

YOU KNOW YOU HAVE MASTERED THE MAIN TOPICS IN THIS CHAPTER IF YOU ARE ABLE TO. . .

- Introduce the study of memory including the basic processes of encoding, storage, and retrieval as well as current theories of how memory works.
- Discuss the information-processing theory of memory in detail including the concepts of sensory, short-term memory, long-term memory, and attention.
- Identify the basic mechanisms and limitations in the retrieval of information including false memories.
- Describe Ebbinghaus's work on forgetting and proposed explanations for forgetting.
- Explain the biological processes thought to underlie memory and the deterioration of memory including sleep, diet, and exercise.

RAPID REVIEW

Memory can be thought of as an active system that receives information from the senses, organizes and alters it as it stores it, and then retrieves information from storage. All the current models of memory involve the three processes of **encoding**, **storage**, and **retrieval**.

Three models or theories about memory are discussed in the text. One is the **levels-of-processing model**, which proposes that how long a memory will be remembered depends on the depth to which it was processed. A second model is the **parallel distributed processing model**, which proposes that memories are created and stored across a network of neural circuits simultaneously, or in other words, in a parallel fashion. The third and currently most accepted model of memory is the **information-processing model**, which proposes that memory is divided into three components—**sensory**, **short term**, and **long term**. Sensory memory is the first stage of memory and involves information from our sensory systems. Visual sensory memory is called **iconic memory** and was studied extensively by **George Sperling** through the use of the partial report method. The capacity of iconic memory is everything that can be seen at one time, and the duration is around half a second. Short-term memory is limited in size and temporary. **Eidetic imagery**, also known as photographic memory, is the ability to access visual sensory memory over a long period of time. Iconic memory is useful for allowing the visual system to view the surroundings as continuous and stable. **Echoic memory** is the memory of auditory information and has the capacity of what can be heard at any one moment and has a duration of about two seconds.

The information-processing model proposes that information moves from sensory memory to short-term memory through the process of **selective attention**. This process explains the phenomenon of the **cocktail party effect**, when you are at a party and hear your name in a conversation across the room. **Divided attention**, the processing of multiple cognitive tasks simultaneously, tends to result in diminishing the ability to successfully process one task at the same level as another due to the limited size of working memory and the scope of the tasks the mind is attempting to process. For example, trying to read and reply to a text message from a friend while listening to a lecture will reduce the ability of a student to recall the content of the lecture. In the case of two very different tasks, the competition between the tasks can be minimized. For example, humming a familiar tune while washing the dishes places a cognitive task against a manual task and results in minimal competition for space in working memory. Another name for short-term memory is **working memory**, and some researchers propose that short-term memory consists of a central control process along with a visual “sketch pad” and auditory “recorder.” **George Miller** studied the capacity of short-term memory using the digit-span memory test and discovered that people can store an average of seven chunks of information (plus or minus two) in their short-term memory. **Chunking** is the process of reorganizing the information into meaningful units. The duration of short-term memory is between 10 and 30 seconds without rehearsal. **Maintenance rehearsal** describes the process of continuing to pay attention to a piece of information, such as reciting a name over and over again in your head.

Long-term memory is the third stage of memory proposed by the information-processing theory and has an essentially unlimited capacity and duration. Information may be encoded into long-term memory through **elaborative rehearsal**, a way of transferring information by making it meaningful. Long-term memories can be divided into two types, procedural and declarative. **Procedural, or nondeclarative memories** are memories for skill and habits, in other words, memories for things people can *do*. **Declarative memories** are memories of facts, or things people can *know*. There are two types of declarative memories, semantic and episodic. **Semantic memory** is memory for the meanings of words and concepts, while **episodic memory** is the memory of events or "episodes." Procedural memories appear to be stored in the cerebellum and amygdala, while declarative memories most likely involve the frontal and temporal lobes. Procedural memory is sometimes referred to as **implicit memory**, and declarative memory can be thought of as **explicit memory**. Explicit memories are easily verbalized, while implicit memories are nearly impossible to state in words. It is not entirely clear how the brain organizes information in long-term memory. The **semantic network model** suggests that information is stored in the brain in a connected fashion with related concepts physically close to each other.

