


UNIT VII
Cognition

MODULES

- 31 Studying and Encoding Memories
- 32 Storing and Retrieving Memories
- 33 Forgetting, Memory Consolidation, and Improving Memory
- 34 Thinking, Concepts, and Creativity
- 35 Solving Problems and Making Decisions
- 36 Thinking and Language



Research on memory's extremes has helped us understand how memory works.

Some disorders, such as Alzheimer's disease, slowly strip away memory.

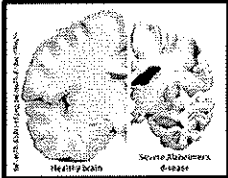
At the other extreme are people who would win gold medals in a memory Olympics.

Learning Targets

- 31-1 Define *memory*, and explain how memory is measured.
- 31-2 Discuss how psychologists describe the human memory system.
- 31-3 Describe the differences between explicit and implicit memories.
- 31-4 Discuss the information we process automatically.
- 31-5 Explain how sensory memory works.
- 31-6 Describe our short-term and working memory capacity.
- 31-7 Describe the effortful processing strategies that help us remember new information.
- 31-8 Discuss the levels of processing and their effect on encoding.


Module 31
Studying and Encoding Memories

Alzheimer's disease



a progressive neurodegeneration and fatal condition

How is *memory* defined?



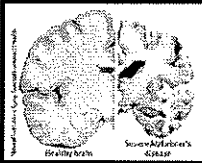
the persistence of learning over time through the **encoding, storage, and retrieval** of information

memory degeneration

Alzheimer's disease begins as difficulty remembering new information and progresses into an inability to do everyday tasks.

Family members and close friends become strangers; complex speech devolves to simple sentences; the brain's memory centers weaken and wither.

(Desikan et al., 2009)



What about the other extreme?

Russian journalist Solomon Shereshevskii, or 'S', had merely to listen while other reporters scribbled notes.

'S' could repeat up to 70 digits, if they were read about 3 seconds apart in an otherwise silent room.

He could recall digits or words backward as easily as forward.

How do we measure memory in life events?

<i>recall</i>	telling your friend about the time you won a goldfish at the carnival
<i>recognition</i>	seeing a brand of cereal on the grocery shelf and recognizing it from the commercial
<i>relearning</i>	traveling to Costa Rica and pulling back the Spanish you learned in 10 th grade

How is memory measured?

<i>recall</i>	<i>retrieving</i> information that is not currently in your conscious awareness but that was learned at an earlier time
<i>recognition</i>	<i>identifying</i> items previously learned
<i>relearning</i>	<i>learning something more quickly</i> when you learn it a second or later time

1. What Would You Answer?

Caitlin, a fifth grader, is asked to remember her second- grade teacher's name. What measure of retention will Caitlin use to answer this question?

A. storage
 B. recognition
 C. relearning
 D. recall
 E. encoding

How do we measure memory on tests in school?

<i>recall</i>	a fill-in-the-blank question, short answer or essay prompt
<i>recognition</i>	multiple choice or matching
<i>relearning</i>	studying for a final exam over the entire year's course content

TRY IT

Rapidly read aloud, eight times over, the following list:

JIH, BAZ, FUB, YOX, SUJ, XIR, DAX, LEQ, VUM, PID, KEL, WAV, TUV, ZOF, GEK, HIW.

Now look away and try to recall the items.

How did Hermann Ebbinghaus test speed of relearning?

Pioneering memory researcher Hermann Ebbinghaus randomly selected a sample of syllables, like those you just saw, practiced them, and tested himself on his ability to accurately recall the items.

The day after learning such a list, Ebbinghaus could recall few of the nonsense syllables.

But they weren't entirely forgotten.

What is *parallel processing*?

considering many aspects of a problem simultaneously; the brain's natural mode of information processing for many functions

What were Hermann Ebbinghaus' findings?

Ebbinghaus found that the more times he practiced a list of nonsense syllables on Day 1, the less time he required to relearn it on Day 2. Speed of relearning is one measure of memory retention. (From Baddeley, 1982.)

Number of repetitions on Day 1	Time in minutes to relearn on Day 2
0	25
5	20
10	15
15	12
20	10
25	8
30	7
35	6
40	5.5
44	5

How does parallel processing function?

Motion

Form

Depth

Color

Recall from Module 18 that when a person sees an object, they don't see just one thing, but rather many specific aspects that combined, allow the person to identify the object in its entirety.

