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4 Learning

Our ability to learn seems boundless. We continue to learn new things every day, and we continually use the products of our past learning. Our learning affects how we perceive, remember, think, and behave. In this chapter, we will focus on what psychologists have learned about how we learn.

In general, two types of psychologists—behavioral psychologists and cognitive psychologists—have studied learning, and they have gone about their research in very different ways. Behavioral psychologists have focused on the learning of associations through classical conditioning and operant conditioning. Classical conditioning involves learning associations between events in our environment, such as that the smell of the turkey roasting in the oven signals that a delicious meal will follow. Operant conditioning focuses on learning associations between our behavior and its environmental consequences, such as that additional studying usually leads to better grades. Cognitive psychologists studying learning are interested in the more complex type of learning involved in human memory—how we encode information into our memory system, store it over time, and later retrieve it for use. A cognitive psychologist would be interested in how you learn the information in this textbook and what type of study technique would lead to the best memory for this information.

In this chapter, we will first focus on what behavioral psychologists have discovered about learning associations through classical conditioning and operant conditioning. Then we will consider some of the biological constraints upon such learning and also begin a discussion of the cognitive approach to learning (covered in detail in the next chapter, on how we remember).

Learning Through Classical Conditioning

Does the name "Pavlov" ring a bell? If you understand this really bad joke, then you are already somewhat familiar with **classical conditioning**—learning that one stimulus signals the arrival of another stimulus. A stimulus (plural: stimuli) is any sight, sound, smell, taste, or body sensation that a human or animal can perceive. You know from Chapter 1 that Pavlov's dogs salivated to the sound of a tone (the first stimulus) because they learned to expect food in their mouth (the second stimulus) after hearing the tone. This may not sound like the research of a Nobel Prize–winning scientist, but it was important work that had a great impact on our understanding of how we learn. Classical conditioning is sometimes referred to as Pavlovian conditioning because Pavlov was the first researcher to study this type of learning systematically. So, let's take a closer look at Pavlov's research to gain an understanding of classical conditioning and its importance in learning.

The Elements and Procedures of Classical Conditioning

Ivan Pavlov was a Russian physiologist who won a Nobel Prize in 1904 for his earlier work on the physiology of digestion. Pavlov studied the digestive processes of dogs. During these

classical conditioning Acquiring a new response (the conditioned response) to a previously neutral stimulus (the conditioned stimulus) that reliably signals the arrival of an unconditioned stimulus.

This is a photograph of Pavlov's experimental laboratory. Look at the dog's left cheek. Pavlov devised a surgical insert that diverted the dog's saliva to exit its cheek so the saliva could be measured accurately.

experiments, the dogs were strapped into harnesses and had tubes inserted in their cheeks to measure salivation, the initial step in the digestive process. Pavlov had cleverly found a way to divert the saliva so that it was excreted through the dogs' cheeks. As part of this research, the dogs were given food (meat powder), and then the amount of saliva excreted was measured. During this research, Pavlov made an accidental discovery. He noticed that the dogs started to salivate before the meat powder was even put in their mouths. For example, the dogs salivated when they heard the footsteps of his assistants bringing the meat powder. Pavlov wanted to know why, and this became the focus of his research for the remainder of his career. So what exactly did he do?

Unconditioned stimulus (UCS) and unconditioned response (UCR). First, let's consider why the dogs salivated when the meat powder was put in their mouths. This is a reflexive response–when food is put in your mouth, you salivate. Dogs do it, I do it, you do it. This is called a **reflex**–a stimulus-response pair (food in the mouth and salivation) in which the stimulus automatically elicits the response. The reflexive stimulus (food in the mouth) that elicits the automatic response (salivation) is referred to as the **unconditioned stimulus (UCS)**, and the response automatically elicited by the UCS is referred to as the **unconditioned response (UCR)**. The key word is "unconditioned." This means that no learning was necessary for this stimulus (the food, in our example) to elicit the response (salivation, in our example). It's a naturally occurring reflex. Now let's examine how such reflexes are used to achieve conditioning.

Conditioned stimulus (CS) and conditioned response (CR). Pavlov began with a neutral stimulus, a stimulus that does not naturally elicit the to-be-conditioned response. Pavlov used various neutral stimuli, such as a tone generated by a tuning fork, a light, and a touch on the leg, in his conditioning research on dogs (Pavlov, 1927/1960). Before conditioning, his dogs did not automatically salivate to these stimuli. They had to learn (be conditioned) to do this. To achieve such conditioning, the neutral stimulus (for example, a tone) is presented just before the UCS (the food). What does "just before" mean? This can mean a few seconds, but the optimal time interval between the onsets of the two stimuli is usually very brief, only a half-second to a full second (Mazur, 1998). In addition, the two stimuli usually need to be paired together for several trials. Nevertheless, there are

reflex A stimulus-response pair in which the stimulus (the unconditioned stimulus) automatically elicits the response (the unconditioned response).

unconditioned stimulus (UCS) The stimulus in a reflex that automatically elicits an unconditioned response.

unconditioned response (UCR) The response in a reflex that is automatically elicited by the unconditioned stimulus.

But think about the Little Albert study by Watson and Rayner. Their original CS was a white rat so the generalization stimuli could not be varied symmetrically around it. What do you think they used to test for generalization? The main objects that they used were other animals—a rabbit, as you can see in the photos of the experiment, and a dog (neither was white)—and Rayner's furry sealskin coat (also nonwhite), but they also used some less similar inanimate objects—for example, a white-bearded Santa Claus mask, a package of white cotton, and some wooden toy blocks. Even though the generalization stimuli did not vary symmetrically around the white rat and the reporting of the generalization data was somewhat imprecise given that it was descriptive (e.g., "pronounced withdrawal of the body and whimpering") and not quantitative, the characteristic pattern of generalization results was by and large observed—as the generalization test stimuli became less similar to the CS (the white rat), the strength of the CR (the fear-avoidance response) decreased. Albert's responses to the animals and the sealskin coat (furry stimuli) were all strongly negative. He showed a much weaker negative response to the bearded Santa Claus mask and only a mild negative response to the white cotton, indicating that Albert generalized his fear more to furry stimuli than to white stimuli (at least the ones used in the study). As would be predicted because of their dissimilarity to the white rat, Albert showed no fear of the toy blocks and actually played with them.

Sometimes we overgeneralize and need to narrow our responding to a specific stimulus or smaller set of stimuli. In the case of the dog bite, we might overgeneralize and fear any dog. This wouldn't be rational, so we would need to learn to discriminate dogs that might bite us from those that would not. Such discrimination learning can be thought of as the opposite of generalization. Generalization leads to the CR being given to a broader set of stimuli; discrimination leads to the CR being given to a narrower set of stimuli. In classical conditioning, **stimulus discrimination** is the elicitation of the CR only by the CS or only by a small set of highly similar stimuli that includes the CS. In the dog bite example, this would be learning only to fear potentially dangerous dogs.

Discrimination training is used to teach stimulus discrimination. We will discuss the simplest case—learning to give the CR only to the original CS. This is the same procedure used to determine the sensory abilities of animals. In this type of discrimination training, the UCS follows only the original CS, the one stimulus to which you want the animal or human to respond (give the CR). None of the other stimuli used in the training are followed by the UCS. During discrimination training, you present many different stimuli numerous times, but the UCS only follows the original CS. What do you think happens? What normally happens to the CR when the UCS is removed in classical conditioning? It is extinguished. This is what discrimination training does; it diminishes the responding to the other stimuli.