Retrieval describes the process of pulling memories out of long-term memory. A **retrieval cue** is a stimulus that aids in the process of remembering. When the environment in which you learned an item serves as a retrieval cue, it is referred to as **encoding specificity**. If an emotional state serves as a retrieval cue, it is called **state-dependent learning**. Information can be retrieved through the process of **recall**, such as filling in the blanks, or **recognition**, such as multiple-choice questions in which the correct answer only needs to be "recognized." Not all information can be recalled equally well. The **serial position effect** describes the finding that information at the beginning and end of a list is more likely to be remembered than the information in the middle. The **primacy effect** proposes that the information at the beginning of the list is remembered due to rehearsal, while the **recency effect** proposes that the information at the end of the list is remembered due to the fact that it is still in short-term memory. Recognition is usually a much easier task than recall since the retrieval cue is the actual piece of information you are trying to remember, yet retrieval errors are still made when using recognition. A **false positive** occurs when someone recognizes a piece of information as a memory even though it did not happen. For example, a witness says he or she saw broken glass at the scene of an accident, when there was no glass broken in the accident. **Elizabeth Loftus** has spent over 30 years investigating the reliability of eyewitness memories and has found that what people see and hear about an event after the fact can affect the accuracy of their memories for that event. **Automatic encoding** is a term used to describe the memory process when we aren't actively paying attention to the information. A **flashbulb memory** is a specific type of automatic encoding that occurs when an unexpected and often emotional event occurs. Flashbulb memories typically contain a great deal of information including many details but might not be as accurate as they appear.

The retrieval of memories is a much more **constructive process** than most people assume. Several factors affect the accuracy of information retrieval. One factor is the **misinformation effect** in which false information presented after an event influences the memory of that event. When suggestions from others create inaccurate or false memories, this is referred to as the **false memory syndrome**. The false memory syndrome has frequently been observed while people are under hypnosis. Research by Loftus has suggested that in order for an individual to interpret a false event as a true memory, the event must seem plausible and the individual should be given information that supports the belief that the event could have happened to them personally. **Hindsight bias** is the tendency of people to falsely believe that they would have been able to accurately predict a result.

Herman Ebbinghaus was one of the first scientists to systematically study the process of forgetting. Using lists of **nonsense syllables**, he discovered that most forgetting occurs in the initial hour after the material is learned. He presented his findings in a visual graph called the **curve of forgetting**. There are at least four different causes for forgetting. **Encoding failure** occurs when the information does not make it past the initial encoding process and never really becomes a memory. Another possible cause of forgetting is the **decay** (or **disuse**) of the **memory trace** in short-term memory or the disuse of the information in long-term memory. The final two causes of forgetting discussed in the textbook have to do with interference. **Proactive interference** occurs when information from the past disrupts newly learned

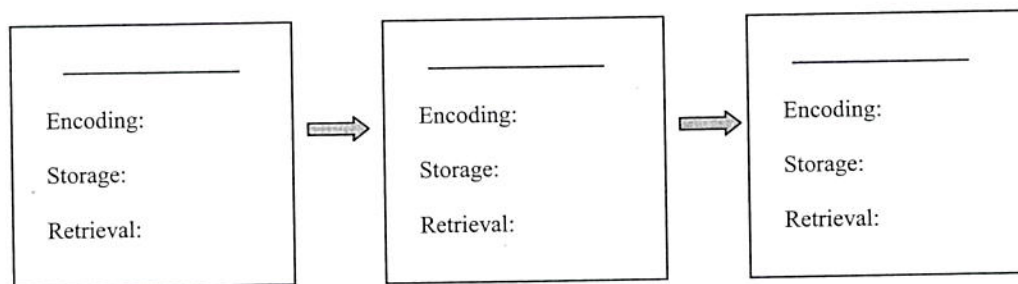
information. **Retroactive interference** occurs when the newly learned information interferes with the memories of the information from the past. Ebbinghaus found he could greatly improve memory if he spaced out his study sessions, a technique called **distributed practice**, as opposed to “cramming” or trying to learn all the information the night before the exam.

It is still unclear exactly how memories are physically stored in the brain. The concept of the physical change that takes place in the brain when memories are formed is called the **engram**, and scientists continue their search for the engram. In general, there is strong evidence to suggest that long-term procedural memories are stored in the cerebellum, while long-term declarative memories are stored in the frontal and temporal lobes. Storage of short-term memories has been associated with the prefrontal cortex and the temporal lobe. The process of physically storing a memory in your brain is called **consolidation** and could consist of a number of changes including an increase in receptor sites, increased sensitivity at the synapse, changes on the dendrites, or changes in proteins in the neuron. The hippocampus has been found to play an important role in the formation of new memories. This fact was mainly discovered by observing patients with damage to the hippocampus and noting their inability to form any new memories. A man named **H.M.** is the most famous of these patients. H.M.’s hippocampi were removed during a surgical procedure to reduce the severity of his epileptic seizures. After the surgery, H.M. could not form any new declarative memories. H.M. could, however, still form new procedural memories. **Amnesia** is a disorder that is characterized by severe memory loss, such as that of H.M., and can take one of two forms. **Retrograde amnesia** is an inability to retrieve memories from the past, while **anterograde amnesia** is an inability to form any new memories. **Alzheimer’s disease**, at least in the beginning, is a form of anterograde amnesia and is one type of dementia that is associated with severe memory loss. Currently, there is no cure for Alzheimer’s disease, but researchers are working hard to find one. An inability to remember events from the first few years of life has been described as **infantile amnesia** and may be due to the implicit, or nonverbal, nature of those memories.

