MYTH OR SCIENCE?

Is it true . . .

- That "flashbulb memories," the vivid memories you form after an important, dramatic event, are no more accurate than other memories?
- That memory is like a video recorder—it preserves a perfect record of your experience?
- That eyewitness testimony is the most reliable form of courtroom evidence?
- That it's common to completely repress memories of traumatic events but that such events can be accurately remembered under hypnosis?
- That all memories, even complex ones, are located in a single part of the brain?

Memory

PROLOGUE

The Drowning

Elizabeth was only 14 years old when her mother drowned. Although Elizabeth remembered many things about visiting her Uncle Joe's home in Pennsylvania that summer, her memory of the details surrounding her mother's death had always been hazy. As she explained:

> In my mind I've returned to that scene many times, and each time the memory gains weight and substance. I can see the cool pine trees, smell their fresh tarry breath, feel the lake's algae-green water on my skin, taste Uncle Joe's iced tea with fresh-squeezed lemon. But the death itself was always vague and unfocused. I never saw my mother's body, and I could not imagine her dead. The last memory I have of my mother was her tiptoed visit the evening before her death, the quick hug, the whispered, "I love you."

Some 30 years later, at her Uncle Joe's 90th birthday party, Elizabeth was told by a relative that she had been the one to discover her mother's body in Uncle Joe's swimming pool. With this realization, memories that had eluded Elizabeth for decades began to come back:

> The memories began to drift back, slow and unpredictable, like the crisp piney smoke from the evening campfires. I could see myself, a thin, dark-haired girl, looking into the flickering blue-and-white pool. My mother, dressed in her nightgown, is floating facedown. "Mom? Mom?" I ask the question several times, my voice rising in terror. I start screaming. I remember the police cars, their lights flashing, and the stretcher with the clean, white blanket tucked in around the edges of the body. The memory had been there all along, but I just couldn't reach it.

As the memory crystallized, it suddenly made sense to Elizabeth why she had always felt haunted by her vague memories of the circumstances surrounding her mother's death. And it also seemed to

explicit memory Information or knowledge that can be consciously recollected; also called *declarative memory*.

The majority of middle-aged and older people are most likely to remember events and experiences that occurred in adolescence and early adulthood—a phenomenon called the *reminiscence bump* (Koppel & Berntsen, 2015; Koppel & Rubin, 2016). One explanation is that this developmental period includes memories of events that are crucially important in the formation of an adult identity, such as high school and university experiences, early professional choices, and relationships (Conway & Holmes, 2004).

As you'll see in the Culture and Human Behavior box on earliest memories, autobiographical memory is also shaped by cultural experience.

Implicit and Explicit Memory: Two Dimensions of Long-Term Memory

Studies with patients who have suffered different types of amnesia as a result of damage to particular brain areas have led memory researchers to recognize that long-term memory is *not* a simple, unitary system. Instead, long-term memory appears to be composed of separate but interacting subsystems and abilities (Slotnick & Schacter, 2007).

What are these subsystems? One basic distinction that has been made is between *explicit memory* and *implicit memory*. Memory *with* awareness is **explicit memory**, *information or knowledge that can be consciously recollected; also called* declarative memory. Thus, remembering what you did last New Year's Day or the

CULTURE AND HUMAN BEHAVIOR

Culture's Effects on Early Memories

For most adults, earliest memories are for events that occurred between the ages of 2 and 4 (Bauer et al., 2014). These early memories mark the beginning of autobiographical memory, which provides the basis for the development of an enduring sense of self (Fivush, 2011; Markowitsch & Staniloiu, 2011). Do cultural differences in the sense of self influence the content of our earliest memories?

Comparing the earliest memories of European American university students and Taiwanese and Chinese university students, developmental psychologist Qi (pronounced "chee") Wang (2001, 2006) found a number of significant differences. First, the average age for earliest memory was much earlier for the U.S.-born students than for the Taiwanese and Chinese students.

Wang also found that the Americans' memories were more likely to be discrete, one-point-in-time events reflecting individual experiences or feelings, such as "I remember getting stung by a bee when I was 3 years old. I was scared and started crying." In contrast, the earliest memories of both the Chinese and Taiwanese students were of general, routine activities with family, schoolmates, or community members, such as playing in the park or eating with family members.