Idealized results of stimulus discrimination training for a CS tone of 1,000 Hz in our Pavlovian classical conditioning example are shown in Figure 4.3. As you can see,

stimulus discrimination (in classical conditioning) The elicitation of the conditioned response only by the conditioned stimulus or only by a small set of highly similar stimuli that includes the conditioned stimulus.

Before Conditioning

Unconditioned Stimulus (UCS) elicits Unconditioned Response (UCR)

Neutral Stimulus (NS) Does not elicit to-be-conditioned response

During Conditioning Trials

Present Neutral Stimulus (NS) just before

Unconditioned Stimulus (UCS) (which automatically elicits UCR)

After Conditioning

Conditioned Stimulus (CS; former NS) elicits Conditioned Response (CR)

Figure 4.1 | **The Elements of Classical Conditioning** | In classical conditioning, you start with a reflex—an unconditioned stimulus (UCS) that automatically elicits an unconditioned response (UCR). To condition a new response to a neutral stimulus, the neutral stimulus is presented just before the unconditioned stimulus. After several pairings, the neutral stimulus elicits a new response called the conditioned response(CR). The neutral stimulus is now referred to as the conditioned stimulus (CS).

as effective if the trace interval between stimuli is very short (Powell, Symbaluk, & MacDonald, 2002). It also appears that for trace conditioning, processing by both the cerebellum and hippocampus is essential for successful conditioning whereas for delayed conditioning, only processing by the cerebellum is necessary (Clark & Squire, 1998). In trace conditioning, processing by the hippocampus is necessary to establish a memory trace of the CS so that it can be associated with the UCS following the trace interval (Bangasser, Waxler, Santollo, & Shors, 2006). In addition, it appears that delayed conditioning can be accomplished without conscious awareness of the temporal relationship between the CS and UCS, but trace conditioning cannot (Clark & Squire, 1998).

The entire classical conditioning process is diagrammed in Figure 4.1. Study the diagram to make sure you understand the four elements that are involved in classical conditioning—the UCS, UCR, CS (the former neutral stimulus), and CR. To ensure that you understand, next we'll consider another famous example of classical conditioning, the Little Albert study.

The Little Albert study. John Broadus Watson, an American psychologist in the early part of the twentieth century, was the founder of behavioral psychology (Watson, 1913, 1919). He was very impressed with classical conditioning and its potential use to make psychology an objective science of behavior. To examine the possible role of such conditioning in human emotional responses such as fear, Watson and his research assistant, Rosalie Rayner, conducted a fear-conditioning study on an infant they referred to as Albert B. (Watson & Rayner, 1920). When the study began, Albert was about 9 months old, and when the study ended, he

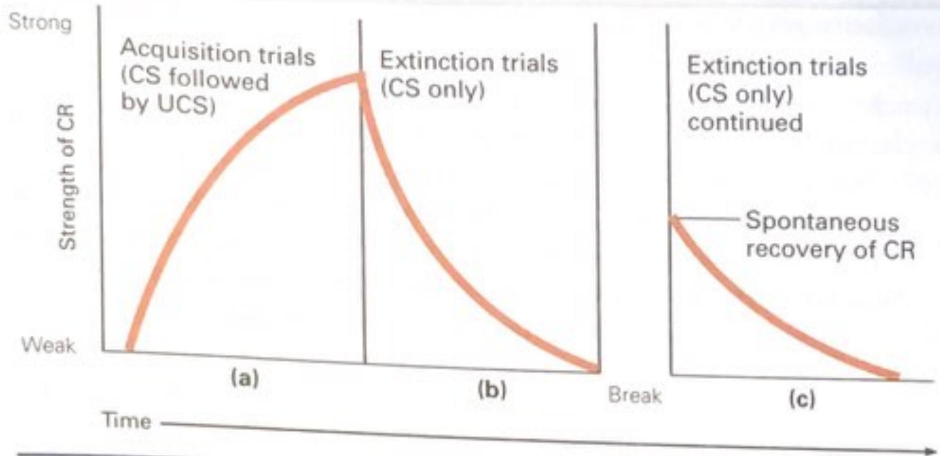


Figure 4.2 | **Acquisition, Extinction, and Spontaneous Recovery** | Panel (a) depicts the acquisition of the CR. Note that during acquisition, the UCS follows the CS on each trial. Acquisition of the CR is reflected in the increase in its strength across conditioning trials. Extinction is depicted in panel (b). On extinction trials, the UCS never follows the CS. This process is reflected in the decrease of the strength of the CR across extinction trials. Note, however, that when a break is taken during extinction training, there is a temporary partial recovery in strength of the CR following the break, depicted in panel (c). This partial recovery is called spontaneous recovery. The amount of recovery lessens as extinction training continues.

following a rest interval. This is called **spontaneous recovery**, a partial recovery in strength of the CR following a break during extinction trials (see Figure 4.2c). As extinction continues, however, the recovery observed following the rest intervals continues to decrease until it is minimized. For example, the dog would salivate very little or not at all to the tone. The spontaneous recovery that occurs during the extinction process indicates, as Pavlov had concluded, that the CR may not be totally lost during extinction, but only greatly weakened or inhibited. Research since Pavlov's time has demonstrated that this is indeed the case (Bouton, 1994; Rescorla, 1996).

Stimulus generalization and discrimination. In addition to acquisition, extinction, and spontaneous recovery, there are two other general learning processes involving the CR—stimulus generalization and discrimination. Let's consider generalization first. After acquisition of a CR (salivating) to a CS (a tone), we observe generalization. In **stimulus generalization**, stimuli similar to the CS elicit the CR. The more similar the stimulus is to the CS, the stronger the response will be. Generalization is an adaptive process. Classical conditioning would not be a very useful type of learning if it only allowed us to learn relationships between specific stimuli. If a dog bites you, isn't it more adaptive to generalize the

spontaneous recovery (in classical conditioning) A partial recovery in strength of the conditioned response following a break during extinction training.

stimulus generalization (in classical conditioning) The elicitation of the conditioned response to stimuli that are similar to the conditioned stimulus. The more similar the stimulus is to the conditioned stimulus, the stronger the response.

response (UCR). The optimal way to pair the two stimuli together in classical conditioning is called delayed conditioning. The CS is presented shortly before the UCS, but the CS continues so that the two stimuli occur together (the tone is turned on and left on until the meat powder is put in the dog's mouth). The learning is the acquisition of a new response, the conditioned response (CR) to the CS (the dog starts salivating to the sound of the tone).

Once this new response is acquired, it will be generalized to stimuli similar to the CS (tones similar in frequency to the particular tone used as the CS in conditioning). Although this generalization of the CR is an adaptive process, we can learn to discriminate the CS (the particular tone used in conditioning) from other stimuli (tones) except those highly similar to the CS. In discrimination learning, we learn that the CS is the only stimulus that is followed by the UCS. When the UCS no longer follows a stimulus, the CR (salivation) is extinguished (no longer given). However, the CR temporarily increases in strength following breaks during the extinction process. This is known as spontaneous recovery and indicates that the CR may still be available in a weakened or inhibited form.

ConceptCheck | 1

At about the same time that Pavlov accidentally discovered classical conditioning and began studying it, an American graduate student at the University of Pennsylvania, Edwin Twitmyer, was conducting his doctoral research (see Twitmyer, 1974). Twitmyer was examining the strength of the knee-jerk reflex and how this reflex might be affected by other physiological factors, such as clenching one's fists. During some of his trials, a bell would ring to signal to the participant to clench his fists, then a hammer would strike the participant's knee, the knee would jerk, and the amount of knee jerk would be measured. After many of these trials, Twitmyer noticed that a participant's knee might jerk before the hammer hit it. It jerked in response to the bell! Like Pavlov, he had accidentally discovered a case of classical conditioning. Identify the UCS, UCR, CS, and CR in this strange case of classical conditioning.