Sleep facilitates the consolidation of memories, and sleep deprivation can reduce the ability to acquire new memories. Brief exercise after learning new information can improve memory consolidation. A diet high in an omega-3 fatty acid called DHA showed in animal research an improvement in memory function.

STUDY HINTS

- Two of the most important concepts presented in this chapter consist of a three-part model. One concept is the basic processes involved in memory—encoding, storage, and retrieval. The other concept is the information-processing model of memory that consists of sensory, short-term, and long-term memory. Students often get these ideas confused. To help you clarify the concepts, correctly identify the components of the information-processing model in the diagram below. Remember that encoding, storage, and retrieval can happen at each of these stages. List an example of encoding, storage, and retrieval for each stage.



- Long-term memory can be divided into two basic types of memory—procedural and declarative. Declarative memories can be further broken down into episodic and semantic. To help you understand the difference between these types of memories, come up with a specific memory from your own life and write it in the appropriate box.

YOU KNOW YOU HAVE MASTERED THE MAIN TOPICS IN THIS CHAPTER IF YOU ARE ABLE TO . . .

- Define learning.
- Explain what classical conditioning is, how it works, and how it was discovered.
- Describe the mechanisms of operant conditioning.
- Cite examples of biological constraints and how they contribute to learning predispositions.
- Introduce the characteristics of insight, latent, and observational/social learning.
- Identify the researchers who contributed to our understanding of the learning process and explain various ways that their ideas can be applied in the real world.

RAPID REVIEW

Learning is the process that allows us to adapt to the changing conditions of the environment around us and is defined as any relatively permanent change in behavior brought about by experience or practice (as opposed to changes brought about by maturation). **Ivan Pavlov**, a Russian physiologist, discovered one of the simplest forms of learning, called **classical conditioning**. In classical conditioning, an organism learns to make a reflex response to a stimulus other than the original stimulus that produced the response in the first place. The original stimulus is called the **unconditioned (or “unlearned”) stimulus (UCS)**, and the reflex response is the **unconditioned response (UCR)**. If a **neutral stimulus (NS)** is repeatedly paired with the UCS, it will eventually produce the same kind of reflexive response. At this point, the NS is called a **conditioned stimulus (CS)** and the response is called a **conditioned, or learned, response (CR)**. The repeated pairing of the NS and UCS is known as **acquisition**. In order for classical conditioning to occur, the CS must occur before the UCS, the CS and UCS must occur close together in time, the CS and UCS must be paired together repeatedly, and the CS should be distinctive. Two other principles of classical conditioning are **stimulus generalization**, the ability of a stimulus that resembles the CS to produce a CR, and **stimulus discrimination**, learning to respond to different stimuli in different ways. In classical conditioning, **extinction** occurs after the CS is repeatedly presented without the UCS and no longer produces a CR. **Spontaneous recovery** occurs when the CS is presented after being absent for a period of time and produces a mild CR. When a powerful conditioned stimulus is paired with a neutral stimulus, the conditioned stimulus itself can function as a UCS and turn the neutral stimulus into a second conditioned stimulus. This process is called **higher-order conditioning**.

John Watson demonstrated a particular type of classical conditioning called **conditional emotional response** with Little Albert and his learned phobia of white rats. **Vicarious conditioning** occurs when a person becomes classically conditioned simply by watching someone else respond to a stimulus. **Conditioned taste aversions** are a unique form of classical conditioning that can occur with only one neutral stimulus–unconditioned stimulus pairing. Superstitions are established in a person’s behavior when an event pairs the behavior with a coincidental reinforcement or punishment. For example, “knocking on wood” is paired with preventing something inevitable and bad from happening after making a favorable or boastful statement. The knocking-on-wood behavior is negatively reinforced by the assumption that something negative was taken away when nothing bad happens, and as a result of the perceived reinforcement the behavior becomes more frequent. Conditioning is believed to occur so rapidly due to the **biological preparedness** of most mammals. Pavlov suggested that classical conditioning works through the process of **stimulus substitution**, in that the close pairing in time of the CS with the UCS eventually leads to the CS serving as a substitute stimulus for the UCS and activating the same brain area as the UCS. Psychologists who agree with the **cognitive perspective**, such as Robert Rescorla, suggested that the CS must provide some information about the upcoming UCS and that it is this expectancy that causes the association to occur.