For Americans, Wang notes, the past is like a drama in which the self plays the lead role. Themes of self-awareness and individual autonomy were more common in the American students' memories, which tended to focus on their own experiences, emotions, and thoughts.

In contrast, Chinese and Taiwanese students were more likely to include other people in their memories. Rather than focusing exclusively on their own behavior and thoughts, their earliest memories were typically brief accounts that centered on collective activities. For the Chinese and Taiwanese students, the self is not easily separated from its social context.

› Culture and Earliest Memories Psychologist Qi Wang (2013) found that the earliest memories of Chinese and Taiwanese adults tended to focus on routine activities that they shared with other members of their family or social group rather than individual events. Perhaps years from now, these children will remember learning to dance with their preschool friends.

Philipp Engelhorn/laif/Redux

Wang (2013, 2014) believes that cultural differences in autobiographical memory are formed in very early childhood, through interaction with family members. For example, *shared reminiscing*—the way that mothers talk to their children about their past experiences—differs in Eastern and Western cultures (Fivush, 2011). When Asian mothers reminisce with their children, they tend to talk about group settings or situations, and to de-emphasize emotions, such as anger, that might separate the child from the group. In comparison, Western mothers tend to focus more on the child's individual activities, accomplishments, and emotional reactions (Ross & Wang, 2010). As Katherine Nelson and Robyn Fivush (2004) observe, such conversations about the personal past "provide children with information about how to be a 'self' in their culture."

Combined, the findings of Lashley and Thompson indicate that memories have the potential to be *both localized* and *distributed*. Very simple memories (Thompson's research) may be localized in a specific area, whereas more complex memories (Lashley's research) are distributed throughout the brain. A complex memory involves clusters of information, and each part of the memory may be stored in the brain area that originally processed the information (Greenberg & Rubin, 2003; Josselyn et al., 2015).

Adding support to Lashley's and Thompson's findings, brain imaging technology has confirmed that many kinds of memories are distributed in the human brain. When we are performing a relatively complex memory task, multiple brain regions are activated—evidence of the distribution of memories involved in complex tasks (Khan & Muly, 2011).

The Focus on Neuroscience box describes a clever study that explored how memories involving different sensory experiences are assembled when they are retrieved.

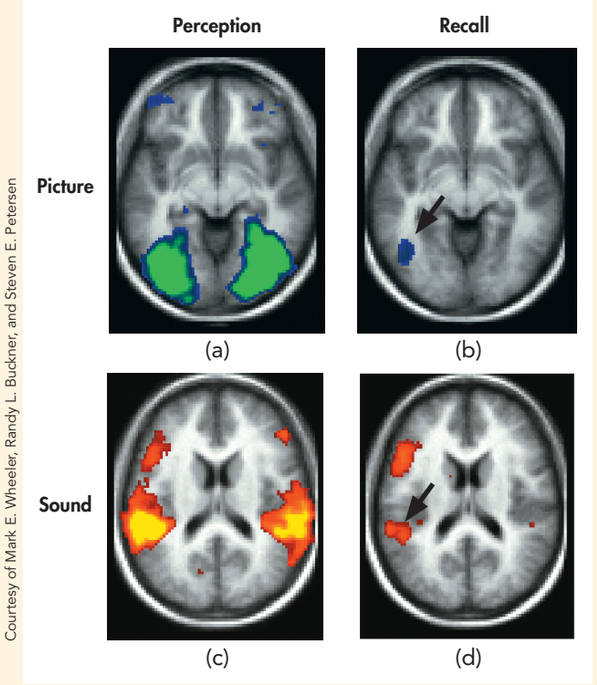
MYTH ◀ **SCIENCE**

Is it true that all memories, even complex ones, are located in a single part of the brain?

FOCUS ON NEUROSCIENCE

Assembling Memories: Echoes and Reflections of Perception

If we asked you to remember the theme from *Star Wars*, you would "hear" the song in your head. Conjure up a memory of your high school cafeteria, and you "see" it in your mind. Memories can include a great deal of sensory information—sounds, sights, and even odors, textures, and tastes. How are such rich sensory aspects of an experience incorporated into a memory that is retrieved?