Explain why Watson and Rayner's Little Albert study is an example of the delayed conditioning procedure, not the trace conditioning procedure.

Explain why generalization and discrimination can be thought of as opposites.

Explain which other general learning process is used in discrimination training.

Learning Through Operant Conditioning

In the previous section, we described classical conditioning—learning about associations between stimuli in our environment. In this section, we will consider another important type of conditioning, **operant conditioning**—learning to associate behaviors with their consequences. Behaviors that are reinforced (lead to satisfying consequences) will be strengthened, and behaviors that are punished (lead to unsatisfying consequences) will be weakened. The behavior that is reinforced or punished is

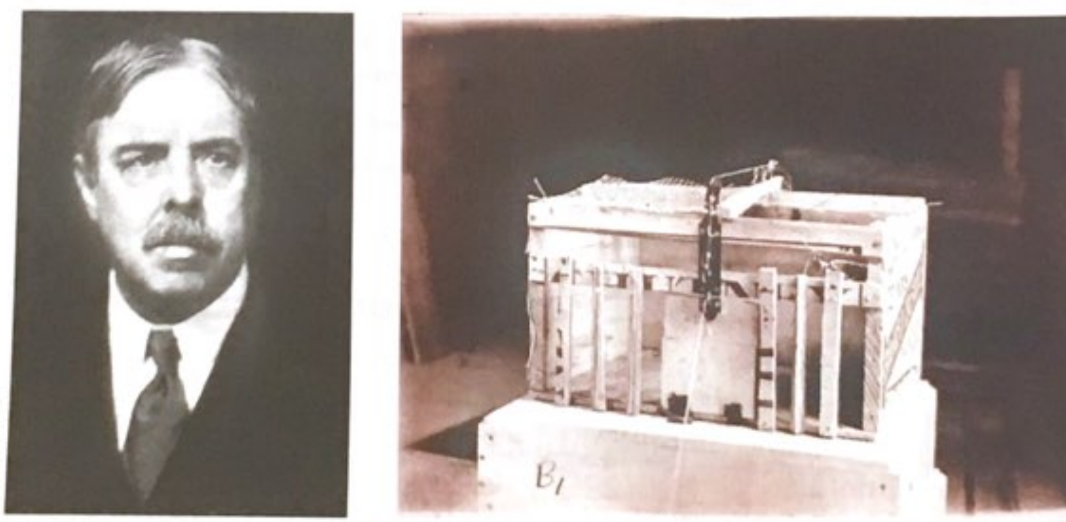
operant conditioning Learning to associate behaviors with their consequences. Behaviors that are reinforced (lead to satisfying consequences) will be strengthened, and behaviors that are punished (lead to unsatisfying consequences) will be weakened.

law of effect A principle developed by Edward Thorndike that says that any behavior that results in satisfying consequences tends to be repeated and that any behavior that results in unsatisfying consequences tends not to be repeated.

referred to as the operant response because it "operates" on the environment by bringing about certain consequences. We are constantly "operating" on our environment and learning from the consequences of our behavior. For example, in meeting someone whom you like and want to date, your behavior (what you say and how you act) will either lead to satisfying consequences (a date) or unsatisfying consequences (no date). Satisfying consequences will lead you to act that way again in the future; unsatisfying consequences will lead you to change your behavior.

Research on how we learn associations between behaviors and their consequences started around the beginning of the twentieth century. American psychologist Edward Thorndike studied the ability of cats and other animals to learn to escape from puzzle boxes (Thorndike, 1898, 1911). In these puzzle boxes, there was usually only one way to get out (for example, pressing a lever would open the door). Thorndike would put a hungry animal in the box, place food outside the box (but in sight of the animal), and then record the animal's behavior. If the animal pressed the lever, as a result of its behavior it would manage to escape the box and get the food (satisfying effects). The animal would tend to repeat such successful behaviors in the future when put back into the box. However, other behaviors (for example, pushing the door) that did not lead to escaping and getting the food would not be repeated.

Based on the results of these puzzle box experiments, Thorndike developed what he termed the **law of effect**—any behavior that results in satisfying consequences tends to be repeated, and any behavior that results in unsatisfying consequences tends not to be repeated. In the 1930s, B. F. (Burrhus Frederic) Skinner, the most influential of all behaviorists, redefined the law in more objective terms and started the scientific examination of how we learn through



Science Source

Robert Mearns Yerkes papers, 1822–1985 (inclusive). Manuscripts & Archives, Yale University

Edward Thorndike used puzzle boxes like the one shown here in his classic learning studies with cats. The boxes varied in how difficult they were for the cats to escape from. The puzzle box was one of the easier boxes—pulling on a looped string raised the bolt to open the door. More difficult boxes required the cat to make more than one response. The results of these puzzle box experiments led Thorndike to develop the law of effect.

operant conditioning (Skinner, 1938). Let's move on to Skinner's redefinition and a description of how operant conditioning works.

Learning Through Reinforcement and Punishment

To understand how operant conditioning works, we first need to learn Skinner's redefinitions of Thorndike's subjective terms, "satisfying" and "unsatisfying" consequences. A **reinforcer** is defined as a stimulus that increases the probability of a prior response, and a **punisher** as a stimulus that decreases the probability of a prior response. Therefore, **reinforcement** is defined as the process by which the probability of a response is increased by the presentation of a reinforcer following the response, and **punishment** as the process by which the probability of a response is decreased by the presentation of a punisher following the response. "Reinforcement" and "punishment" are terms that refer to the process by which certain stimuli (consequences) change the probability of a behavior; "reinforcer" and "punisher" are terms that refer to the specific stimuli (consequences) that are used to strengthen or weaken the behavior.

Let's consider an example. If you operantly conditioned your pet dog to sit by giving her a food treat each time she sat, the food treat would be the reinforcer, and the process of increasing the dog's sitting behavior by using this reinforcer would be called reinforcement. Similarly, if you conditioned your dog to stop jumping on you by spraying her in the face with water each time she did so, the spraying would be the punisher, and the process of decreasing your dog's jumping behavior by using this punisher would be called punishment.

Just as classical conditioning is best when the CS is presented just before the UCS, immediate consequences normally produce the best operant conditioning (Gluck, Mercado, & Myers, 2011). Timing affects learning. If there is a significant delay between a behavior and its consequences, conditioning is very difficult. This is true for both reinforcing and punishing consequences. The learner tends to associate reinforcement or punishment with recent behavior; and if there is a delay, the learner will have engaged in many other behaviors during the delay. Thus, a more recent behavior is more likely to be associated with the consequences, hindering the conditioning process. For instance, think about the examples we described of operantly conditioning your pet dog to sit or to stop jumping on you. What if you waited 5 or 10 minutes after she sat before giving her the food treat, or after she jumped on you before spraying her. Do you think your dog would learn to sit or stop jumping on you very easily? No, the reinforcer or punisher should be presented right after the dog's behavior for successful conditioning.

Normally then, immediate consequences produce the best learning. However, there are exceptions. For example, think about studying now for a psychology exam in two weeks. The consequences (your grade on the exam) do not immediately follow your present study behavior. They come two weeks later. Or think about any job that you have had. You likely didn't get paid immediately. Typically, you are

reinforcer A stimulus that increases the probability of a prior response.

punisher A stimulus that decreases the probability of a prior response.

reinforcement The process by which the probability of a response is increased by the presentation of a reinforcer.

punishment The process by which the probability of a response is decreased by the presentation of a punisher.