How do psychologists describe the human memory system?

Psychologists propose an *information-processing model* which likens human memory to computer operations. To remember any event, we must...

Encode (put in) the new information...

store (organize) the information....

retrieve (pull out) the information.

What did early models of memory formation look like?

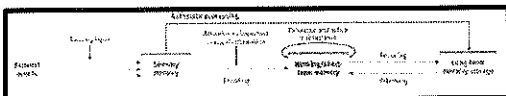
Richard Atkinson and Richard Shiffrin proposed a three-stage model of memory.

sensory memory: the immediate, very brief recording of sensory information in the memory system.

short-term memory: memory that holds a few items briefly before the information is stored or forgotten.

long-term memory: relatively permanent and limitless storehouse of the memory system.

How have early models been modified?



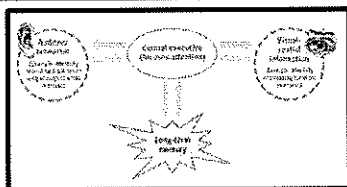
Today's researchers recognize other ways long-term memories form. For example, some information slips into long-term memory via a "back door," without our consciously attending to it (*automatic processing*). So much active processing occurs in the short-term memory stage that many now prefer the term *working memory*.

What is the role of the central executive?



Baddeley's idea of a *central executive* is key to the new model. The central executive coordinates focused processing without which, information often fades.

What is working memory?



a newer understanding of short-term memory that adds conscious, active processing of incoming auditory and visual information, and of information retrieved from long-term memory

What are *explicit* and *implicit* memories?

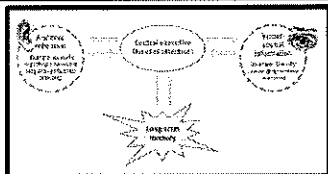
explicit memory

retention of facts and experiences from *long-term memory* that one can consciously know and "declare"
(Also called *declarative memory*.)

implicit memory

retention of learned skills or classically conditioned associations in *long-term memory* independent of conscious recollection
(Also called *nondeclarative memory*.)

How does Baddeley's model address working memory?



Alan Baddeley's (2002) model of *working memory*, includes *visual-spatial* and *auditory rehearsal* of new information. A hypothetical *central executive* (manager) focuses our attention, and pulls information from *long-term memory* to help make sense of new information.

How do *explicit* and *implicit* memories differ?

explicit memory

We encode explicit memories through *conscious effortful processing*; encoding that requires attention and conscious effort.

implicit memory

Automatic processing is unconscious encoding of incidental information, such as space, time, and frequency, and of well-learned information, such as word meanings.

What information do we process automatically?

space	Can you remember the page or side of the book certain charts, graphs or material is located?
time	Have you ever retraced your steps through the sequence of your day to find a lost item?
frequency	Can you recall how many times today you have run into a good friend?

What is *iconic memory*?

Sperling's sensory memory experiment demonstrated **iconic memory**, a fleeting sensory memory of visual stimuli.

For a few tenths of a second, our eyes register a picture-image memory of a scene, and we can recall any part of it in amazing detail.

TRY IT

Look at these letters for one second.

K	Z	R
Q	B	T
S	G	N

What is *echoic memory*?

We also have an impeccable, though fleeting, sensory memory for auditory stimuli, called **echoic memory** (Cowan, 1988; Lu et al., 1992).

Picture yourself in class, as your attention drifts to thoughts of the weekend. If your mildly irked teacher tests you by asking, "What did I just say?" you can recover the last few words from your mind's echo chamber.

Auditory echoes tend to linger for 3 or 4 seconds.

What was George Sperling's sensory memory experiment?

When George Sperling (1960) flashed a group of letters similar to this for 1/20th 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.

K	Z	R
Q	B	T
S	G	N

How are *short-term* and *working memory* related?

Recall that **short-term memory** refers to what we can briefly retain.

The related idea of **working memory** also includes our active processing, as our brain makes sense of incoming information and links it with stored memories.

What are the limits of what we can hold in this middle, short-term stage?

What is our short-term memory capacity?

George Miller (1956) proposed that we can store somewhere between 5 and 9 pieces of information (often referred to as 7 ± 2) in short-term memory.

Other researchers have confirmed that we can, if nothing distracts us, recall about seven digits.

But the number varies by task; we tend to remember about six letters and only about five words.

(Baddeley et al., 1975; Cowan, 2015)

What is the benefit of a large working memory capacity?