Operant conditioning is a type of learning more strongly associated with voluntary behavior and is based on **Edward Thorndike’s** work with cats and the puzzle box. Based on his research, Thorndike formulated the **Law of Effect** which states that if a response is followed by a pleasurable consequence it

will tend to be repeated and if a response is followed by an unpleasant consequence it will tend not to be repeated. **B.F. Skinner** expanded on Thorndike's Law of Effect and coined the term "operant conditioning" for this type of learning, since the term **operant** refers to any voluntary behavior. While classical conditioning focuses on what happens *before* the response, the key to operant conditioning is what happens *after* the response, or in other words, the consequence. **Reinforcement** or a **reinforcer** is a consequence that is pleasurable and strengthens the response that came before it. There are two types of reinforcers. **Primary reinforcers** satisfy basic needs and don't need to be learned. **Secondary reinforcers** get their reinforcing power through prior associations with a primary reinforcer and thus are learned. Reinforcement works by adding a pleasurable consequence after a response occurs (**positive reinforcement**) or removing something unpleasant after a response occurs (**negative reinforcement**). Both positive and negative reinforcement increase the likelihood that the response will occur again.

An important principle that Skinner discovered is that the timing of reinforcement can make a significant difference on how fast a response is learned. **Continuous reinforcement** occurs when a reinforcer is presented after every response. **Partial reinforcement** occurs when a reinforcer is given after some, but not all, of the correct responses. Partial reinforcement takes longer to go through extinction, or in other words, is more resistant to extinction. This is known as the **partial reinforcement effect**. The timing of partial reinforcement is referred to as the **schedule of reinforcement**. There are four different schedules of reinforcement: **fixed ratio**, **variable ratio**, **fixed interval**, and **variable interval**. A ratio schedule occurs when a reinforcer depends on the number of responses that are made. In an interval schedule, reinforcers are presented after a certain period of time has passed. If the reinforcers are always given after a set period of time or number of responses, the schedule is said to be fixed. If the reinforcer is given after varying periods of time or numbers of responses, the schedule is labeled as variable.

Punishment, on the other hand, always decreases the likelihood of a response. Punishment is any consequence of a response that causes that response to be less likely to happen again. While reinforcement strengthens a response that already exists, the goal of punishment is often to eliminate the response, which is usually a much harder task. Typically punishment only temporarily suppresses the response. **Positive punishment** describes the situation in which a response is followed by the addition of something unpleasant. Positive punishment is not the most effective way to modify behavior and has a number of serious drawbacks. **Negative punishment** occurs when a response is followed by the removal of something pleasant. Punishment can be made more effective if it is administered immediately after the undesired behavior, is administered consistently, and is paired with reinforcement for the right behavior.

Shaping involves the use of operant conditioning to reward **successive approximations** until the desired response is obtained. Operant conditioning has several parallels with classical conditioning, such as that **extinction** involves the removal of the reinforcement and **spontaneous recovery** occurs when an organism attempts a previously learned response in order to receive a reward. In addition, a **discriminative stimulus** is defined as any stimulus that provides an organism with a signal or cue for making a certain response in order to get reinforcement. In the lab, researchers found that even though animals could be operantly conditioned to perform certain tasks, they possessed biological constraints to learning other tasks and often had a tendency to go back to their genetic, or natural, way of doing things. This tendency to revert to genetically controlled patterns is called **instinctive drift**.

The term **behavior modification** is used to describe the process of using operant conditioning to change behavior. A **token economy** involves the use of tokens to modify behavior. **Time-outs** are an example of negative punishment where the child is removed from a situation where he or she could get attention from others. **Applied behavior analysis (ABA)** uses shaping techniques to obtain a desired behavior and is particularly successful with children with disorders such as autism. The technique called **biofeedback** uses operant conditioning to modify involuntary behaviors such as blood pressure and heart rate. When this technique is used to try to change brain wave activity, it is referred to as **neurofeedback**.

Cognitive learning theorists focus on the mental processes (or cognitions) that occur during learning. **Edward Tolman** studied the phenomenon of **latent learning** in rats placed in a maze but not reinforced for finding their way out. He found that when the rats were subsequently reinforced, learning occurred much faster than for rats that had never been in the maze. **Martin Seligman** studied a phenomenon he called **learned helplessness** in dogs. He found that dogs classically conditioned to a tone

followed by a painful shock would not later try to escape the shock when provided the opportunity. Seligman extended the concept of learned helplessness to humans in an attempt to explain depression. A third cognitive psychologist, **Wolfgang Köhler**, studied the phenomenon of **insight learning** in animals. Köhler believed insight learning involved a sudden perception of relationships that could not be gained through trial and error learning. All three theories of learning are related in that they focus on what's going on inside the learner's mind during the learning process as opposed to the external stimuli and rewards of classical and operant conditioning.

