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Chapter 6

Learning *and* Behavior

In March 2007, the U.S. Fish and Wildlife Service announced that after thirty years of conservation efforts the grizzly bear populations were no longer considered endangered in the Yellowstone Park area. While the population of these bears has increased significantly so, too, has the threat of a grizzly bear attack. Each year several visitors to the park are attacked by bears (NPS, 2012). Trying to protect an endangered species that may pose a significant danger to humans has presented some special problems for conservationists.

These problems are particularly evident in the Yellowstone and Glacier National Parks regions of Montana and around the resort town of Whistler in British Columbia, Canada. After years of living close to civilization and foraging through garbage cans and camp sites, both grizzly and black bears in these areas behave as if they have lost their fear of humans. In the past, before these regions were as heavily populated, the bears avoided human contact whenever they could. Now bears that have become accustomed to humans react differently with the result that in recent years a number of people have been injured or killed. Bears that injure humans must be destroyed; thus rangers have been put in the position of bringing the grizzly bear even closer to extinction. Over one thousand black bears and more than 380 grizzlies were shot in British Columbia in 2011 because of conflicts with humans. These numbers have been rising steadily over the last decade as bears have learned to forage in neighborhoods and campgrounds (Pynn, 2012)

Most efforts to relocate bears to other areas have been remarkable for their lack of success. For instance, when bears are trapped and transported deep into the wild, they often return to human habitats where the living is easy. Recently, however, wildlife officials have begun a new program that looks far more promising. The goal of this program is to reestablish fear of humans in these animals, using aversive conditioning (Harden, 2002). Aversive conditioning has utilized rubber bullets, loud noises, dogs, and other forms of hazing; however, brief electric shocks have been the most effective in reestablishing fear of humans in these animals.

Protecting endangered species may seem to be far from the topic at hand; yet it illustrates some of the principles that are basic to learning processes, not just in bears, but also in humans and other animals. As we will see, much of our learning takes place by associating events, just as the bears learned to associate painful shocks with the presence of humans.

An understanding of learning is relevant to many other fields that seem to have little to do with psychology, from designing behavior treatment programs to understanding our immune system. The pages that follow present at least a portion of what psychologists have learned about learning, and they help to explain how we can apply this knowledge to our lives. Before we discuss the applications of learning, we begin by defining what we mean by learning.

6.1 Defining Learning

Learning may be defined as a relatively permanent change in potential behavior that results from experience. This definition contains three important elements. The first element is change. Most learning tends to produce lasting changes in the behavior of the learner. We hope that the bears in the opening example of this chapter will continue to associate humans with the discomfort they experienced during aversive conditioning.

Second, this definition excludes changes in behavior that result from anything other than experience. For example, behavior can be modified by non-experiential events like diseases, injury, or maturation. A broken leg would result in numerous changes in your behavior, few of which are learned. We know that grizzly bears have learned to associate people with aversive consequences when we see that they now avoid humans and the places where humans are likely to be.

Learning Relatively enduring change in potential behavior that results from experience

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The third element of this definition speaks of *potential* behavior. Although learning causes changes in behavior, it is not always reflected directly in performance. The absence of observable behavior change does not necessarily mean that no learning has taken place; however, a change in behavior under the appropriate conditions must be observable at some time to claim that learning has occurred. For example, suppose a young boy often sees his father strike his mother during arguments. For the time being, the father's actions may have no apparent effect on the boy's behavior. When the boy becomes an adult, however, he strikes his wife during an argument. During the boy's childhood, we would have had no reason to believe that he had learned to be physically violent when frustrated. However, the potential for this behavior clearly was acquired; it simply required the necessary circumstances for it to occur.

Rats in a maze demonstrate another example of learning that cannot be observed immediately. If there is no reinforcement (such as food) at the end of the maze, rats explore the alleys with no indication that learning is taking place. When food is placed at the end of the maze, however, they quickly negotiate the twists and turns to reach it. Some learning had taken place during the exploration, but it required a proper incentive to be reflected in actual performance.

6.1a How Learning Takes Place

You should now have an understanding of what learning is. But how does it take place? For instance, you go to a familiar restaurant and order something unique that you've never eaten before. Throughout the meal you comment on how distinctive and flavorful your dish is. Later in the evening you become quite ill and nauseous. This illness may be completely unrelated to the meal you had eaten earlier. Perhaps it's a touch of the flu. However, the association of illness with the meal leads to an aversion to this unique dish that you found flavorful earlier. This aversion may last for years. Most of us can think of examples of food aversions we've acquired such as this. For patients undergoing radiation or chemotherapy, food aversions can be quite common, and they are acquired in the same fashion. A flavor or smell that is followed by treatment that makes the patient ill is less desirable than before. This is an example of a conditioned taste aversion, a subject to which we will return later (Garcia & Koelling, 1966).