Having a large **working memory** capacity—the ability to juggle multiple items while processing information—tends to aid information retention after sleeping and creative problem solving.

(De Dreu et al., 2012; Fenn & Hambrick, 2012; Wiley & Jarosz, 2012)

How fast do short-term memories disappear?

Psychologists Peterson and Peterson asked subjects to remember three-consonant groups, such as *CHJ*.

Without rehearsal, after 3 seconds, people recalled the letters only about half the time; after 12 seconds, they seldom recalled them at all.

What are some effortful processing strategies that can help us encode and retrieve?

- chunking
- mnemonics
- hierarchies

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.

What is our working memory capacity?

Working memory capacity varies, depending on age and other factors.

Compared with children and older adults, young adults have a greater working memory capacity.

TRY IT

Look at the letters and numbers below for one minute. Then look away and try to recall as many as you can.

FBICIADAEFEMAIRS

1861186519141918

TRY IT

Would it be any easier to memorize now?

FBI CIA DEA FEMA IRS

1861 1865 1914 1918

What is a mnemonic device?

memory aids, especially those techniques that use vivid imagery and organizational devices, like acronyms or acrostics

We more easily remember concrete, visualizable words (like bicycle or book) than we do abstract words (like peace or love).

What is chunking?

FBICIADAEAFEMAIRS

FBI CIA DEA FEMA IRS

Chunking is organizing items into familiar, manageable units. 16 items would be too much for the STM to hold, but chunked into 5 meaningful items, fits the 7 +/- 2 capacity of short-term memory. Were you able to recall the letters easier when chunked or grouped in the second way?

What is the peg-word system

The peg-word system is a mnemonic device that utilizes visual imagery and this simple jingle. First, memorize the peg-word pairs on the right.

One – bun
Two – shoe
Three – tree
Four – door
Five – bee hive
Six – sticks
Seven – heaven
Eight – gate
Nine – swine
Ten – hen

TRY IT

Do you know these acronyms and acrostics?

HOMES

My Very Energetic Mother Just Served
Up Nine Pancakes

ROYGBIV

How does the peg-word system work?

Next visually associate the peg-words with to-be-remembered items. Close your eyes and see the image you create. Really focus on it.

Now let's try a short grocery list to remember:
Carrots? Stick them into the imaginary **bun**. See it?
Milk? Fill the **shoe** with it. See it?
Paper towels? Lay them over the **tree** branch. See it?

Think **bun**, **shoe**, **tree** and you see their associated images: carrots, milk, paper towels.

TRY IT

Try the peg-word technique to memorize the characteristics of the four stages of sleep from Module 23.

One – bun Two – shoe Three-tree Four-door	NREM-1: hypnagogic sensations and hallucinations NREM-2: sleep spindles NREM-3: delta waves, hard to awaken REM: rapid eye movement, dreams, muscle paralysis
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TRY IT

How would you use hierarchies to group this list of grocery items? Cont.

Did you make categories such as:
 PRODUCE: carrots, oranges, beans, red peppers, bananas
 DAIRY: milk, eggs, sour cream, yogurt, cheese
 MEAT: bacon, chicken produce
 SNACKS: pretzels, crackers, popcorn

Where did you place 'orange juice'?

How do hierarchies aid retrieval?

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            graph TD
            A[Effects processing and retrieval processes] --> B[Sensory memory]
            A --> C[Capacity of short-term and working memory]
            A --> D[Effects processing strategies]
            D --> E[Chunking]
            D --> F[Mnemonics]
            D --> G[Hierarchies]
            
