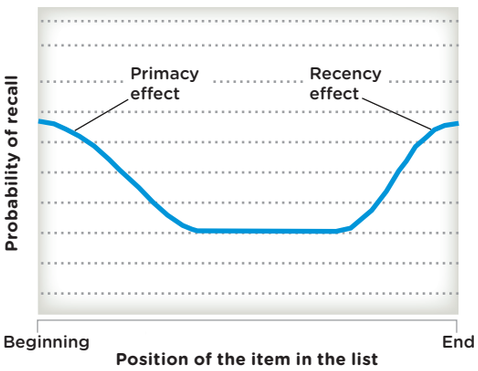


FIGURE 6.9
The Serial Position Effect
People are more likely to recall items at the beginning of a list and items at the end of a list; we call this the serial position effect.

Imagine you are on your way to the store to buy supplies for a dinner party, but your cell phone battery is about to die. Your housemate calls asking you to pick up the following items: napkins, paper towels, dish soap, butter, laundry soap, paper plates, sparkling water, ice cream, plastic spoons, bread, pickles, and flowers. Without any way to write down this list, you are at the mercy of the serial position effect. In all likelihood (and if you don't use mnemonics), you will return home with napkins, paper towels, and a bottle of dish soap (due to the primacy effect), as well as bread, pickles, and flowers (due to the recency effect); the items in the middle will more likely be forgotten. The serial position effect also seems to influence which items are ordered from restaurant menus. Foods tend to be more "popular" when listed at the beginning or end of a menu, as opposed to the middle; presumably, they pop into your head more easily when you are ordering your meal (Bar-Hillel, 2015).

ACROSS THE WORLD

MEMORY AND CULTURE

Culture is another factor that may influence what types of information are available for retrieval (Wang, 2019). For example, if you ask people from the United States and China to recount some life memories, you may detect some interesting cultural themes in their reports. Research suggests that Chinese people are more likely than North Americans to remember social and historical occurrences and focus their memories on other people. Americans, on the other hand, tend to recall events as they relate to their individual actions and emotions (Schmidt & Qiao, 2020; Wang, 2016; Wang & Conway, 2004). Why is this so?

MEMORIES OF WE, OR MEMORIES OF ME?

It may have something to do with the fact that China—like many countries in Asia, Africa, and Latin America—has a *collectivist* culture, whereas the United States is more *individualistic.* People in collectivist societies tend to prioritize the needs of family and community over those of the individual. Individualistic cultures are more "me" oriented, or focused on autonomy and independence. It thus makes sense that people from the collectivist culture of China would have more community-oriented memories than their U.S. counterparts. Keep in mind this is just a general trend—not a rule that applies to every person from China and the United States. Within any society, there is substantial variation with regard to individualism and collectivism, and this may relate to levels of urbanization. For example, a study conducted in Turkey (a collectivist society) found that country-dwelling children were more likely than urban children to have memories involving social interactions, and this could be related to the more collectivistic orientation of rural communities (Göz et al., 2017). What are some of your most important memories, and do you think culture helped shape them?

The Encoding Specificity Principle

Now that we have touched on how cultural context might influence memory, let's explore context in a more general sense. How does your environment—both internal and external—impact your ability to retrieve memories?

LO 9 Illustrate how encoding specificity relates to retrieval cues.

CONTEXT IS EVERYTHING In a classic study, participants learned lists of words under two conditions: while underwater (using scuba gear) and on dry land (Godden & Baddeley, 1975). Then they were tested for recall in both conditions: If they learned

From the pages of SCIENTIFIC AMERICAN

DRUNK WITNESSES REMEMBER A SURPRISING AMOUNT

Interviewing an inebriated person at the scene may be more accurate than waiting until he or she is sober.

Police officers investigating a crime may hesitate to interview drunk witnesses. But waiting until they sober up may not be the best strategy; people remember more while they are still inebriated than they do a week later, a new study finds.

Malin Hildebrand Karlén, a senior psychology lecturer at Sweden's University of Gothenburg, and her colleagues recruited 136 people and gave half of them vodka mixed with orange juice. The others drank only juice. In 15 minutes women in the alcohol group consumed 0.75 gram of alcohol per kilogram of body weight, and men drank 0.8 gram (that is equivalent to 3.75 glasses of wine for a 70-kilogram woman or four glasses for a man of the same weight, Hildebrand Karlén says). All participants then watched a short film depicting a verbal and physical altercation between a man and a woman. The researchers next asked half the people in each group to freely recall what they remembered from the film. The remaining participants were sent home and interviewed a week later.

The investigators found that both the inebriated and sober people who were interviewed immediately demonstrated better recollection of the film events than their drunk or sober counterparts who were questioned later. The effect held even for people with blood alcohol concentrations of 0.08 or higher—the legal limit for driving in most of the U.S. (Intoxication levels varied because different people metabolize alcohol at different speeds.) The results suggest that intoxicated witnesses should be interviewed sooner rather than later, according to the study, which was published online [. . .] in *Psychology, Crime & Law*.

The findings are in line with previous research, says Jacqueline Evans, an assistant professor of psychology at Florida International University, who was not involved in the new work. Evans co-authored and published a 2017 study in *Law and Human Behavior* that found similar results for moderately drunk witnesses. "Any effect of intoxication is not as big as the effect of waiting a week to question somebody," she says.

The new study also found that some aspects of the drunk people's recollections were not that different from those of the sober participants. For instance, both groups seemed particularly attuned to the details of the physical aggression portrayed in the film. "This research should at least make us more interested in what intoxicated witnesses have to say," Hildebrand Karlén says, "and perhaps take them a bit more seriously."

