Cognition

Modules

31  Studying and Building Memories
32  Memory Storage and Retrieval
33  Forgetting, Memory Construction, and Memory Improvement
34  Thinking, Concepts, and Creativity
35  Solving Problems and Making Decisions
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I revised this unit's first three modules after collaborating with Janie Wilson, Professor of Psychology at Georgia Southern University and Vice President for Programming of the Society for the Teaching of Psychology.

Throughout history, we humans have both bemoaned our foolishness and celebrated our wisdom. The poet T.S. Eliot was struck by "the hollow man...Head-piece filled with straw." But Shakespeare's Hamlet enticed the human species as "noble in reason...infinite in faculties...in apprehension how like a god!" In the preceding units, we have likewise marveled at both our abilities and our errors. Elsewhere in this text, we study the human brain—three pounds of wet tissue the size of a small cabbage, yet containing circuitry more complex than the planet's telephone networks. We appreciate the amazing abilities of newborns. We marvel at our sensory system, translating visual stimuli into nerve impulses, distributing them for parallel processing, and reassembling them into colorful perceptions. Little wonder that our species has had the collective genius to invent the camera, the car, and the computer; to unlock the atom and crack the genetic code; to travel out to space and into our brain's depths. Yet we have also seen that our species is kin to the other animals, influenced by the same principles that produce learning in rats and pigeons. We have noted that we not-so-wise humans are easily deceived by perceptual illusions, pseudopsychic claims, and false memories.

In this unit, we encounter further instances of these two images of the human condition—the rational and the irrational. We will ponder our memory's enormous capacity, and the ease with which our two-track mind processes information, with and without our awareness. We will consider how we use and misuse the information we receive, perceive, store, and retrieve. We will look at our gift for language and consider how and why it develops. And we will reflect on how deserving we are of our species name, Homo sapiens—wise human.

Module 31

Studying and Building Memories

Module Learning Objectives

31-1  Define memory;

31-2  Explain how psychologists describe the human memory system.

31-3  Distinguish between explicit and implicit memories.

31-4  Identify the information we process automatically.

31-5  Explain how sensory memory works.

31-6  Describe the capacity of our short-term and working memory.

31-7  Describe the effortful processing strategies that help us remember new information.

31-8  Describe the levels of processing and their effect on encoding.

Be thankful for memory. We take it for granted, except when it malfunctions. But it is our memory that accounts for time and defines our life. It is our memory that enables us to recognize family, speak our language, find our way home, and locate food and water. It is our memory that enables us to enjoy an experience and then mentally replay and enjoy it again. And it is our memory that occasionally pits us against those whose offenses we cannot forget.
Memory Models

31-1 How do psychologists describe the human memory system?

Architects make miniature house models to help clients imagine their future homes. Similarly, psychologists create memory models to help us think about how our brain forms and retrieves memories. Information-processing models are analogies that compute human memory for a computer's operations. Thus, to remember in this way, we must:

- get information into our brain, a process called encoding.
- retain that information, a process called storage.
- later get the information back out, a process called retrieval.

Like all analogies, computer models have their limits. Our memories are less literal and more fragile than a computer's. Moreover, as computers process information sequentially, even while alternating between tasks. Our dual-track brain processes many things simultaneously (some of them unconsciously) by means of parallel processing. As you enter this lunchroom, you simultaneously—in parallel—process information about you see, the sounds of voices, and the smell of food.

To focus on this complex, simultaneous processing, one information-processing model, connectionism, views memories as products of interconnected neural networks. Specific memories arise from particular activation patterns within these networks. Every time you learn something new, your brain's neural connections change, forming and strengthening pathways that allow you to interact with and learn from your constantly changing environment.

To explain our memory-forming process, Richard Atkinson and Richard Shiffrin (1968) proposed another model, with three stages:

1. We first record to-be-remembered information as a fleeting sensory memory.
2. Then from there, we process information into short-term memory, where we encode it through rehearsal.
3. Finally, information moves into long-term memory for later retrieval.

Other psychologists have updated this model (Figure 31.2) to include important never concepts, including working memory and automatic processing.

WORKING MEMORY

Alun Baddeley and others (Baddeley, 2001, 2002; Engle, 2002) challenged Atkinson and Shiffrin's view of short-term memory as a small, brief storage space for recent thoughts and experiences. Research shows that this stage is not just a temporary shell for holding incoming information. It's an active desktop where your brain processes information, making sense of new input and linking it with long-term memories. Whether we hear eye-scream as "Ice cream" or "I scream" will depend on how the context and our experience guide us in interpreting and encoding the sounds.