A third category of learning is that of **observational learning**, or the learning of a new behavior by observing someone else who is performing that behavior. The term **learning/performance distinction** describes the fact that learning can take place without actual performance. **Albert Bandura** has been a major contributor to the study of observational learning and conducted a series of classic studies observing children's learned behaviors with a blow-up "Bobo" doll. Bandura concluded that four elements were needed for observational learning to occur; the four elements are attention, memory, imitation, and desire/motivation.

Behavior	Consequence	Is something good or bad taken away?	Is this negative reinforcement or negative punishment?	Will the behavior increase or decrease?
Taking an aspirin for a headache.	Headache goes away.	<i>bad</i>	<i>negative reinforcement</i>	<i>increase</i>
Running a red light.	Driver's license is taken away.			
Cleaning your room so that you are no longer grounded.	You are no longer grounded.			
Drinking coffee in the morning when you are very tired.	You no longer feel tired.			
Staying out past your curfew.	Your parents ground you.			
Getting in a fight with a friend.	Your friend will not talk to you anymore.			
Fastening your seatbelt when the buzzer is making a noise.	The buzzer stops.			
Driving your car until it runs out of gas.	You can't drive your car anymore.			
Your boyfriend nags you until you take him out to dinner.	The nagging stops.			

Suggested answers

Behavior	Consequence	Is something good or bad taken away?	Is this negative reinforcement or punishment?	Will the behavior increase or decrease?
Taking an aspirin for a headache.	Headache goes away	<i>bad</i>	<i>negative reinforcement</i>	<i>increase</i>
Running a red light.	Driver's license is taken away.	<i>good</i>	<i>negative punishment</i>	<i>decrease</i>
Cleaning your room so that you are no longer grounded.	You are no longer grounded.	<i>bad</i>	<i>negative reinforcement</i>	<i>increase</i>

Drinking coffee in the morning when you are very tired.	You no longer feel tired.	<i>bad</i>	<i>negative reinforcement</i>	<i>increase</i>
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Your boyfriend nags you until you take him out to dinner.	The nagging stops.	<i>bad</i>	<i>negative reinforcement</i>	<i>increase</i>

CHAPTER 9: COGNITION

IF YOU LEARN ONLY SIX THINGS IN THIS CHAPTER . . .

1. Cognition is the study of mental processes.
2. STM seems to be limited to 7 ± 2 items at any given time.
3. The differences between encoding, storage, and retrieval are important.
4. Models of LTM deal with how we organize information that we know.
5. Problem solving involves applying what we know in an organized way to issues that we face.
6. Language is a complex system of communication that allows us to use complex symbols to talk about things in the past or the future, not just the present.

INTRODUCTION

One of the more recent areas of psychology to attract attention is **cognition**. This area has actually been around for most of the history of psychology, but only in the past 30 years has it taken on its modern form.

Chapter 3 on the history of psychology described the work of Wilhelm Wundt. Wundt was interested in the internal workings of the mind, specifically the way that consciousness is organized and structured. This idea is echoed in modern cognitive psychology as we focus on how our knowledge is organized. However, modern cognitive psychology has developed empirical techniques to study the organization of knowledge and memory.

In this chapter, we will discuss some of the modern conceptions of memory and how we have gone about studying these processes.

MEMORY

One of the early attempts at explaining memory broke the concept down into the following processes:

Sensory memory Short-term memory (STM) Long-term memory (LTM)

According to this model (often called the **Atkinson–Shiffrin** model and referred to generally as a **model of information processing**), information enters into a sensory memory for a brief period (typically described as 250 milliseconds). Information that we pay attention to is then moved to short-term memory (capacity about 7 ± 2 items of information), where we elaborate on it, and it stays for only about 30 or 40 seconds. If we elaborate sufficiently, the information is then transferred to long-term memory.

Each process described here was thought to involve some underlying neurological process, but it was not specified at the time how the brain actually created this activity.

ENCODING

Memory involves three processes called **encoding**, **storage**, and **retrieval**. In short, these are the processes by which we get information in (encoding), hang on to it (storage), and then get it back out when we need it (retrieval).

Information from the environment is encoded when it enters the body through the senses. The three primary ways information is captured are by **visual encoding** (images), **acoustic encoding** (sounds), and **semantic encoding** (meanings). Visual encoding tends to be the most effective of the three, but the most effective way to successfully encode is to combine these: for example, learning the sounds and meanings of new words, or seeing pictures while a storyteller spins a tale. If we want to remember large amounts of information, our recall will be easier if we can use **chunking** to group information together. Remembering a 10-digit phone number is much easier if we remember in the pattern 3-3-4 rather than trying to recall 10 unconnected numbers.