This kind of learning is called **associative learning**. It describes the process by which we make a connection or an association between two events, such as the flavor of a particular food and illness—or how the bears, in the opening example, learn to associate pain with humans. Associative learning may take place in two primary ways: Through Pavlovian conditioning and through operant conditioning. Both of these processes contribute continually to your ongoing behavior.

Pavlovian conditioning (or classical conditioning) involves learning an association between two stimuli and results in a change in behavior. For example, the flavor of our unique dish at the restaurant becomes associated with illness, a small child learns to associate the sight of a physician's syringe with the discomfort of an injection, or bears learn to associate painful shocks with humans. We will see later that Pavlovian conditioning contributes to your emotional states, the functioning of your digestive and immune systems, and even to the development of tolerance to drugs.

In **operant conditioning**, people or other animals learn to associate their own behavior with its consequences, which results in a change in behavior. Thus a child learns that pressing a button brings an elevator, a college student learns that answering questions in a certain class produces praise, a porpoise learns that jumping through a hoop results in a tasty morsel of fish, and you learn that driving through a stop sign produces a ticket.

Associative Learning
Learning by making an association between two stimulus events (Pavlovian conditioning) or by learning an association between a response and its consequence (operant conditioning)

Pavlovian Conditioning
This is learning that takes place when a neutral stimulus (CS) is paired with a stimulus (UCS) that already produces a response (UCR). After conditioning, the organism responds to the neutral stimulus (CS) in some way. The response to the CS is called a conditioned response (CR).

Operant Conditioning
Learning an association between one's behavior and its consequence (reinforcement or punishment)

Psychologists believe that most kinds of learning can be described in terms of Pavlovian and operant conditioning. However, certain kinds of learning, such as learning language, may involve more complex processes. This kind of learning is labeled **template learning** because there appears to be a neural template that facilitates it. First, however, we turn our attention to Pavlovian and operant conditioning processes.

Template Learning Learning that depends on a particular type of perceptual experience during a critical time in development (examples would include imprinting and language learning)

6.2 Pavlovian Conditioning

Some years ago, one of the author's psychology students came to him with a problem. She was enrolled in a biology class in which students spent much of their time in a laboratory. When she entered the lab early in the term, she suddenly felt an overwhelming state of anxiety bordering on terror. She was unable to remain in the laboratory; consequently, she could not complete her assignments. Perplexed and concerned, she tried a number of times to return to the lab, but she could not shake her feeling of terror.

Here are some of the facts in the case just described: The student had completed two previous terms of biology without experiencing any discomfort in the laboratory segments. Between her previous biology class and the present term was a one-year absence from college, during which she gave birth to her first child. Her problem in the biology laboratory commenced immediately after returning to resume her studies. Take a moment to consider the facts and try to explain the woman's fear response before reading on.

If you guessed that the student had some terrible experience during her year's absence from college that somehow became associated with the environment of the biology laboratory, you are correct. Because of complications during the delivery of her baby, her physician decided to perform a caesarean section (surgical removal of the baby through an incision in the abdomen and uterus). There was not time for her to be psychologically prepared, and she panicked. She found herself unable to breathe when she received an injection of anesthesia (a rare response during this type of medical procedure and probably related to stress). For a few terrible moments she was convinced she would die. Fortunately, the feeling subsided quickly, and the operation proceeded smoothly.

Let's see how Pavlovian conditioning may have contributed to her present anxiety in the biology laboratory. The trigger for this woman's original fear response was her experience on the operating table. Because this experience took place in an environment with medical smells, the woman associated these smells with her awful experience at the hospital. The odors of antiseptic and anesthetic agents in the biology laboratory were similar enough to the medical smells of the operating room to trigger the same fear response that the woman had developed while receiving anesthesia for her operation.

The connection was not a conscious one. In fact, Pavlovian conditioning rarely occurs at a conscious level. In this case the woman was not aware that she had been conditioned. Yet it followed a Pavlovian model that was first recognized around the turn of the century by the Russian physiologist Ivan Pavlov (1849–1936). You will see in this section that most of your emotional responses are conditioned similarly.

