# Chapter 5: Memory Systems

## Overview

It is helpful to start by reviewing what is meant by "memory." Memory refers to the encoding storage and retrieval of information. In the **modal model of memory**, Atkinson and Shiffrin proposed memory as consisting of three stores. The first store is **sensory memory** which, although it can register a large amount of information, is unable to retain it for more than one second. **Short-term memory** receives information from both sensory and long-term memory but, without rehearsal, can only hold information for approximately 18 seconds. The final store is **long-term memory**, where information is stored and returned back to short-term memory when needed.

Baddeley later proposed **working memory**, which provides temporary storage while allowing the manipulation of information required for various cognitive activities. He described four components of working memory: the **central executive**, **phonological loop**, **visuo-spatial sketchpad**, and **episodic buffer**. Each component handles distinct types of information or facilitates the movement of information between the components.

Memory can be divided between two broad categories – declarative and non-declarative, each of which can be divided into sub-categories. **Episodic**, **semantic**, and **procedural** memory are all the result of accumulated knowledge but they are quite distinct phenomenally. Of course, human memory isn't really as simple or as compartmentalized as these straightforward divisions make it seem, but making these separations is a convenient way of organizing our knowledge.

In-class demonstrations allow students to experience various memory phenomena. Demonstrations of **working memory**, for example, provide a much richer understanding than a description alone. With a word list and the "slide transition" option of PowerPoint (for timing), such tests can be easily created. Alternatively, demos are available online (for example, see http://gocognitive.net/demos).

The **tip-of-the-tongue phenomenon** is more difficult to elicit. Definitions of low-frequency words can sometimes elicit a tip-of-the-tongue feeling. For example, given the definition "a special quality of leadership that captures the popular imagination and inspires unswerving allegiance," some might have trouble coming up with the word "charisma" but may feel like it is on the tip of their tongue. Ask those who experience that feeling if they can name the first letter of the word or if they can come up with a word that sounds kind of like the target word. They may be able to report accurate partial information.

With changing age demographics in our society, there is a growing interest in memory deficits associated with advanced age. Older adults are often stereotyped as cognitively slow or impaired but, as the text indicates, they tend to have difficulty only with certain types of memory performance (i.e., those that require detailed, contextualized recall of episodes). **Implicit memory** seems to remain intact. Point out to students that there may also be aspects of cognitive performance that improve with age. Consider, for example, the construct of "wisdom," which is related to memory. It is difficult to put together an operational definition of wisdom, which makes it difficult to measure. The ubiquitous age effects (with older adults performing more poorly than young adults) found in cognitive experiments perhaps do not tell the whole story. The types of tasks that older adults would be likely to perform better tend to be the types that are much less often and less reliably measured. As

well, it is important to consider that older adults are likely to be different than young adults in many ways that would impact memory performance. They may be less healthy and have poorer sensory functioning. They are likely to have less education and be more out of practice in taking tests. They are likely to be less familiar with technology and therefore more intimidated by tests done on computers. Cohort effects, in general, may affect cognitive performance in a way that favours young adults. It should be kept in mind, then, that a young–old difference on a test of memory needs to be considered in the context of other differences.

Students are fascinated by the affects of amnesia. Amnesic Syndrome is so often used as a plot device in movies and television that students may have the wrong idea about the nature of amnesia or may be surprised that it exists at all. Videos of people with amnesia (such as the Clive Wearing video referenced below) are extremely helpful in giving students a sense of what amnesia is and the devastating toll it takes on everyday life.

## Learning Objectives

In this chapter students will:

- Distinguish between various memory systems.
- Explore sensory and short-term memory.
- Distinguish between short-term and working memory.
- Outline Tulving's approach to memory.
- Look at various models of semantic memory.
- Review experimental evidence for the role of spreading activation in semantic memory.
- Examine the concept of working memory.
- Identify what the study of older individuals and people with memory deficits tells us about the nature of memory.

## Key Concepts with Illustrative Examples

**disconnection syndrome** (see page 153)

Disconnection syndrome refers to any condition in which the transfer of information is interrupted or blocked. For example, Broca's aphasia could be considered a type of disconnection syndrome as the person knows the words and their meaning, but are unable to transfer the information to the brain region responsible for speech production. The text uses the term to de-

scribe a condition found in amnesic patients whereby they are able to acquire new information and yet not be aware that learning has taken place.