```

When we organize words or concepts into hierarchical groups, as illustrated here with some of the concepts from this section, we remember them better than when we see them presented randomly.

TRY IT

How would you use hierarchies to group the information on memory in this Unit?

long-term memory, short-term memory, working memory, sensory memory, explicit and implicit memory, iconic and echoic imagery

Categorizing items into hierarchies increases recall.

TRY IT

How would you use hierarchies to group this list of grocery items?

Carrots, yogurt, pretzels, orange juice, bananas, milk, eggs, oranges, beans, chicken, bacon, cheese, crackers, popcorn, red peppers, sour cream.

Categorizing items into hierarchies increases recall.

How can the spacing effect impact memory retrieval?

The **spacing effect** is the tendency for *distributed* study or practice to yield better long-term retention than is achieved through *massed* study or practice.

Massed practice (cramming) can produce speedy short-term learning and a feeling of confidence. But to paraphrase Ebbinghaus (1885), those who learn quickly also forget quickly.

Distributed practice produces better long-term recall.

How can the testing effect impact memory retrieval?

One effective way to distribute practice is *repeated self-testing*, a phenomenon that researchers Roediger and Jeffrey Karpicke (2006) have called the **testing effect**.

Testing does more than assess learning and memory: it improves them.
(Brown et al., 2014; Pan et al., 2015; Trumbo et al., 2016)

TRY IT

Rapidly answer the following questions:

Sample Questions	Word Flashed	Yes	No
Shallow: Is the word in capital letters?	CHAIR	_____	_____
Shallow: Does the word rhyme with train?	train	_____	_____
Deep: Would the word fit in this sentence? The girl put the _____ on the table.	chair	_____	_____

Fergus Craik and Endel Tulving's work on processing levels showed the deeper, semantic processing triggered by the third question yielded better recall than did the shallower processing elicited by the second or first question.

What is the best strategy for learning?

"Two techniques that students frequently report using for studying—highlighting (or underlining) text and rereading text—[have been found] ineffective."

Happily, "retrieval practice (or testing) is a powerful and general strategy for learning."
Roediger (2013)

2. What Would You Answer?

Which of the following is most likely to lead to semantic encoding of a list of words?

- A. thinking about how the words relate to your own life
- B. practicing the words for a single extended period
- C. breaking up the practice into several relatively short sessions
- D. noticing where in a sentence the words appear
- E. focusing on the number of vowels and consonants in the words

What are two levels of processing?

<i>Shallow processing</i>	<i>Deep processing</i>
encoding on a basic level, based on the structure or appearance of words	encoding semantically, based on the meaning of the words; tends to yield the best retention

AP® Exam Tip

Are you often pressed for time?

The most effective way to cut down on the amount of time you need to spend studying is to increase the meaningfulness of the material.

If you can relate the material to your own life—and that's pretty easy when you're studying psychology—it takes less time to master it.


Use this tip while studying for the AP® exam.

Why should I make material meaningful?

From his experiments on himself, Ebbinghaus estimated that, compared with learning nonsense syllables, learning meaningful material required 1/10th the effort.

As memory researcher Wayne Wickelgren 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.*"

Learning Target 31-2 Review

 Discuss how 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**.
- Through **parallel processing**, the human brain processes many things simultaneously.
- The connectionism information-processing model views memories as products of interconnected neural networks.

What is the self-reference effect?


Most people excel at remembering personally relevant information.

Asked how well certain adjectives describe someone else, we often forget them; asked how well the adjectives describe us, we often remember them.

This tendency, called the **self-reference effect**, is especially strong in members of individualist Western cultures.

(Symons & Johnson, 1997; Wagar & Cohen, 2003)

Learning Target 31-2 Review cont.

 Discuss how psychologists describe the human memory system.

- 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.

Learning Target 31-1 Review



Define **memory**, and explain how memory is measured.

- **Memory** is learning that has persisted over time, through the storage and retrieval of information.
- Evidence of memory may be seen in an ability to **recall** information, **recognize** it, or **relearn** it more easily on a later attempt.

Learning Target 31-3 Review



Describe the differences between long-term explicit and implicit memories.

- **Explicit** (declarative) **memories**—our conscious memories of facts and experiences—develop with **effortful processing**, which requires conscious effort and attention.
- **Implicit** (nondeclarative) **memories**—of skills and classically conditioned associations—happen without our awareness, through automatic processing.

Learning Target 31-4 Review



Discuss the information we process automatically.

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

Learning Target 31-7 Review



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

- Effective **effortful processing** strategies include **chunking**, **mnemonics**, hierarchies, and distributed practice sessions (which produce results due to the **spacing effect**).
- The **testing effect** is the finding that consciously retrieving, rather than simply rereading, information enhances memory.

Learning Target 31-5 Review



Explain how sensory memory works.

- **Sensory memory** feeds iconic and echoic information into working memory for active processing.
- An **iconic memory** is a very brief sensory memory of visual stimuli; an **echoic memory** is a three- or four-second sensory memory of auditory stimuli.

Learning Target 31-8 Review



Discuss the levels of processing and their effect on encoding.

- Depth of processing affects long-term retention.
 - In **shallow processing**, we encode words based on their structure, appearance, or sound.
 - 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.

Learning Target 31-6 Review



Describe our short-term and working memory capacity.

- **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.