Figure 31.2

A modified three-stage processing model of memory: Atkinson and Shiffrin's classic three-stage model helps us think about how memories are processed, but today's researchers disagree on three ways long-term memories form. For example, some information slips into long-term memory via a "back door" without our consciousness attending it (automatic processing). And so much active processing occurs in the short-term memory stages that many now prefer the term working memory.
Automatic Processing and Implicit Memories

31.4 What information do we automatically process?

Our implicit memories include procedural memory for automatic skills (such as how to ride a bike) and classically conditioned associations among stimuli. Visiting your dentist, you may, thanks to a conditioned association linking the dentist's office with the painful drill, find yourself with sweaty palms. You didn't plan to feel that way when you got to the dentist's office; it happened automatically.

Without conscious effort you also automatically process information about:

- space. While studying, you often encode the place on a page or in your notebook where certain material appears; later, when you want to retrieve information about automatic processing, for example, you may visualize the location of that information on this page.
- time. While going about your day, you unintentionally note the sequence of its events. Later, realizing you've left your backpack somewhere, the event sequence your brain automatically encoded will enable you to retrace your steps.
- frequency. You effortlessly keep track of how many times things happen, as when you suddenly realize, This is the third time I've run into her today.

Our two-track mind engages in impressively efficient information processing. As one track automatically tucks away many routine details, the other track is free to focus on conscious, effortful processing. This reinforces an important principle introduced in Module 19's description of parallel processing: Mental feats such as vision, thinking, and memory may seem to be single abilities, but they are not. Rather, we split information into different components for separate and simultaneous processing.

Effortful Processing and Explicit Memories

Automatic processing happens so effortlessly that it is difficult to shut off. When you see words in your native language, perhaps on the side of a delivery truck, you can't help but read them and register their meaning. Learning to read wasn't automatic. You may recall working hard to pick out letters and connect them to certain sounds. But with experience and practice, your reading became automatic. Imagine now learning to read reversed sentences like this:

calamitosa emeseb nac gnisescorp lutroff!

At first, this requires effort, but after enough practice, you would also perform this task much more automatically. We develop many skills in this way. We learn to drive, to text, to speak a new language with effort, but then these tasks become automatic.

31.5 How does sensory memory work?

Sensory memory (recall Figure 31.2) feeds our active working memory, recording momentary images of scenes or echoes of sounds. How much of this page could you sense and recall with less exposure than a lightning flash? In one experiment (Spilro, 1962), people viewed three rows of letters each, for only one-twentieth of a second (FIGURE 31.5). After the nine letters disappeared, they could recall only about half of them.

Was it because they had insufficient time to glimpse them? No. The researcher, George Spilro, cleverly demonstrated that people actually could see and recall all the letters, but only momentarily. Rather than ask them to recall all nine letters at once, he asked them to recall them one at a time, with response latency and recognition accuracy.

- K Z R
- Q B T
- S G N

Figure 31.5
Total recall—briefly. When George Spilro flashed a group of letters similar to this for one-hundredth of a second, people could recall only about half the letters. But when signaled to recall a particular row immediately after the letters had disappeared, they could do so with near-perfect accuracy.
Iconic memory: a momentary memory for visual stimuli; a photographic or picture-image memory lasting no more than a few tenths of a second.

Echoic memory: a momentary memory for auditory stimuli; if attention is elsewhere, words and sounds can still be recalled within 3 or 4 seconds.

CAPACITY OF SHORT-TERM AND WORKING MEMORY

What is the capacity of our short-term and working memory?

George Miller (1956) proposed that short-term memory can retain about seven information (give or take two). Other researchers have confirmed that we can, if nothing distracts us, recall about seven digits, or about six letters or five words (Baddeley et al., 1975). How quickly do our short-term memories disappear? To find out, researchers asked people to remember three consonant groups, such as CHF (Peterson & Peterson, 1959). To prevent rehearsal, the researchers asked them, for example, to start at 100 and count aloud backward by threes. After 3 seconds, people recalled the letters only about half the time; after 12 seconds, they seldom recalled them at all (Figure 3.16). Without the active processing that we now understand to be a part of our working memory, short-term memories have a limited life.

Working-memory capacity varies, depending on age and other factors. Compared with children and older adults, young adults have more working-memory capacity, so they can use their mental workspace more efficiently. This means their ability to multitask is relatively greater. But whatever our age, we do better and more efficient work when focused, without distractions, on one task at a time. "One of the most stubborn, persistent phenomenon of the mind," notes cognitive psychologist Daniel Willingham (2010), "is that when you do two things at once, you don't do either one as well as when you do them one at a time." The bottom line: It's probably a bad idea to try to watch TV, text your friends, and write a psychology paper at the same time!