6.2a Pavlov's Discovery

Ivan Pavlov's real interest was the physiological mechanisms involved in digestion. In fact, he never associated his own research with psychology and insisted that he was dealing only with physiological mechanisms. Toward this end, Pavlov was investigating the salivation responses of dogs by placing the animals in a harness like apparatus, shown in Figure 6-1. A surgical procedure exposed each dog's salivary glands, which were connected

Figure 6-1 Pavlov's Conditioning Apparatus

During a typical conditioning session an assistant, sitting behind the mirror, rang a bell (the CS) and then presented food (the UCS) to the hungry dog. Salivation was measured by collecting it via a tube attached to the dog's salivary gland. A revolving drum recorded the amount of saliva collected. Initially salivation occurred only after food was presented (the UCR). After several condition trials, however, salivation occurred (the CR) after the presentation of the CS.

directly to a device that measured the flow of saliva. Pavlov then presented a stimulus, meat powder. When food entered the dog's mouth, the immediate result was the natural, reflexive response of salivation.

However, Pavlov soon noted an unexpected occurrence. His dogs began to salivate to stimuli other than food in their mouths. For example, an animal might start salivating at the mere sight of the experimenter. The sound of Pavlov's footsteps or the sight of the food dish also caused salivation.

This discovery changed the course of Pavlov's study, for Pavlov now began to investigate how other stimuli could cause dogs to salivate. His experiments are generally recognized as the first systematic study of learning, and the processes that he outlined came to be called primary (as in "the first") conditioning. (Pavlovian conditioning is also called classical conditioning because Pavlov described it as conditioning of the classical type.) A basic outline of this model of learning follows.

A hungry dog, secured in Pavlov's apparatus, hears a bell. A moment later, the dog is given meat powder; copious salivation results. This procedure is repeated several times, with one stimulus (the sound of the bell) followed consistently by another stimulus (food). Eventually, the dog salivates when it hears the bell, even when no food follows. The dog has associated the bell with food. However, what is learned is more than a mere association between two stimuli. Rather, Pavlovian conditioning may be best described as the learning of relations among events so as to allow the organism to represent its environment (Rescorla, 1988). Put another way, Pavlov's dog learned something about important relationships existing in its environment, namely that the sounding of a bell signaled the availability of food. Consequently, when the bell rang, the dog salivated in *anticipation* of eating food. Many conditioned responses function to prepare the learner for a change in events.

The fact that a previously neutral stimulus (a stimulus, such as the sound of the bell, that does not elicit the to-be-learned response) eventually produces a response (salivation) ordinarily associated with another stimulus (food) is clear evidence that learning has taken place. Pavlov identified four key events or elements for Pavlovian conditioning:

1. **The Unconditioned Stimulus (UCS)** Meat causes dogs to salivate. This response occurs automatically, without learning or conditioning. A stimulus that elicits an unlearned response or reflex is called an unconditioned stimulus (UCS). In our opening example of aversive conditioning with bears, electric shock was a UCS.

2. **The Unconditioned Response (UCR)** Salivating at the presentation of meat is an automatic response that does not require learning. An unlearned response is called an unconditioned response (UCR). In our opening example of aversive conditioning, fear and anxiety following electric shocks were UCRs.

3. **The Conditioned Stimulus (CS)** The bell initially is a neutral stimulus in that it does not elicit the to-be-learned response by itself. It causes salivation only when the dogs learn the association between the bell and the unconditioned stimulus, the food. A stimulus to which an organism learns to respond is called a learned or conditioned stimulus (CS). In our opening example of aversive conditioning, seeing humans or being in places where humans are likely to occur are examples of CSs.

4. **The Conditioned Response (CR)** Pavlov's dogs were conditioned to salivate when a bell sounded. Such a learned response is called a conditioned response (CR). In our opening example of aversive conditioning, fear and the motivation to avoid humans are examples of CRs. Notice that Pavlovian CRs are changes in emotional or motivational states, not overt behaviors such as running away.

Figure 6-2 summarizes the steps by which conditioning took place in Pavlov's model.

The conditioning in Pavlov's dogs was measured by collecting saliva secreted following the presentation of the CS. Other conditioned responses may take place and be measured at a physiological level. For instance, in the Health, Psychology, and Life segment at the end of this chapter we discuss Pavlovian conditioning of the immune system, which could have far-reaching medical implications.