AP EXPERT TIP

Incorrect answers on a test can be explained as either encoding, storage, or retrieval problems.

STORAGE

Storage involves the previously mentioned sensory memory, short-term memory, and long-term memory. Short-term memory has a limit not only on the number of items it can hold but also on duration, since it appears to last for about 20 seconds or so. Psychologists today often refer to short-term memory as “working memory.” So, when you recall something like a childhood birthday party, those memories are temporarily retrieved from storage and into this working memory. Memories much longer than 20 seconds are part of long-term memory, and we can use **rehearsal** to increase the likelihood that those memories will be recalled. Long-term memory is often divided into **explicit memories**, such as knowing the capital of Brazil, and **implicit memories**, such as remembering how to move your body when you are walking.

RETRIEVAL

When we talk about memory, we can't just talk about encoding. Encoding is, without a doubt, critical; after all, one cannot “remember” without first laying down a clear memory trace. But we must also talk about retrieval—without a good retrieval strategy, we can't get the information back out. The key to accessing information from long-term memory is to have an **appropriate retrieval cue**.

What acts as an effective retrieval cue? For one, what we are currently thinking about. The process has to do with the organization of long-term memory (to be discussed later), but for now, understand that long-term memory *is* in fact organized. We do not simply retrieve information in a happenstance way.

We often want to be more deliberate, rather than just rely on chance to remember things. When we put in a concerted effort to remember things, we often rely on **mnemonics**. A mnemonic is a memory aid. The range of devices that one can rely on is huge, but the one key component of a mnemonic is that it relies on a **reorganization of information** to allow for easier retrieval. Creating a song, for instance, can help us remember things for an exam, or creating a rhyme can help us remember the names of states. By helping us to develop a deeper level of processing, mnemonics allow us to elaborate on what we are trying to remember. The deeper level of processing allows for a better representation of the information.

Evidence also suggests that retrieval is better when the context in which we're trying to retrieve something matches the context in which it was learned. This is called **encoding specificity** or **transfer appropriate processing**. The idea is that when we learn something, the context is part of the overall memory. By reinstating that context when retrieval is occurring, we are creating an **optimal recall situation**.

ORGANIZATION

To understand how encoding, storage, and retrieval work, we must explore how semantic or long-term memory might be organized. It turns out, this is one area in cognitive psychology that has been examined more than most others.

The two biggest assumptions of long-term memory are:

1. Capacity is unlimited
2. Once the information gets into long-term memory, it is there forever

To accommodate both assumptions, several models have been developed and tested by researchers.

In the most common model of long-term memory concepts are represented as nodes, and relationships between concepts are represented as links. The closer the two concepts are in terms of links, the more related they are.

Activation is the process of “thinking” about a concept. When we activate a node, that activation spreads down the links to related nodes. So if you think about college, classes might be the first thing that comes to mind, and then the other concepts might come to mind later.

Recently, psychologists have divided memory into what has been called explicit and implicit memory. **Explicit memory** is memory for information that you are aware of. **Implicit memory** is memory that influences your behavior but for which you have no conscious awareness. You might remember how to tie your shoes, but you don't necessarily remember when you learned to tie them. The implicit memory is that of the ability to tie the shoes, not the memory of actually learning the process. Implicit memory helps us in a variety of ways from “behind the scenes.”

PROBLEM SOLVING

Cognitive psychologists are also interested in the concept of thinking and **problem solving**. In general, the study of problem solving is done by having people solve problems and then studying the strategies they use.

Heuristics are shortcuts to a solution, often used when we have expertise in an area. If we do mental arithmetic, we might rely on shortcuts based on our knowledge of math. **Algorithms** are approaches to problems that will definitely result in a correct solution. They are long—yet certain—approaches to a problem. By studying problem solving, psychologists are able to see *how* we use what we store.

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RAPID REVIEW

Learning is the process that allows us to adapt to the changing conditions of the environment around us and is defined as any relatively permanent change in behavior brought about by experience or practice (as opposed to changes brought about by maturation). **Ivan Pavlov**, a Russian physiologist, discovered one of the simplest forms of learning, called **classical conditioning**. In classical conditioning, an organism learns to make a reflex response to a stimulus other than the original stimulus that produced the response in the first place. The original stimulus is called the **unconditioned (or “unlearned”) stimulus (UCS)**, and the reflex response is the **unconditioned response (UCR)**. If a **neutral stimulus (NS)** is repeatedly paired with the UCS, it will eventually produce the same kind of reflexive response. At this point, the NS is called a **conditioned stimulus (CS)** and the response is called a **conditioned, or learned, response (CR)**. The repeated pairing of the NS and UCS is known as **acquisition**. In order for classical conditioning to occur, the CS must occur before the UCS, the CS and UCS must occur close together in time, the CS and UCS must be paired together repeatedly, and the CS should be distinctive. Two other principles of classical conditioning are **stimulus generalization**, the ability of a stimulus that resembles the CS to produce a CR, and **stimulus discrimination**, learning to respond to different stimuli in different ways. In classical conditioning, **extinction** occurs after the CS is repeatedly presented without the UCS and no longer produces a CR. **Spontaneous recovery** occurs when the CS is presented after being absent for a period of time and produces a mild CR. When a powerful conditioned stimulus is paired with a neutral stimulus, the conditioned stimulus itself can function as a UCS and turn the neutral stimulus into a second conditioned stimulus. This process is called **higher-order conditioning**.