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Morris, Öhman, & Dolan, 1998; Olsson & Phelps, 2004). Using delayed conditioning, Clark and Squire, for example, successfully conditioned the eyeblink response in both normal and amnesic participants who were not aware of the tone–air puff relationship. Participants watched a movie during the conditioning trials, and postconditioning testing indicated that they had no knowledge of the CS-UCS association.

General Learning Processes in Operant Conditioning

Now that we have a better understanding of how we learn through reinforcement and punishment, let's consider the five general learning processes in operant conditioning that we discussed in the context of classical conditioning—acquisition, extinction, spontaneous recovery, generalization, and discrimination. Because some of the examples of these processes are concerned with operant conditioning of animals, it's important to know how such animal research is conducted. It's also important to learn how to read cumulative records because they are used to measure and depict operant responding in the general learning processes.

Nina Leen/Time-Life Pictures/Getty Images

B. F. Skinner and one of his operant conditioning chambers, a "Skinner box." When the rat presses the lever, an electrical relay system is activated and reinforcement (such as a food pellet) is delivered. In addition to a lever, operant chambers may contain other response mechanisms, such as a key for a pigeon to peck.

For control purposes, behavioral psychologists conduct much of their laboratory research on nonhuman animals. In conducting their experiments with animals, operant conditioning researchers use operant chambers, which resemble large plastic boxes. These chambers are far from simple boxes, though. Each chamber has a response device (such as a lever for rats to press or a key for pigeons to peck), a variety of stimulus sources (such as lamps behind the keys to allow varying colors to be presented on them), and food dispensers. Here, "key" refers to a piece of transparent plastic behind a hole in the chamber wall. The key or other response device is connected to a switch that records each time the animal responds. Computers record the animal's behavior, control the delivery of food, and maintain other aspects of the chamber. Thus, the operant chamber is a very controlled environment for studying the impact of the animal's behavior on its environment. Operant chambers are sometimes referred to as "Skinner boxes" because B. F. Skinner originally designed this type of chamber.

What if the animal in the chamber does not make the response that the researcher wants to condition (for example, what if the pigeon doesn't peck the key)? This does happen, but behavioral researchers can easily deal with this situation. They use what they call **shaping**; they train the animal to make the and when they needed to use it (when reinforcement became available), they did. This explanation was tested further by blocking the optimal route to the goal box to see if the rats would use their cognitive map to take the next best route. The rats did.

observational learning (modeling) Learning by observing others and imitating their behavior.

How would such a map be created in the rat's brain and how would it allow the rat to navigate its way through a complex environment, such as a maze? A few decades elapsed after Tolman's research before these questions were answered. The answer involves the discovery of two types of neurons in the brain, place cells and grid cells. Physiological psychologist John O'Keefe identified the place cells located in the hippocampus that function to build an inner map of the environment (O'Keefe, 1976; O'Keefe & Dostrovsky, 1971), and May-Britt and Edvard Moser identified the grid cells located in the entorhinal cortex, a cortical region next to the hippocampus, that generate a coordinate system and allow precise positioning and pathfinding, a sort of inner GPS (Fyhn, Molden, Witter, Moser, & Moser, 2004; Hafting, Fyhn, Molden, Moser, & Moser, 2005; Moser and Moser, 2016; Sargolini et al., 2006). For their key contributions to our understanding of this system, John O'Keefe and May-Britt and Edvard Moser shared the 2014 Nobel Prize in Physiology or Medicine. Brain imaging research along with studies of patients undergoing neurosurgery have provided evidence that place and grid cells also exist in the human brain and work as in the rat brain to provide us with an inner GPS (Ekstrom et al., 2003; Jacobs et al., 2013). Other research has shown that this is true also for bats and monkeys (Finkelstein et al., 2014), suggesting that this navigational system arose early in mammalian evolution and that similar neural positional algorithms are used across various mammalian species.

Observational learning. Much learning by humans is more cognitive in nature and does not involve conditioning through direct experience. Observational learning, sometimes called modeling, is a good example. By watching a model, we learn through vicarious reinforcement and punishment without being conditioned directly. We learn to anticipate a behavior's consequences in situations like those that we have observed. **Observational learning (modeling)**–learning by observing others and imitating their behavior– plays a major role in human learning (Bandura, 1973). For example, observational learning helps us learn how to play sports, write the letters of the alphabet, and drive a car. We observe others and then do our best to imitate their behavior. We also often learn our attitudes and appropriate ways to act out our feelings by observing good and bad models. Today's sports and movie stars are powerful models for such learning. In sum, imitation is pervasive in humans, even infants (Jones, 2007).


Courtesy of Albert Bandura

Albert Bandura

Albert Bandura's famous experiments on learning through modeling involved a Bobo doll, a large inflated clown doll, and aggressively toward the doll than the children who had not been exposed to any consequences for acting aggressively toward the doll. The children's behavior was affected by the consequences witnessed in the film. Then Bandura cleverly asked the children if they could imitate the behavior in the film for reinforcement (snacks). Essentially, all of the children could do so. This is an important point. It means that the children all learned the behavior through observation regardless of whether the behavior was reinforced, punished, or neither.

According to Lansford (2012), researchers subsequently questioned the generalizability of Bandura's findings both with respect to the context (the studies were conducted in a laboratory setting) and the temporal proximity between the children's observation of the adult model's aggression and their own aggression (there was a close temporal proximity in the studies). Would children imitate aggression in other settings and after lengthier delays? It turns out that they do. More recent studies have found that Bandura's finding of children imitating aggression does hold in a variety of nonlaboratory settings and after lengthy delays between observing the aggression and then acting aggressively (Bushman & Huesmann, 2010; Guerra, Huesmann, & Spindler, 2003; Slater, Henry, Swaim, & Anderson, 2003).

Much of the research on observational learning since Bandura's pioneering studies has focused on the question of whether exposure to violence in media leads people to behave more aggressively. There is clearly an abundance of violence on television and in other media. It has been estimated that the average child has viewed 8,000 murders and 100,000 other acts of violence on television alone by the time he finishes elementary school (Huston et al., 1992), and more recent research indicates that the amount of violence on television and in other media has increased since Huston et al.'s study. For example, the Parents Television Council (2007) found that violence in prime-time television increased 75% between 1998 and 2006, and the National Television Violence Study evaluated almost 10,000 hours of broadcast programming from 1995 through 1997 and found that 61% of the programming portrayed interpersonal violence, much of it in an entertaining or glamorized manner, and that the highest proportion of violence was in children's shows (American Academy of Pediatrics, 2009). But do we learn to be more aggressive from observing all of this violence on television and in other media?

Literally hundreds of studies have addressed this question, and as you would expect, the findings are both complicated and controversial. Leading scientists reviewing this literature, however, came to the following general conclusion: "Research on violent television and films, video games, and music reveals unequivocal evidence that media violence increases the likelihood of aggressive and violent behavior in both immediate and long-term contexts" (Anderson et al., 2003). Similarly, the authors of a recent meta-analysis of over 130 studies of video game play with 130,296 participants across Eastern and Western cultures concluded that exposure to violent video games is a causal risk factor for increased aggressive behavior, aggressive cognition, and aggressive affect and for decreased empathy and prosocial behavior (Anderson et al., 2010). Huesmann (2010, p. 179) argues that this meta-analysis "proves beyond a reasonable doubt that exposure to video game violence schedules as it would be with a continuous schedule. Obviously, it is easier to extinguish the response if the reinforcement had been given continuously for every response in the past. If a response is made and doesn't get reinforced, the responder knows immediately something is wrong because they have always been reinforced after each response. With partial schedules, if a response is made and doesn't get reinforced, the responder doesn't know that anything is wrong because they have not been reinforced for every response. Thus, it will take longer before extinction occurs for the partial schedules because it will take longer to realize that something is wrong.