Effortful Processing Strategies

What are some effortful processing strategies that can help us remember new information?

Research shows that several effortful processing strategies can boost our ability to form new memories. Later, when we try to retrieve a memory, these strategies can make the difference between success and failure.

Alien memory effects: chunking, mnemonics, and rehearsal.
HIERARCHIES: When people develop expertise in an area, they process information not only in chunks but also in hierarchies composed of a few broad concepts divided and subdivided into narrower concepts and facts. This section, for example, aims to help you organize some of the memory concepts we have been discussing (FIGURE 31.9).

Organizing knowledge in hierarchies helps us retrieve information efficiently, as Gordon Bower and his colleagues (1969) demonstrated by presenting words either randomly or grouped into categories. When the words were organized into categories, recall was two to three times better. Such results show the benefits of organizing what you study—in giving special attention to the module objectives, headings, and Ask Yourself and Test Yourself questions. Taking class and text notes in outline format—a type of hierarchical organization—may also prove helpful.

DISTRIBUTED PRACTICE
We retain information (such as classmates' names) better when our encoding is distributed over time. More than 300 experiments over the last century have consistently revealed the benefits of this spacing effect (Cepeda et al., 2006). Massed practice (cramming) can produce speedy short-term learning and a feeling of confidence. But to paraphrase pioneer memory researcher Hermann Ebbinghaus (1885), those who learn quickly also forget quickly. Distributed practice produces better long-term recall. After you've studied long enough to master the material, further study at that time becomes inefficient (Roediger & Pashler, 2007). Better to spread that extra reviewing time later—a day later if you need to remember something 10 days hence, or a month later if you need to remember something 6 months hence (Cepeda et al., 2008).

Spreading your learning over several months, rather than over a shorter term, can help you retain information for a lifetime. In a 9-year experiment, Harry Bahrick and three of his family members (1993) practiced foreign language word translations for a given number of times, at intervals ranging from 14 to 56 days. Their consistent finding: The longer the space between practice sessions, the better their retention up to 5 years later.

One effective way to distribute practice is repeated self-testing, a phenomenon that researchers Henry Roediger and Jeffrey Karpicke (2006) have called the testing effect. In this text, for example, the testing questions interspersed throughout and at the end of each module and unit offer such opportunities. Better to practice retrieval (as any exam will demand) than merely to recite material (which may dull you into a false sense of mastery).

The point to remember: Spaced study and self-assessment beat cramming and recurring practice may not make perfect, but smart practice—occasional rehearsal with self-testing—makes for lasting memories.

LEVELS OF PROCESSING
31.8 What are the levels of processing, and how do they affect encoding?

Memory researchers have discovered that we process verbal information at different levels and that depth of processing affects our long-term retention. Shallow processing encodes on a very basic level, such as a word's letters or, at a more intermediate level, a word's sound.

Deep processing encodes semantically, based on the meaning of the words. The deeper (more meaningful) the processing, the better our retention.

In one classic experiment, researchers Fergus Craik and Endel Tulving (1975) flashed words at people. Then they asked the viewers a question that would elicit different levels of processing. To experience the task yourself, rapidly answer the following sample questions:

<table>
<thead>
<tr>
<th>Sample Questions to Elicit Processing</th>
<th>Word</th>
<th>Flashed</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Is the word in capital letters?</td>
<td>CHAIR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Does the word rhyme with brain?</td>
<td>brain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Would the girl fit in this sentence? The girl put the</td>
<td>doll</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Which type of processing would best prepare you to recognize the words at a later time? In Craik and Tulving's experiment, the deeper, semantic processing triggered by the third question yielded a much better memory than did the shallow processing elicited by the second question or the very shallow processing elicited by question 1 (which was especially ineffective).

MAKING MATERIAL PERSONALLY MEANINGFUL
If new information is not meaningful or related to our experience, we have trouble processing it. Put yourself in the place of the students whom John Bransford and Maria Johnson (1972) asked to remember the following recorded passage.

The procedure is actually quite simple. First you arrange things into different groups. Of course, one pile may be sufficient depending on how much there is to do. . . . After the procedure is completed arrange the materials into different groups again. Then they can be put into their appropriate places. Eventually they will be used once more and the whole cycle will then have to be repeated. However, that is part of life.

When the students heard the paragraph they had just read, without a meaningful context, they remembered little of it. When told the paragraph described washing clothes (something meaningful to them), they remembered much more of it—as you probably could now after rereading it.