Courtesy of Mark E. Wheeler, Randy L. Buckner, and Steven E. Petersen

Researchers set out to investigate this question using a simple memory task and fMRI (Wheeler et al., 2000; Herholz et al., 2012). Participants studied names for common objects that were paired with either a picture or a sound associated with the word. For example, the word *dog* was either paired with a picture of a dog or the sound of a dog barking. The researchers then used fMRI to measure brain activity when the volunteers were instructed to recall the words they'd memorized.

The results? Retrieving the memory activated a subset of the same brain areas that were involved in perceiving the sensory stimulus. Participants who had memorized the word *dog* with a *picture* of a dog showed a high level of activation in the *visual cortex* when they retrieved the memory. And participants who had memorized the word *dog* with the *sound* of a barking dog showed a high level of activation in the *auditory cortex* when they retrieved the memory.

Of course, many of our memories are highly complex, involving not just sensations but also thoughts and emotions. Neuroscientists assume that such complex memories involve networks of neurons that are widely distributed throughout the brain. However, they still don't completely understand how all these neural records are bound together and interrelated to form a single, highly elaborate memory (Josselyn et al., 2015).

Retrieving the Memory of a Sensory Experience Top row: (a) Perceiving a picture activates areas of the visual cortex. (b) When the memory of the picture is recalled, it reactivates some of the same areas of the visual cortex *(arrow)* that were involved in the initial perception of the picture. Bottom row: (c) Perceiving a sound activates areas of the auditory cortex. (d) When the memory of the sound is recalled, it reactivates some of the same areas of the auditory cortex *(arrow)* that were involved in the initial perception of the sound.

anterograde amnesia Loss of memory caused by the inability to store new memories.

stress hormones that are released during emotional arousal tend to *enhance* memory consolidation (Nielson & Lorber, 2009).

Anterograde Amnesia: Disrupting the Formation of Explicit Memories

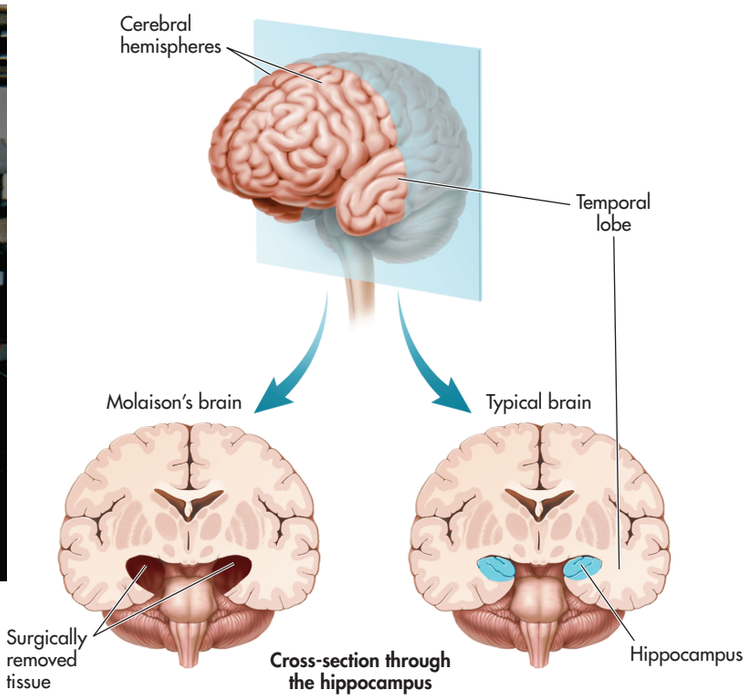
Another form of amnesia is **anterograde amnesia**—the *loss of memory caused by the inability to store new memories*. *Anterograde* means "forward moving." The most famous case study of anterograde amnesia lasted over 50 years. It was of a man who for years was known only by his initials—H. M. But the need to protect H. M.'s privacy ended when Henry Molaison died at the age of 82 on December 2, 2008.

In 1953, Molaison was 27 years old and had a history of severe, untreatable epileptic seizures. Molaison's doctors located the brain area where the seizures seemed to originate. With no other options available at the time, the decision was made to surgically remove portions of the *medial* (inner) *temporal lobe* on each side of Molaison's brain, including the brain structure called the *hippocampus* (Scoville & Milner, 1957). Portions of the left and right *amygdala* were also removed (Annese et al., 2014).