Do you think there are any differences in this resistance to extinction between the various partial schedules of reinforcement? Think about the fixed schedules versus the variable schedules. Wouldn't it be much more difficult to realize that something is wrong on a variable schedule? On a fixed schedule, it would be easy to notice that the reinforcement didn't appear following the fixed number of responses or fixed time interval. On a variable schedule, however, the disappearance of reinforcement would be very difficult to detect because it's not known how many responses will have to be made or how much time has to elapse. Think about the example of a variable-ratio schedule with the rat pressing a lever. Because there is no fixed number of responses that have to be made, the rat wouldn't realize that its responding was being extinguished. It could be that the number of lever presses necessary to get the next reinforcement is very large. Because of such uncertainty, the variable schedules are much more resistant to extinction than the fixed schedules.

Motivation, Behavior, and Reinforcement

We have just learned about how reinforcement works and that partial-reinforcement schedules are powerful. But what initiates our behavior and guides it toward obtaining reinforcement? The answer is **motivation,** the set of internal and external factors that energize our behavior and direct it toward goals. Its origin is the Latin word *movere,* meaning to set in motion. Motivation moves us toward reinforcement by initiating and guiding our goal-directed behavior. There are several explanations of how motivation works. We will first consider a few general theories of motivated behavior and then a distinction between two types of motivation and reinforcement, extrinsic versus intrinsic.

Theories of motivation. One explanation of motivation, **drive-reduction theory,** proposes that first, a bodily need (such as hunger) creates a state of bodily tension called a drive; then, motivated behavior (seeking food) works to reduce this drive by obtaining reinforcement (food) to eliminate this need and return the body to a balanced internal state. Drives are disruptions of this balanced bodily state. We are "pushed" into action by these unpleasant drive states. They motivate our behavior to reduce the drive. Drive-reduction theory does a

motivation The set of internal and external factors that energize our behavior and direct it toward goals.

drive-reduction theory A theory of motivation that proposes that our behavior is motivated to reduce drives (bodily tension states) created by unsatisfied bodily needs to return the body to a balanced internal state.

good job of explaining some of our motivated behaviors, especially those concerned with biological needs, such as hunger and thirst; but it cannot explain all motivated behavior. Our behaviors are clearly motivated by factors other than drive reduction. Even eating and drinking aren't always cases of drive-reduction motivation. What if you accidentally run into someone that you really want to date and she/he asks you to lunch, but you had eaten a full lunch 15 minutes earlier? You would probably eat another lunch, wouldn't you? We eat for reasons other than hunger. Similarly, I'm sure that you often drink beverages without being truly thirsty. And is it really a "thirst" for knowledge that motivates your study behavior? A complementary theory, the incentive theory of motivation, has been proposed to account for such behavior.

In contrast to being "pushed" into action by internal drive states, the **incentive theory** of motivation proposes that we are "pulled" into action by incentives, external environmental stimuli that do not involve drive reduction. The source of the motivation, according to incentive theory, is outside the person. Money is an incentive for almost all of us. Good grades and esteem are incentives that likely motivate much of your behavior to study and work hard. Incentive theory is much like operant conditioning. Your behavior is directed toward obtaining reinforcement.

Another explanation of motivation, **arousal theory**, extends the importance of a balanced internal environment in drive-reduction theory to include our level of physiological arousal and its regulation. According to arousal theory, our behavior is motivated to maintain an optimal level of arousal, which varies within individuals (Zuckerman, 1979). When below the optimal level, our behavior is motivated to raise our arousal to that level. We seek stimulation. We might, for example, go see an action movie. If overaroused, then our behavior is motivated to lower the arousal level. We seek relaxation, so we might take a nap or a quiet walk. So in arousal theory, motivation does not always reduce arousal as in drive-reduction theory, but rather regulates the amount of arousal (not too much, not too little).

In addition, arousal theory argues that our level of arousal affects our performance level, with a certain level being optimal. Usually referred to as the **Yerkes-Dodson law** because Robert Yerkes and James Dodson (1908) originally proposed it, this relationship between level of arousal and performance quality is rather simple. Shown in Figure 4.9, it is an inverted U-shaped relationship. Increased arousal will aid performance to a point (the optimal amount of arousal), after which further arousal impairs performance. Think about exams. You need to be aroused to do well on them; but if you are too aroused, your performance will be negatively affected.

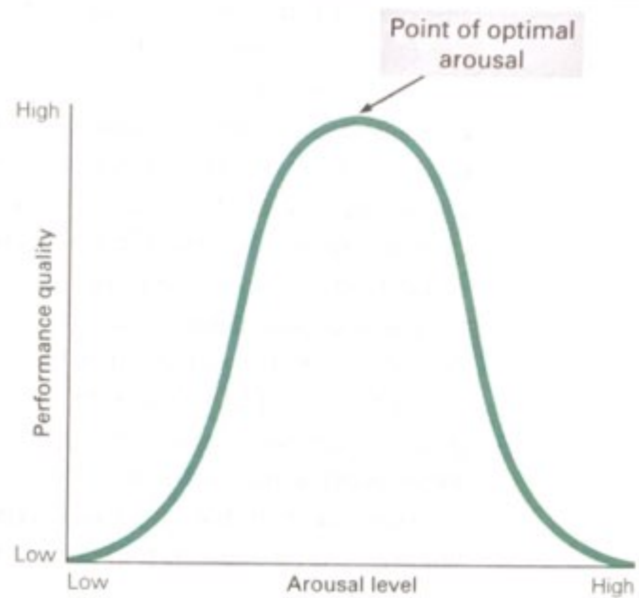
To solidify your understanding of these three theories of motivation, they are summarized in Table 4.4.

incentive theory A theory of motivation that proposes that our behavior is motivated by incentives, external stimuli that we have learned to associate with reinforcement.

arousal theory A theory of motivation that proposes that our behavior is motivated to maintain an optimal level of physiological arousal

Yerkes-Dodson law A law describing the relationship between the amount of arousal and the performance quality on a task—increasing arousal up to some optimal level increases performance quality on a task, but increasing arousal past this point is detrimental to performance.

Figure 4.9 | The Yerkes-Dodson Law | The Yerkes-Dodson law is very straightforward. As arousal increases, the quality of performance increases—up to the point of optimal arousal. Further increases in arousal are detrimental to performance.



Extrinsic motivation versus intrinsic motivation. Motivation researchers make a distinction between **extrinsic motivation,** the desire to perform behavior to obtain an external reinforcer or to avoid an external aversive stimulus, and **intrinsic motivation,** the desire to perform a behavior for its own sake. In cases of extrinsic motivation, reinforcement is not obtained from the behavior, but is a result of the behavior. In intrinsic motivation, the reinforcement is provided by the activity itself. Think about what you are doing right now. What is your motivation for studying this material? Like most students, you want to do well in your psychology class. You are studying for an external reinforcer (a good grade in the class), so your behavior is extrinsically motivated. If you enjoy reading about psychology and studying it for its own sake and not to earn a grade (and I hope that you do), then your studying would be intrinsically motivated. It is not an either-or situation. Both types of motivation are probably involved in your study behavior, but the contribution of each type varies greatly for each student.