John Watson demonstrated a particular type of classical conditioning called **conditional emotional response** with Little Albert and his learned phobia of white rats. **Vicarious conditioning** occurs when a person becomes classically conditioned simply by watching someone else respond to a stimulus. **Conditioned taste aversions** are a unique form of classical conditioning that can occur with only one neutral stimulus–unconditioned stimulus pairing. Superstitions are established in a person’s behavior when an event pairs the behavior with a coincidental reinforcement or punishment. For example, “knocking on wood” is paired with preventing something inevitable and bad from happening after making a favorable or boastful statement. The knocking-on-wood behavior is negatively reinforced by the assumption that something negative was taken away when nothing bad happens, and as a result of the perceived reinforcement the behavior becomes more frequent. Conditioning is believed to occur so rapidly due to the **biological preparedness** of most mammals. Pavlov suggested that classical conditioning works through the process of **stimulus substitution**, in that the close pairing in time of the CS with the UCS eventually leads to the CS serving as a substitute stimulus for the UCS and activating the same brain area as the UCS. Psychologists who agree with the **cognitive perspective**, such as Robert Rescorla, suggested that the CS must provide some information about the upcoming UCS and that it is this expectancy that causes the association to occur.

Operant conditioning is a type of learning more strongly associated with voluntary behavior and is based on **Edward Thorndike’s** work with cats and the puzzle box. Based on his research, Thorndike formulated the **Law of Effect** which states that if a response is followed by a pleasurable consequence it

will tend to be repeated and if a response is followed by an unpleasant consequence it will tend not to be repeated. **B.F. Skinner** expanded on Thorndike's Law of Effect and coined the term "operant conditioning" for this type of learning, since the term **operant** refers to any voluntary behavior. While classical conditioning focuses on what happens *before* the response, the key to operant conditioning is what happens *after* the response, or in other words, the consequence. **Reinforcement** or a **reinforcer** is a consequence that is pleasurable and strengthens the response that came before it. There are two types of reinforcers. **Primary reinforcers** satisfy basic needs and don't need to be learned. **Secondary reinforcers** get their reinforcing power through prior associations with a primary reinforcer and thus are learned. Reinforcement works by adding a pleasurable consequence after a response occurs (**positive reinforcement**) or removing something unpleasant after a response occurs (**negative reinforcement**). Both positive and negative reinforcement increase the likelihood that the response will occur again.

An important principle that Skinner discovered is that the timing of reinforcement can make a significant difference on how fast a response is learned. **Continuous reinforcement** occurs when a reinforcer is presented after every response. **Partial reinforcement** occurs when a reinforcer is given after some, but not all, of the correct responses. Partial reinforcement takes longer to go through extinction, or in other words, is more resistant to extinction. This is known as the **partial reinforcement effect**. The timing of partial reinforcement is referred to as the **schedule of reinforcement**. There are four different schedules of reinforcement: **fixed ratio**, **variable ratio**, **fixed interval**, and **variable interval**. A ratio schedule occurs when a reinforcer depends on the number of responses that are made. In an interval schedule, reinforcers are presented after a certain period of time has passed. If the reinforcers are always given after a set period of time or number of responses, the schedule is said to be fixed. If the reinforcer is given after varying periods of time or numbers of responses, the schedule is labeled as variable.

Punishment, on the other hand, always decreases the likelihood of a response. Punishment is any consequence of a response that causes that response to be less likely to happen again. While reinforcement strengthens a response that already exists, the goal of punishment is often to eliminate the response, which is usually a much harder task. Typically punishment only temporarily suppresses the response. **Positive punishment** describes the situation in which a response is followed by the addition of something unpleasant. Positive punishment is not the most effective way to modify behavior and has a number of serious drawbacks. **Negative punishment** occurs when a response is followed by the removal of something pleasant. Punishment can be made more effective if it is administered immediately after the undesired behavior, is administered consistently, and is paired with reinforcement for the right behavior.