**episodic vs semantic memory** (see page 134)

Episodic and semantic memory are the two subdivisions of declarative memory. Episodic memory is concerned with personal experience, such as your tenth birthday party. Semantic memory, on the other hand, is concerned with general facts and knowledge, such as the earth is the third planet from the sun. Sometimes, what begins as an episodic memory later becomes a semantic memory. For example, if you learned about declarative memory today, tomorrow you might remember the experience of learning, such as the classroom, the professor, etc. (episodic). Two years from now, however, you may have forgotten the details of how you learned the information, but still remember you learned about declarative memory (semantic).

**non-declarative (implicit) memory** (see page 138)

Non-declarative or implicit memory occurs when previous experience aids in performing a task but there is no conscious recollection. Consider the example of listening to a song on the radio. If you have heard the song numerous times before, you may find yourself singing along. You are probably not consciously thinking back to any of the other times you've heard that song but those past experiences result in the lyrics just coming to you effortlessly.

**priming** (see page 141)

Priming occurs when we recognize or respond to a particular item because we have been previously exposed to either the same or a related item—even if we are unaware of the initial exposure. It is believed that priming plays a key role in stereotyping, in that exposure to negative trait descriptions such as "stupid" or "idiot" can cause us to use these words more frequently to describe others—whether we truly believe it or not.

**prospective memory** (see page 157)

Prospective memory involves remembering *to do* something in the future. Examples include remembering to return a book to the library, remembering to pay the phone bill, or remembering to get your car's oil changed.

**recency vs primacy bias** (see page 136)

Recency bias refers to the tendency to recall the most recent experiences. Further, we sometimes use the most recent experiences to predict the future. For example, a person who has recently experienced a gain in the stock market may make the decision to invest far more money on the assumption that they will again experience gains. Primacy bias is the opposite of recency bias in that it refers to the tendency to remember information we heard first rather than more recent information. You might have found that after a conversation with your doctor, you seem to remember the information you were told first as opposed to the information you were given just before you left the appointment. This would be an example of primacy bias.

**spreading activation** (see page 145)

In the network of semantic memory, characteristics of a given item ("car," for example) are connected. Activation spreads through the links in the network. When presented with the word "car," the car node is activated and, through spreading activation, nodes that are close in the network (e.g., "wheels") will be activated as well. More distant nodes ("assembly line") will be only weakly activated. Imagine pouring a glass of water on a rug—the centre of the downpour will be wettest but the wetness will spread to the surrounding area as well.

**tacit knowledge** (see page 142)

The process we use when we perform a task is not always easy to explain to others. While we are able to write down much of the knowledge we have, tacit knowledge is knowledge that we have that we are not able to convey to others. For example, a baker would find it very difficult to explain to another person how to knead bread dough. This is knowledge that the baker probably gained through observing others and experience.

**working memory** (see page 131)

Working memory can be thought of as a temporary store for information that is currently being processed. The central executive of working memory coordinates ongoing metal activities. If you are, for example, in an unfamiliar city and you stop to ask for directions, you may be given instructions like this: "Go two blocks up, turn left, go three blocks, turn right." You will need to keep all that in mind as you drive, accessing long-term memory as necessary.

## Discussion and Debate Ideas

1. Have students come up with examples of the importance of context in real-life memory situations. Here's one example: let's say you have a meeting scheduled for 1:00 pm and you check the clock to make sure that you're not late. You see that it is 12:30 pm. Several minutes later, you may find yourself thinking "I'm hungry, is it time for lunch?" You, of course, know what time it is, after all, you just checked, but the time may not come to mind in the context of lunch since it was encoded in the context of your upcoming meeting. It might be a good idea to ask students ahead of time to take note of experiences like this and bring to class any examples that may have come up.

2. The phonological loop and the visuo-spatial sketchpad are both temporary stores of information. Which do students believe is used more frequently? We humans think of ourselves as primarily visually-driven but there is plenty of evidence that, given the opportunity, we will apply a label to a visual stimulus and remember it phonologically instead. How could we force people to use the visuo-spatial sketchpad?

3. The tip-of-the-tongue phenomenon is quite difficult to study because it is notoriously hard to induce in participants. Brainstorm ideas for how to induce a tip-of-the-tongue state.

4. Have the class brainstorm ideas for a game that would improve memory performance for individuals with memory deficits. Point out that, with older adults in particular, there could poten-

tially be a real market for an enjoyable memory game that could be organized into a social activity. Ideas that incorporate aspects of errorless learning and the method of vanishing cues would be particularly helpful.

5. Discuss how the primacy and recency biases might influence the outcome of a trial depending on who is the first to present opening arguments and the last to present closing arguments. If you were a defendant, what would be the ideal order of presentation?