*The mind is slow in unlearning what it has been long in learning.*—Powers, A. C. (1963). In W. C. Bisho (Ed.), Training and Skill Acquisition (pp. 6-45).
Can you repeat the sentence about the rioter that I gave you at this module's beginning? ("The angry rioter threw . . .") Perhaps, like those in an experiment by William Brewer (1977), you recalled the sentence by the meaning you encoded when you read it (for example, "The angry rioter threw the rock through the window") and not as it was written ("The angry rioter threw the rock at the window"). Referring to such mental mismatches, researchers have likened our minds to theater directors who, given a raw script, imagine the finished stage production (Bower & Morrow, 1990). Asked later what we heard or read, we recall not the literal text but what we encoded. Thus, studying for a test, you may remember your class notes rather than the class itself.

We can avoid some of these mismatches by rephrasing what we see and hear into meaningful terms. From his experiments on himself, German philosopher Hermann Ebbinghaus (1850-1909) estimated that, compared with learning nonsense material, learning meaningful material required one-tenth the effort. As memory researcher Wayne Wickelgren (1977, p. 346) noted, "The time you spend thinking about material you are reading and relating it to previously stored material is about the most useful thing you can do in learning any new subject matter."

Psychologist—actor team Helga Noice and Tony Noice (2006) have described how actors inject meaning into the daunting task of learning "all those lines." They do it by first coming to understand the flow of meaning: "One actor divided a half-page of dialogue into three [intentions]: 'to flatter,' 'to draw him out,' and 'to aly his fears.'" With this meaningful sequence in mind, the actor more easily remembered the lines.

We have especially good recall for information we can meaningfully relate to ourselves. Asked how well certain adjectives describe someone else, we often forget them; asked how well the adjectives describe us, we remember the words well. This tendency, called the self-reference effect, is especially strong in members of individualistic Western cultures (Symons & Johnson, 1997; Vlager & Cohen, 2003). Information deemed "relevant to me" is processed more deeply and remains more accessible. Knowing this, you can profit from taking time to find personal meaning in what you are studying.

The point to remember: The amount remembered depends both on the time spent learning and on your making it meaningful for deep processing.

**Module 31 Review**

**31.1 What is memory?**
- Memory is learning that has persisted over time, through the storage and retrieval of information.

**31.2 How do psychologists describe the human memory system?**
- Psychologists use memory models to think and communicate about memory.
- Information-processing models involve three processes: encoding, storage, and retrieval.
- The connectionism information-processing model views memories as products of interconnected neural networks.
- The three processing stages in the Atkinson-Shiffrin model are sensory memory, short-term memory, and long-term memory. More recent research has updated this model to include two important concepts: (1) working memory, to stress the active processing occurring in the second memory stage; and (2) automatic processing, to address the processing of information outside of conscious awareness.

**31.3 How do explicit and implicit memories differ?**
- Through parallel processing, the human brain processes many things simultaneously, on dual tasks.
- Explicit (declarative) memories—our conscious memories of facts and experiences—form through effortful processing, which requires conscious effort and attention.
- Implicit (nondeclarative) memories—of skills and classically conditioned associations—happen without our awareness, through automatic processing.

**31.4 What information do we automatically process?**
- In addition to skills and classically conditioned associations, we automatically process incidental information about space, time, and frequency.

**31.5 How does sensory memory work?**
- Sensory memory feeds some information into working memory for active processing there.
- An iconic memory is a very brief (a few tenths of a second) sensory memory of visual stimuli; an echoic memory is a three- to four-second sensory memory of auditory stimuli.

**31.6 What is the capacity of our short-term and working memory?**
- Short-term memory capacity is about seven items, plus or minus two, but this information disappears from memory quickly without rehearsal.
- Working memory capacity varies, depending on age, intelligence level, and other factors.

**31.7 What are some effortful processing strategies that can help us remember new information?**
- Effective effortful processing strategies include chunking, mnemonics, hierarchies, and distributed practice sessions.
- The testing effect is the finding that consciously retrieving, rather than simply resaying, information enhances memory.

**31.8 What are the levels of processing, and how do they affect encoding?**
- Depth of processing affects long-term retention.
  - In shallower processing, we encode words based on their structure or appearance.
  - Retention is best when we use deep processing, encoding words based on their meaning.
- We also more easily remember material that is personally meaningful—the self-reference effect.

**Before You Move On**

**ASK YOURSELF**
Can you think of three ways to employ the principles in this section to improve your own learning and retention of important ideas?

**TEST YOURSELF**
What would be the most effective strategy to learn and retain a list of names of key historical figures for a week? For a year?

Answers to the Test Yourself questions can be found in Appendix D at the end of the book.