Shaping involves the use of operant conditioning to reward **successive approximations** until the desired response is obtained. Operant conditioning has several parallels with classical conditioning, such as that **extinction** involves the removal of the reinforcement and **spontaneous recovery** occurs when an organism attempts a previously learned response in order to receive a reward. In addition, a **discriminative stimulus** is defined as any stimulus that provides an organism with a signal or cue for making a certain response in order to get reinforcement. In the lab, researchers found that even though animals could be operantly conditioned to perform certain tasks, they possessed biological constraints to learning other tasks and often had a tendency to go back to their genetic, or natural, way of doing things. This tendency to revert to genetically controlled patterns is called **instinctive drift**.

The term **behavior modification** is used to describe the process of using operant conditioning to change behavior. A **token economy** involves the use of tokens to modify behavior. **Time-outs** are an example of negative punishment where the child is removed from a situation where he or she could get attention from others. **Applied behavior analysis (ABA)** uses shaping techniques to obtain a desired behavior and is particularly successful with children with disorders such as autism. The technique called **biofeedback** uses operant conditioning to modify involuntary behaviors such as blood pressure and heart rate. When this technique is used to try to change brain wave activity, it is referred to as **neurofeedback**.

Cognitive learning theorists focus on the mental processes (or cognitions) that occur during learning. **Edward Tolman** studied the phenomenon of **latent learning** in rats placed in a maze but not reinforced for finding their way out. He found that when the rats were subsequently reinforced, learning occurred much faster than for rats that had never been in the maze. **Martin Seligman** studied a phenomenon he called **learned helplessness** in dogs. He found that dogs classically conditioned to a tone

followed by a painful shock would not later try to escape the shock when provided the opportunity. Seligman extended the concept of learned helplessness to humans in an attempt to explain depression. A third cognitive psychologist, **Wolfgang Köhler**, studied the phenomenon of **insight learning** in animals. Köhler believed insight learning involved a sudden perception of relationships that could not be gained through trial and error learning. All three theories of learning are related in that they focus on what's going on inside the learner's mind during the learning process as opposed to the external stimuli and rewards of classical and operant conditioning.

A third category of learning is that of **observational learning**, or the learning of a new behavior by observing someone else who is performing that behavior. The term **learning/performance distinction** describes the fact that learning can take place without actual performance. **Albert Bandura** has been a major contributor to the study of observational learning and conducted a series of classic studies observing children's learned behaviors with a blow-up "Bobo" doll. Bandura concluded that four elements were needed for observational learning to occur; the four elements are attention, memory, imitation, and desire/motivation.

Behavior	Consequence	Is something good or bad taken away?	Is this negative reinforcement or negative punishment?	Will the behavior increase or decrease?
Taking an aspirin for a headache.	Headache goes away.	<i>bad</i>	<i>negative reinforcement</i>	<i>increase</i>
Running a red light.	Driver's license is taken away.			
Cleaning your room so that you are no longer grounded.	You are no longer grounded.			
Drinking coffee in the morning when you are very tired.	You no longer feel tired.			
Staying out past your curfew.	Your parents ground you.			
Getting in a fight with a friend.	Your friend will not talk to you anymore.			
Fastening your seatbelt when the buzzer is making a noise.	The buzzer stops.			
Driving your car until it runs out of gas.	You can't drive your car anymore.			
Your boyfriend nags you until you take him out to dinner.	The nagging stops.			

Suggested answers

Behavior	Consequence	Is something good or bad taken away?	Is this negative reinforcement or punishment?	Will the behavior increase or decrease?
Taking an aspirin for a headache.	Headache goes away	<i>bad</i>	<i>negative reinforcement</i>	<i>increase</i>
Running a red light.	Driver's license is taken away.	<i>good</i>	<i>negative punishment</i>	<i>decrease</i>
Cleaning your room so that you are no longer grounded.	You are no longer grounded.	<i>bad</i>	<i>negative reinforcement</i>	<i>increase</i>

Drinking coffee in the morning when you are very tired.	You no longer feel tired.	<i>bad</i>	<i>negative reinforcement</i>	<i>increase</i>
Staying out past your curfew.	Your parents ground you.	<i>good</i>	<i>negative punishment</i>	<i>decrease</i>
Getting in a fight with a friend.	Your friend will not talk to you anymore.	<i>good</i>	<i>negative punishment</i>	<i>decrease</i>
Fastening your seatbelt when the buzzer is making a noise.	The buzzer stops.	<i>bad</i>	<i>negative reinforcement</i>	<i>increase</i>
Driving your car until it runs out of gas.	You can't drive your car anymore.	<i>good</i>	<i>negative punishment</i>	<i>decrease</i>
Your boyfriend nags you until you take him out to dinner.	The nagging stops.	<i>bad</i>	<i>negative reinforcement</i>	<i>increase</i>