6. Have students suggest a task that would rely on working memory (e.g., cooking from a recipe). Break down the task to identify which components of working memory would play a role in the task.

7. Have students generate examples of priming in everyday life. Some examples would be driving past a billboard for fast food without noticing it and then experiencing a sudden craving for a burger.

8. Have students identify tasks they might do using procedural memory (e.g., cycling, writing, talking, athletic performance, walking). To demonstrate the implicit nature of the behaviour, have them try to explain how to do the behaviour.

9. Have students create a semantic network. Provide them with a starting word and have them offer words that are related to the initial word and then words related to each of the other words. Discuss which words would be most susceptible to priming effects according to spreading activation.

## Further Reading, Media Suggestions, and Teaching Aids

1. **Implicit Memory Test (Dot Clearing): http://www.gocognitive.net/demo/implict-memory-test-dot-clearing**

   This site provides a handy demonstration of an implicit memory test. Words are shown, one at a time, for 2 seconds each, and participants are to read each word silently, with no attempt at memorization. In the test phase, the words are again presented one at a time but at first, each word is occluded. Eventually the word is uncovered completely. Participants are to call out the word as soon as possible. Words that have been presented previously tend to be recognized sooner (with more occlusion).

2. **Vattano, F.J., Bennett, T.L. and Butler, M. 2000. [Modules 10 and 11] Life without memory: The case of Clive Wearing [and] Clive Wearing, part 2: Living without memory. *The Mind Teaching Modules* (2nd ed.). Worth Publishers: New York, NY. Faculty Guide available at: http://worthpublishers.com/catalog/static/worth/psychmedia/MindFacultyGuide.pdf**

   **Video available on YouTube: http://www.youtube.com/watch?v=OmkiMlvLKto.**
   This PBS program is a fascinating two-part documentary on Clive Wearing who, after a case of encephalitis, had severe damage to the hippocampus and areas close to the hippocampus. He

lives completely in the present; as soon as he takes in information, it very quickly fades away. Wearing does have some remaining long-term memory (for example, he can recognize his wife) and shows some implicit memory ability. An accomplished musician before his illness, Wearing retains much of his musical ability. Part 1 was filmed shortly after his illness and Part 2 takes place roughly ten years later.

3. **Whittlesea, B.W.A., and Williams, L.D. 1998. Why do strangers feel familiar, but friends don't? A discrepancy-attribution account of feelings of familiarity. *Acta Psychologica, 98,* 141–165.**

   Whittlesea and Williams propose that feelings of familiarity are produced by processing fluency (the ease of processing). However, they qualify this by saying that it is *relative* fluency of processing that determines familiarity. Feelings of familiarity occur only when processing of the item is more fluent or less fluent than expected. Context and expectations play a major role in the subjective feeling of familiarity. This helps to explain why seeing your roommate in your living room does not result in a feeling of familiarity, even though processing of that person is very fluent. And it explains why, in seeing your butcher on the bus, you may experience a rush of familiarity. The difference between the two situations, of course, lies in your expectations: you expected to process easily and identify the face you saw in the living room; you didn't expect to see an easily processed face (or at least that particular one) on the bus.

4. **Working Memory Demonstration:**
   http://www.gocognitive.net/sites/default/files/stm.v1.0.a_1_0.swf

   This demonstration provides students with the opportunity to test their own working memory using the digit span test. Numbers are shown one at a time. Afterward, students are asked to click on the numbers in the order in which they were presented.

5. **Brenda Milner, Neuropsychologist** https://www.youtube.com/watch?v=JliczINA__Y

   Brenda Milner, McGill University, is a world-renowned neuropsychologist, famous for her work with patient Henry Molaison (H.M.). In this video, Dr. Milner discusses her work with H.M., including the evidence that he had retained implicit memory.

6. **Lerner, I., & Shriki, O. 2014. Internally- and externally-driven network transitions as a basis for automatic and strategic processes in semantic priming: theory and experimental validation. *Frontiers in Psychology*, 5:314.**

   This article discusses a semantic-priming model that explains many of the empirical findings within one conceptual network. The authors depict semantic memory in terms of classic automatic and controlled processing.

## Homework or Study Questions

1. **How do cases of amnesic patients provide evidence for the distinction between episodic and semantic memory?**

Episodic personal knowledge would consist of memories of specific events, instances of the person's own behaviour. Semantic personal knowledge would include facts *about* the person (e.g., historical details, personality characteristics). In the days after her injury, amnesic patient WJ could report no episodic memories for the preceding six or seven months. She could, however, report numerous details about her life (which classes she was enrolled in, for example). Furthermore, self-ratings of personality traits by WJ while she was amnesic closely matched ratings she gave after her amnesia had lifted. The amnesia, then, temporarily destroyed WJ's episodic memory and left her semantic memory intact. This suggests that the two are independent from one another.