After the experimental surgery, the frequency and severity of Molaison's seizures were greatly reduced. However, it was quickly discovered that Molaison's ability to form new memories of events and information had been destroyed. Although the experimental surgery had treated Molaison's seizures, it also dramatically revealed the role of the hippocampus in forming new explicit memories for episodic and semantic information.

Psychologists **Brenda Milner** (1970) and **Suzanne Corkin** (2013) studied Molaison extensively over the past 50 years. He was well aware of his memory problem. When Suzanne Corkin (2002) once asked him, "What do you do to try to remember?" Molaison quipped, "Well, that I don't know because I don't remember [chuckle] what I tried."

"Henry Molaison, aged 60, at MIT in 1986. Photograph by Jenni Ogden, first published in her book "Trouble in Mind: Stories from a Neuropsychologist's Casebook."



Henry Gustav Molaison: The Real H. M. (1926–2008) At the age of nine, Molaison jarred his head badly when he was hit by a bicyclist. Not long after, he began experiencing seizures. By early adulthood, Molaison's seizures had increased in both severity and frequency. In an effort to control the seizures, an experimental surgery was performed, removing the hippocampus, the surrounding cortical tissue, and the amygdala on each side of Molaison's brain. Because of the profound anterograde amnesia caused by the surgery, Molaison became one of the most intensive case studies in psychology and neuroscience. Over the next half century, Molaison participated in hundreds of studies that fundamentally altered the scientific understanding of memory. Molaison died on December 2, 2008, but his contributions to science continue. Neuroscientist Jacopo Annese and his team (2014) dissected Molaison's brain, slicing it into 2,400 micro-thin slices in a marathon, three-day session that was streamed online. Photographs of each slice were taken to create a virtual 3-D digital model of Molaison's brain.

CONCEPT MAP › Memory

Memory

Key processes:
- Encoding
- Storage
- Retrieval

Travis Morisse

The Stage Model of Memory

Memory is the process of transferring information from one memory stage to another.

Sensory memory:
- Briefly stores sensory information about the environment
- Each sense thought to have its own sensory memory.
- **George Sperling** (b. 1934) demonstrated that visual sensory memory holds information for about half a second before fading.

Short-term memory (STM):
- Temporarily stores information transferred from sensory memory and information retrieved from long-term memory.
- Capacity is limited to a few "slots," or units of information.
- **Maintenance rehearsal** keeps information active and in STM.
- If not actively rehearsed, information is lost within 20 seconds.

Long-term memory (LTM):
- Stores a potentially unlimited amount of information for up to a lifetime.
- **Elaborative rehearsal** involves focusing on the meaning of information encoded into LTM.
- Information in LTM is clustered and associated with related groups during recall.
- **Semantic network model** describes the organization of LTM as a complex network of associations.

Working memory: The active, conscious manipulation of verbal or spatial information temporarily held in STM; thought to consist of:
- Phonological loop
- Visuospatial sketchpad
- Central executive

Hill Street Studios/Sarah Golonka/Blend Images/Alamy Stock Photo

Explicit memory (declarative memory): Memory with conscious recall

Implicit memory (nondeclarative memory): Memory without conscious recall

Episodic memory: Events you have experienced

Semantic memory: General facts, knowledge

Procedural memory: Motor skills, actions

Retrieval

Process of accessing information stored in long-term memory

Retrieval cue: Hint or prompt that helps trigger recall of stored memories
Retrieval cue failure: Recall failure due to inadequate or missing retrieval cues; common example is a **tip-of-the-tongue experience.**
Recall, cued recall, and **recognition** are strategies to test retrieval of information.
Serial position effect: Tendency to have better recall of first and last items in a series
Encoding specificity principle: Forms include the **context effect** and **mood congruence.**
Flashbulb memories: Vivid memories perceived as accurate but actually no more accurate than ordinary memories.

Forgetting

Inability to recall information that was previously available

Hermann Ebbinghaus (1850–1909) Identified basic pattern of forgetting: rapid loss of some information, then stable memories of the remaining information

Bettmann/Getty Images

Factors contributing to forgetting:
- **Encoding failure**
- **Retrieval cue failure** contributes to **prospective memory** failures
- **Decay theory**
- **Retroactive interference** and **proactive interference**
- **Suppression** and **repression**