Prosecutors often tell people who have witnessed crimes not to speak to each other, and with good reason. Information provided by one witness can "contaminate" the memory of another (Wells et al., 2020). Suppose two people see an elderly woman being robbed. One witness remembers a bearded man wearing a blue jacket swipe the woman's purse. The other noticed the blue jacket but *not* the beard. If, however, the two witnesses exchange stories of what they saw, the second witness may unknowingly incorporate the beard into their "memory." Information learned after the event (that is, the "fact" that the thief had a beard) can get mixed up with memories of that event (Loftus, 2005; Loftus et al., 1978). If we can instill this type of "false" information into a "true" memory, do you suppose it is possible to give people memories for events that never happened? Indeed, it is.

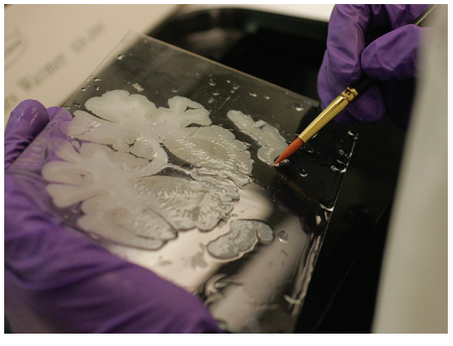
Tracking Memory in the Brain

Whether with lab rats or case studies, psychologists have spent decades tracking the location of memory in the brain. Their findings point to a complex system involving multiple brain regions. Memory is formed, processed, and stored throughout the brain, and different types of memory have different paths. So it helps to know your way around the brain's structures. Remembering the amygdala's role in processing basic emotion, for instance, can help you understand its role in processing the emotional content of memories.

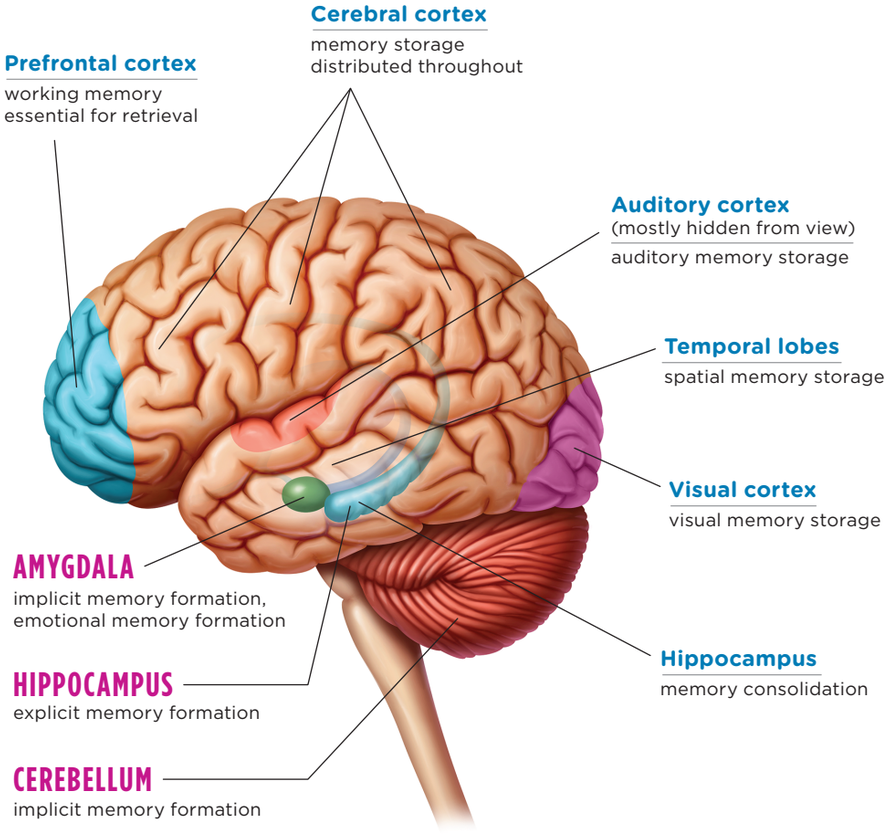
Learning from H.M.

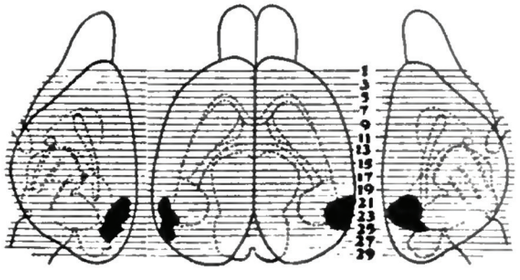
Henry Molaison, or "H.M." (1926–2008), may be the "best known single patient in the history of neuroscience" (Squire, 2009, p. 6). Following the surgical removal of his hippocampus, H.M. lost the ability to form new explicit memories, but he could still create certain types of implicit memories. This suggests that the hippocampus plays a key role in the creation of explicit—but not necessarily implicit—memories.

After his death, H.M.'s brain was cut into over 2,000 slices that were preserved and digitized for research.



John Gibbins/ZUMApress/Newscom.





Journal of Comparative Neurology, K. S. Lashley, L. E. Wiley, Copyright © 1933 The Wistar Institute of Anatomy and Biology.

Lashley kept a careful record of the sizes and locations of lesions made in each rat as part of his experiments.

Lashley's Quest

Through his experiments with rats, Karl Lashley tried to find the physical location of memories in the brain. He would train the rats to navigate mazes, make slices in various parts of their cortices, and then observe how their memories of the mazes were affected. In many cases, these slices had minimal impact on the rats' ability to navigate the mazes. With the help of modern technologies, researchers have discovered that memory activities occur in many areas of the brain (Shen, 2018). In a process called *memory consolidation,* which is thought to occur in the hippocampus and cortex, information is moved into long-term storage (Genzel et al., 2017).