Table 4.4 Theories of Motivation

Theory	Explanation
Drive-reduction theory	Our behavior is motivated to reduce drives (bodily tension states) created by unsatisfied bodily needs to return the body to a balanced internal state
Incentive theory	Our behavior is motivated by incentives (external stimuli that we have learned to associate with reinforcement)
Arousal theory	Our behavior is motivated to maintain an optimal level of physiological arousal

The reinforcers in cases of extrinsic motivation—such as food, money, and awards—are called extrinsic reinforcers.

extrinsic motivation The desire to perform a behavior for external reinforcement.

intrinsic motivation The desire to perform a behavior for its own sake.

Courtesy of Jackie Saccoccio and 11R, NY

5 Memory

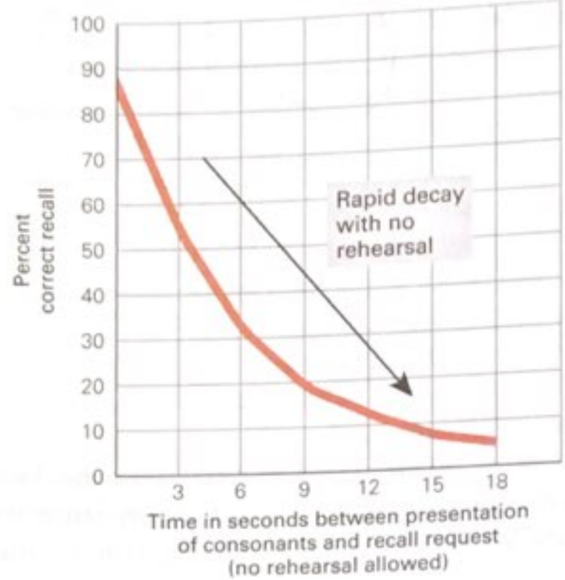


Figure 5.4 | Results for the Short-Term Memory Distractor Task | This figure shows how forgetting in short-term memory occurs over time. As the length of the distractor interval increases, forgetting increases very rapidly. In less than 30 seconds, recall is essentially zero. (Data from: Peterson, L. R., & M. J. Peterson, M. J. (1959). Short-term retention of individual verbal items. *Journal of Experimental Psychology, 58,* 193–198.)

It enters your conscious short-term memory. You start to concentrate on it so you can dial the number. Now what would happen to that number if you heard someone screaming outside and you ran to see what had happened? Chances are that you would forget the phone number (just like participants forget the three consonants in studies using the distractor task), and then have to look it up again. Information in short-term memory is in a temporary storage state, and we need to concentrate on it to prevent it from being lost. Usually we use maintenance rehearsal to accomplish this. **Maintenance rehearsal** is repeating the information in short-term memory over and over again in order to maintain it. For example, in the case of the phone number, we rehearse it over and over again to ourselves until we dial it.

Maintenance rehearsal is just one type of work (processing and manipulating information) performed in short-term memory. As we pointed out earlier, because of all of the various types of work done in short-term memory, it is now often referred to as working memory. For our purposes here, you can think of **working memory** as a more detailed description of short-term memory that includes the mechanisms that allow short-term memory to accomplish its tasks. To explain how working memory does this, researchers have proposed differing models of the mechanisms in working memory (Miyake & Shah, 1999). The most influential explanatory model is that of Alan Baddeley (2007, 2012; Baddeley & Hitch, 1974). In brief, Baddeley proposes that there are four components of working memory: (1) a phonological loop, (2) a visuospatial sketchpad, (3) an episodic buffer, and (4) a central executive. The phonological

maintenance rehearsal A type of rehearsal in short-term memory in which the information is repeated over and over again in order to maintain it.

working memory A more detailed version of short-term memory that includes the mechanisms that allow short-term memory to accomplish its tasks.

loop allows you to work with verbal information for a short period of time. It is what allows us to repeat the phone number in the maintenance rehearsal example over and over in order to maintain it. Similarly, the visuospatial sketchpad works with visual and spatial information, such as the figures and illustrations on a page in this book, as well as their spatial positions on the page. The episodic buffer integrates information from the phonological loop, the visuospatial sketchpad, and long-term memory, such as the integration of the visual information of your teacher writing on the blackboard, the verbal input from his lecture, and the meaning of all of this input from long-term memory. It is called the episodic buffer because it represents a temporary storage place (a buffer) for the integrated representation of what is happening at any moment in time (an episode). Lastly, the central executive component is responsible for coordinating the activities of and distributing resources to the other three components so that the work (the processing and manipulation of information) can be optimally accomplished. It is also the mechanism for controlling our attention and communicating with long-term memory. In brief, it is the CEO of working memory.

Now that we have a better understanding of how short-term memory works, we need to think about what our goal is when we are trying to learn. It is not merely to maintain information in short-term memory. Our goal is to put that information into long-term storage so that we can retrieve and use it in the future, and our short-term memory plays a large role in this task. In the last two major sections of this chapter, we will look at the process of encoding information from short-term memory into long-term memory and of retrieving that information from long-term memory back into short-term memory at some later time. But first we need to get an overview of long-term memory, the last memory stage in the three-stage model.

Long-Term Memory

When we use the word "memory," we normally mean what psychologists call long-term memory. **Long-term memory (LTM)** allows storage of information for a long period of time (perhaps permanently), and its capacity is essentially unlimited. Remember the trillions of possible synaptic connections in the brain that we discussed in Chapter 2? They represent the capacity of long-term memory. The brain's memory storage capacity has been estimated to be around 2.5 petabytes (a million gigabytes), which would be enough to hold 3 million hours of television shows if your brain worked like a video recorder (Reber, 2010). You would have to leave the television running continuously for more than 300 years to use up all that storage. We will consider the duration or permanence of information in long-term memory in more detail later in this chapter when we consider theories of forgetting.

The durations and capacities for all three stages of memory are summarized in Table 5.1 (page 210). Review these so that you have a better understanding of how these three stages differ. Next, let's consider different types of long-term memories.

long-term memory (LTM) The memory stage in which information is stored for a long period of time (perhaps permanently) and whose capacity is essentially unlimited.

Table 5.1 Durations and Capacities of the Three Memory Stages

Memory Stage	Duration	Capacity
Sensory memory	< 1 sec for iconic memory; 4–5 secs for echoic memory	Large
Short-term memory	Up to 30 secs without rehearsal	7 ± 2 chunks
Long-term memory	A long time (perhaps permanently)	Essentially unlimited

Types of long-term memories. Memory researchers make many distinctions between various types of long-term memories (Squire, 2004). The first distinction is between memories that we have to recall consciously and make declarative statements about and those that don't require conscious recall or declarative statements (see Figure 5.5). What if someone asked you, "Who was the first president of the United States?" You would retrieve the answer from your long-term memory and consciously declare, "George Washington." This is an example of what is called **explicit (declarative) memory**—long-term memory for factual knowledge and personal experiences. Explicit memory requires a conscious explicit effort to remember.

explicit (declarative) memory Long-term memory for factual knowledge and personal experiences. This type of memory requires a conscious effort to remember and entails making declarations about the information remembered.