Another amnesic patient, NN/KC, retained semantic memory abilities following his traumatic brain injury, but never regained episodic memory abilities. Again, this suggests the two memory systems are independent.

2. **Describe Baddeley's model of working memory.**

According to Baddeley, working memory is not just a storehouse where things exist; it is best thought of as a workbench where information is manipulated. New information can be acquired from the environment and information can be accessed from long-term memory. Working memory is made up of four components:

- the phonological loop, which temporarily stores a limited number of sounds;
- the visuo-spatial sketchpad, which temporarily stores visual and spatial information;
- the episodic buffer, which provides a temporary storehouse where information from the other components of the memory system is gathered; and
- the central executive, which coordinates information from the phonological loop, the visuo-spatial sketchpad, and the episodic buffer.

3. **Describe the components of the modal model of memory in terms of their function and limitations.**

There are three components in the modal model of memory. Sensory memory is able to register large amounts of information; however, it can only retain it for a maximum of one second unless attention is focused on a specific item. Short term memory receives information from both sensory and long-term memory; however, unless the information is rehearsed it will decay within approximately 18 seconds. The third component is long-term memory, which stores information for long periods of time. It also brings information from short-term memory for immediate usage.

4. **Explain the importance of George Sperling's findings.**

Sperling's findings were important for three reasons:

1) They show our sensory memory can store large amounts of information at a single glance.
2) Sensory memory may help us see the world in a continuous manner.
3) Not all information from sensory memory enters short-term memory.

5. **What do the cases of NN and WJ tell us about declarative memory?**

They tell us that semantic and episodic memory are independent systems. Meaning that it is possible to lose one system to damage but retain the other system.

6. **What makes priming and procedural memory "implicit"?**

   Both of these are implicit because previous exposure or learning influences the future responses without there having to be awareness of the initial exposure or learning.

7. **How does the connectionist model of memory differ from other models?**

   The connectionist model differs from other models in that it suggests that items are not "stored in memory", but rather memories consist of certain patterns of activity. Additionally, copies of a particular experience are not stored as memory traces. Instead, neuron-like units representing each of the properties of the experience are connected to other neuron-like units. As a unit can represent properties of a number of experiences, recalling a particular experience requires both excitation of some units and inhibition of others.

## Suggestions for Research Paper Topics

1. Review the recent literature on Alzheimer's disease. Are we close to knowing what causes the disease and what can be done to prevent it? How optimistic should we be regarding future treatment and cure?

2. Individuals differ in their working memory span. That is, they differ in how many items can be held in working memory at once. Working memory span can predict performance in a lot of areas: the larger your working memory span, the better you tend to perform on a wide variety of cognitive tasks. On which cognitive tasks do high working memory span individuals tend to differ from low working memory span individuals?

3. Some researchers have suggested that working memory span is a better predictor of academic success than traditional measures of IQ. Review the relevant literature. Do you agree?

4. It is clear that young adults demonstrate superior performance over older adults on numerous types of memory tests. On which, if any, cognitive tasks (memory or otherwise) do older adults out-perform the young?

5. Research suggests that persons who are born profoundly deaf still develop language in similar ways as typically developing children. Does Baddeley's working memory model apply to those who cannot hear? Specifically, does research support the presence of a phonological loop in persons who are deaf?

6. Chapter 5 covers both iconic and echoic memory but mentions that there is a sensory memory system for all the senses. Imagine you are conducting a study on the olfactory system (sense of smell). How might you design a study to explore olfactory sensory memory? What would be the limitations of using a version of the partial report for this?

7. Write a critique of one of the experiments described in the chapter (e.g., Sperling's partial/whole report; lexical decision task; Mey, Schvanveldt & Ruddy's priming procedure, etc.).

8. Clive Wearing was a musicologist who, after contracting encephalitis, sustained damage to the hippocampus and areas surrounding the hippocampus. As a result, he is unable to remember anything more than the past 20-30 seconds. Despite the severity of his amnesia, he is still able to play the piano as proficiently as he could before his illness. Review the literature about Clive Wearing and explain why he has been able to retain this amazing skill when everything else seems to have been lost from memory.

9. Review the literature on one of the memory disorders discussed in the book. Examine which types of memory deficits are related to the disorder and how these deficits are exhibited.