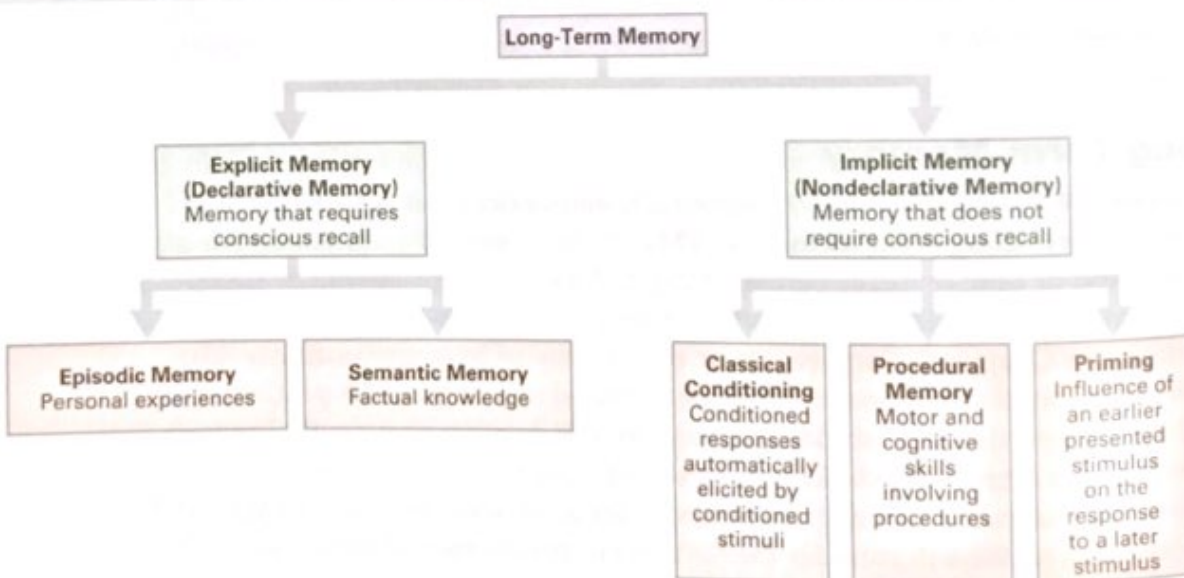


Figure 5.5 | **Types of Long-Term Memory** | Memory researchers make a distinction between two major types of long-term memory—explicit memory, which requires conscious recall, and implicit memory, which does not. Each of these two major types of long-term memory is further subdivided into more specific types of long-term memory, as defined in the figure.

Encoding Information into Memory

There are three essential processes in our memory system—encoding, storage, and retrieval. **Encoding** is the process of transferring information from one memory stage to the next (from sensory into short-term memory and from short-term into long-term memory). **Storage** refers to the process of maintaining information in a particular stage. Storage is temporary except for in long-term memory. **Retrieval** is the process of bringing information stored in long-term memory to the conscious level in short-term memory. Let's go back to the flow chart of the three-stage model of memory in Figure 5.1. Encoding and retrieval determine the flow of information within the three-stage system. Information is first encoded from sensory memory to short-term memory, where it can be stored temporarily. Information is then encoded from short-term to long-term memory, where it is stored more permanently but can be retrieved and brought back into short-term memory when we need to use it.

In this section, we will cover encoding and its role in moving information from short-term into long-term memory. Our focus will be on the best ways to achieve this transfer. We begin with a consideration of general encoding strategies.

How We Encode Information

The first distinction to consider is automatic versus effortful processing (Hasher & Zacks, 1979). **Automatic processing** is processing that occurs subconsciously and does not require attention. In contrast, **effortful processing** is processing that occurs consciously and requires attention. For a particular type of processing to become automatic, much practice is needed. A good example is reading. At first, learning to read is very effortful, but after years of practice it becomes easier and more automatic. Wouldn't it be nice if encoding to learn (studying) were an automatic process? It is unlikely that studying can become as automatic as reading, but we can get better at it by using better encoding strategies and practicing these strategies. In this section, we'll discuss some better ways to encode.

This distinction between automatic and effortful processing can also be applied to the three-stage memory model and the explicit versus implicit long-term memory difference that we discussed in the last section. The three-stage memory model is an explanation of how we process explicit memories, which require conscious effortful processing. Subconscious automatic processing, however, is responsible for storing implicit memories. If this automatic processing were to be represented in the three-stage memory model depicted in Figure 5.1, it would be an arrow going straight from the sensory input to long-term memory, bypassing the first two memory stages and hence our conscious awareness. The encoding strategies that we will discuss next, however, involve effortful processing leading to explicit memories, so

encoding The process of moving information from one memory stage to the next (from sensory memory into short-term memory or from short-term memory to long-term memory).

storage The process of maintaining information in a memory stage.

retrieval The process of bringing information stored in long-term memory into short-term memory.

automatic processing Memory processing that occurs subconsciously and does not require attention.

effortful processing Memory processing that occurs consciously and requires attention.

mood-dependent memory Long-term memory retrieval is best when a person's mood state at the time of encoding and retrieval of the information is the same.

mood-congruence effect Tendency to retrieve experiences and information that are congruent with a person's current mood.

mnemonic A memory aid.

method of loci A mnemonic in which sequential pieces of information to be remembered are encoded by associating them with sequential locations in a very familiar room or place and then the pieces of information are retrieved by mentally going around the room (place) and retrieving the piece at each location.

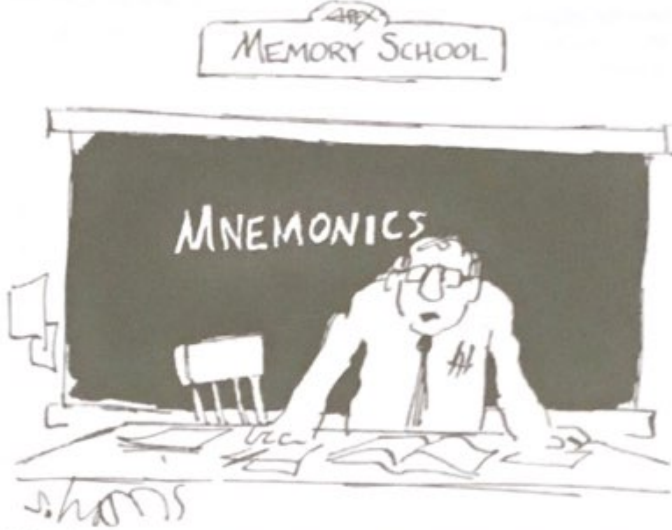
There are similar effects on memory that depend on the relationship between a person's emotional states, such as being happy or sad, at time of encoding and retrieval. Because one's mood is involved, these effects are referred to as **mood-dependent memory,** the retrieval of a particular memory is better when a person's mood at retrieval is the same as it was during encoding. Like state-dependency effects, mood-dependency effects furnish support for the encoding specificity principle—context is important for successful memory retrieval. There is also a related phenomenon called the **mood-congruence effect**—the tendency to recall memories that are congruent with a person's current mood. A particular mood cues memories that are consistent with that mood (Eich, 1995). We tend to remember more positive events when we are feeling good and more negative events when we are feeling down. These events have been associated with the accompanying emotions. Thus, the emotions serve as retrieval cues for the events. This congruence effect may hinder recovery in depressed people because they will tend to remember negative events and not positive ones. In fact, this is the case. Depressed patients report more memories related to illness, injury, and death than nondepressed people (Schacter, 2000). Think positively, and the mood-congruence effect will help maintain that positive attitude.

In summary, elaborative rehearsal is the most effective strategy for encoding. Research has found that actors working to learn their lines use elaborative rehearsal including encoding specificity, mood-congruence effects, and the self-reference effect (Noice & Noice, 1997). They do not use shallow processing and just memorize their lines. (Neither should students try this in their courses!) Elaborative rehearsal is the key to more effective learning. It is important to practice this type of rehearsal. You should integrate information that you are trying to learn with as much other information in your knowledge base as you can, especially relating it to yourself. You will get better at this elaboration strategy as you practice it, and learning will become easier.

How to Improve Encoding

In this section, we will discuss a few more specific ways to improve memory. We'll start with some techniques to improve memory for lists and more organized sets of concepts. These techniques use a **mnemonic,** a memory aid. Mnemonics are useful for remembering lists of items, especially ordered lists, speeches, and long passages of text. We'll start with a mnemonic that was used by ancient Greek orators to remember speeches.

The Greek orators used a mnemonic called the **method of loci** (Yates, 1966). "Loci" is the plural of "locus," which means place or location. In the method of loci, the sequential pieces of information to be remembered are first associated with sequential locations in a very familiar room or place. Then, when retrieving the information, one would merely mentally go around the room (or place) and retrieve the item stored at each sequential location. The Greek orators would mentally store the major points of a speech at sequential locations in the room where they were speaking. Then, during the speech an orator would go from location to location within the room to retrieve the key points of his speech. If you were trying to remember an ordered list of items for an exam, you could pair the items systematically with locations within the classroom and then during the exam mentally go from location to location within the classroom to retrieve them. The method of loci is a type of elaborative rehearsal using mental imagery. You elaborate upon items that you want to remember by visually associating them with a series of locations that you already know well or that will be available at the time of recall.



"You simply associate each number with a word, such as 'table' and 3,476,029."

All mnemonics work by using some type of elaboration. In another mnemonic, the **peg-word system,** you visually associate the items in a list with a jingle that you first memorize. The jingle is "One is a bun, two is a shoe, three is a tree, four is a door, five is a hive, six is sticks, seven is heaven, eight is a gate, nine is swine, and ten is a hen." You then associate each successive item in the list with the object for each successive number. For example, the first item on the list would be associated visually in a mental image with bun. If the word to be remembered were "dog", then you might construct an image of a big bun with a dog in it. Then, as you go through the peg words, you retrieve the associated image, so you can retrieve the list.

One might think that these mnemonic techniques require much more effort than just memorizing the information that we want to remember. But researchers have found that people using mnemonics demonstrate much better memory than those who have just attempted to memorize a list. Why? As we discussed earlier, elaborative rehearsal is better for encoding into long-term memory. Professional memory experts do not have exceptional intelligence or structural brain differences but rather have their own unique mnemonic techniques and are superior at using them (Maguire, Valentine, Wilding, & Kapur, 2003). Their techniques, like the ones that we have described, are all essentially based on elaborative encoding,

peg-word system A mnemonic in which the items in a list to be remembered are associated with the sequential items in a memorized jingle and then the list is retrieved by going through the jingle and retrieving the associated items.

spacing (distributed study) effect Superior long-term memory for spaced study versus massed study (cramming).

the key to superior memory. For a fascinating journey into the world of these memory experts, you should read Joshua Foer's engaging book, *Moonwalking with Einstein: The Art and Science of Remembering Everything* (2011). Under the tutelage of some of these experts, Foer went from being a journalist with an average memory to winning the U.S. Memory Championship in 2006, testifying to the effectiveness of mnemonic techniques.

Mnemonics that involve little elaboration have not been found to be very effective. A good example is the first-letter technique (Gruneberg & Herrmann, 1997). In the first-letter technique, you compose a word, acronym, or sentence from the first letters of the words you want to remember. This is the mnemonic that we suggested in Chapter 3 to use to remember the colors of the spectrum (the name ROY G. BIV—**R**ed, **O**range, **Y**ellow, **G**reen, **B**lue, **I**ndigo, **V**iolet). This mnemonic helps, but it is not as effective as the other, more elaborative mnemonics, especially for more complex information.

So what else—in addition to elaborative rehearsal and the use of mnemonics—improves encoding and retrieval? There are three concepts that will help: (1) distributed study is better than cramming, (2) practice makes perfect, and (3) testing enhances memory. The superior memory for spaced study versus cramming is called the **spacing (distributed study) effect.** Your memory will improve if you distribute your studying for an exam over the entire preparation interval and not just the few days before the exam (Payne & Wenger, 1996). Hundreds of experiments have shown the benefits of distributed study (Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006). In fact, for best results, distribute your studying *and* cram. The more you study, the more you learn. Overlearning, continuing to study material past the point of initial learning, improves memory (Rohrer & Taylor, 2006). Remember what we said about practice and automatic processing. Continued practice will make retrieval more automatic. Such practice may not make you "perfect," but you'll definitely do better. Lastly, don't just study. Incorporate repeated self-testing during your distributed study periods. Such testing will enhance your memory by allowing you to practice retrieval, which is what exams require (Roediger & Karpicke, 2006). Don't wait for an exam to test your retrieval; test it regularly during study. It will not only help you to practice retrieval but also help you to guide your study by pointing out what you have learned and what you have not learned.

Section Summary

In this section, we discussed the most effective encoding strategy, elaborative rehearsal, which is relating new information to well-known information in long-term memory. Elaboration is most effective when we relate the new information to ourselves, the self-reference effect. Elaborative rehearsal leads to better memory because we create good retrieval cues when we integrate the new information with older, well-known information. This relates to the encoding specificity principle, which states that the best retrieval cues are those present during encoding.

the particular probability judgment. To understand, let's consider the following problem (Tversky & Kahneman, 1983).

> **You will read a brief description of Linda, and then you will be asked to make a judgment about her. Here's the description:**
>
> **Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations.**
>
> **Which of the following alternatives is more likely?**
>
> **Linda is a bank teller.**
>
> **Linda is a bank teller and active in the feminist movement.**

representativeness heuristic A heuristic for judging the probability of membership in a category by how well an object resembles (is representative of) that category (the more representative, the more probable).

The representativeness heuristic. To decide which alternative is more probable, most people would use what is called the **representativeness heuristic**—a rule of thumb for judging the probability of membership in a category by how well an object resembles (is representative of) that category. Simply put, the rule is: the more representative, the more probable. Using this heuristic, most people, including undergraduates, graduate students, and professors, judge that the second alternative (Linda is a bank teller and active in the feminist movement) is more likely than the first alternative (Tversky & Kahneman, 1983). Why? Linda resembles someone active in the feminist movement more than she resembles a bank teller. However, it is impossible for the second alternative to be more likely than the first. Actually the description of Linda is totally irrelevant to the probability judgment!

Let's look at the set diagram in Figure 6.1. This diagram illustrates what is known as the conjunction rule for two different uncertain events (in this case, being a bank teller and being active in the feminist movement). The conjunction rule is that the likelihood of the overlap of two uncertain events (the green section of the diagram) cannot be greater than the likelihood of either of the two events because the overlap is only part of each event. This means that all of the tellers who are active in the feminist movement make up only part of the set of all bank tellers. Because the set of bank tellers is larger and includes those tellers who are active in the feminist movement, it is more likely that someone is a bank teller than that someone is a bank teller and active in the feminist movement. Judging that it is more likely that Linda is a bank teller and

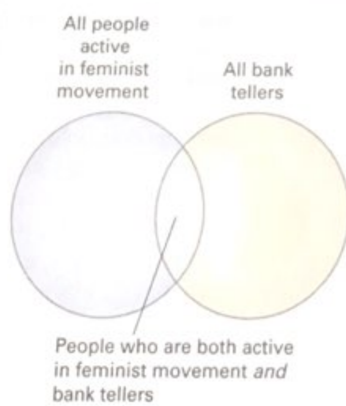


Figure 6.1 | The Overlapping Set Diagram for the Linda Problem | The overlap (the green area) of the two sets (all bank tellers and all people active in the feminist movement) indicates the probability of being both a bank teller and active in the feminist movement. Because this area is a subset (part) of each of the two sets, its probability has to be less than that for either of the two sets. This is the conjunction rule.