Unconditioned Stimulus (UCS) In Pavlovian conditioning, a stimulus that elicits an unlearned response or reflex

Unconditioned Response (UCR) In Pavlovian conditioning, an unlearned response or reflex caused by an unconditioned stimulus

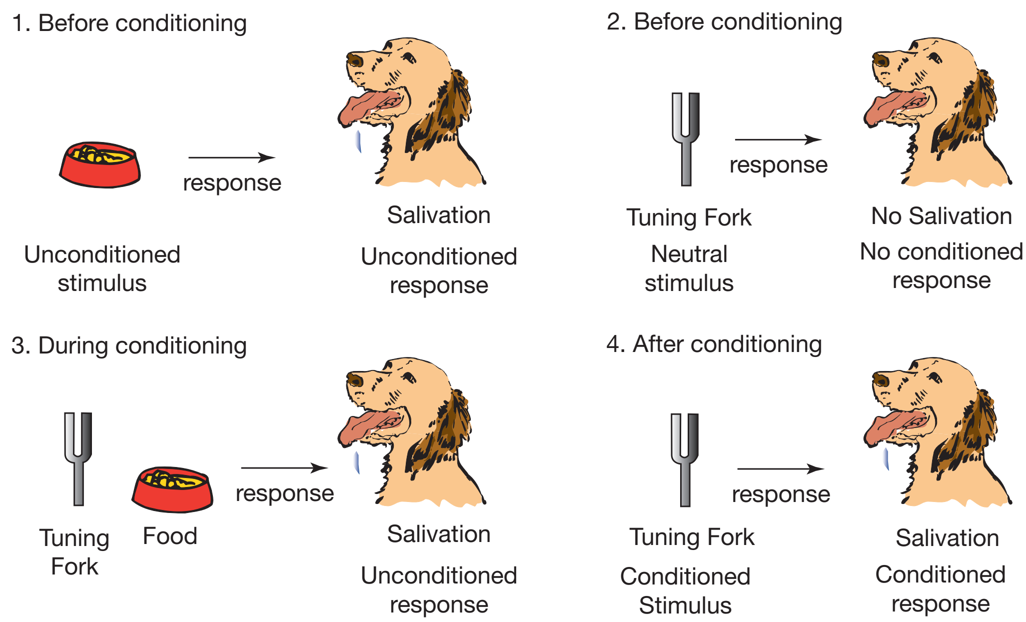
Conditioned Stimulus (CS) In Pavlovian conditioning, a stimulus that elicits a response only after being associated with an unconditioned stimulus

Conditioned Response (CR) In Pavlovian conditioning, a learned response to a conditioned stimulus

Differentiating Between the UCR and the CR

At first glance, the unconditioned response and conditioned response often appear to be identical. The UCR in Pavlov's experiments occurred when the dogs salivated in response to meat, and the CR was also salivation. However, the UCR and the CR may be quite different depending on both the nature of the CS and the UCS. In our opening example of taste aversion conditioning, illness was the UCR and an aversion to food was the CR. In some cases, the CR and the UCR can be opposites. In the author's laboratory, for example, the context of morphine or cocaine administration (CS) elicits tolerance to the drug (CR), while the UCRs to morphine and cocaine are analgesia and euphoria. This is demonstrated by testing the effectiveness of morphine to acute thermal pain. After

Figure 6-2 Pavlov's Conditioning Procedure



repeated trials where morphine is administered in a certain context, animals become tolerant and morphine is no longer effective. If, however, these animals are tested in a novel context, morphine is once again an effective analgesic.

Unconditioned and conditioned responses also differ in their intensity. An unconditioned response is generally more intense than is a response that has been conditioned. For example, dogs salivate more copiously when meat is actually placed in their mouths than they do when they either hear a bell or see the person who feeds them.

What do dogs salivating to a sound have to do with our lives as humans? We can best put this question in perspective by returning to the case of the biology student. The same elements that Pavlov traced in his dogs can be found in this conditioning experience. The unconditioned response is fear, a natural response to the frightening event in the hospital room (the UCS). Fear or anxiety is the learned or conditioned response. Just as Pavlov's dogs learned to associate the bell with food, the young woman may have learned to associate medical smells (the CS) with the hospital event.

In this case, the woman needed to be exposed to only one conditioning event. One profoundly frightening event can establish a conditioned fear that may last a lifetime. In other cases, several conditioning trials or events may be necessary for learning. Fortunately, conditioned phobias (persistent, irrational fears) may be eliminated or extinguished using therapy techniques that are also based on Pavlovian conditioning principles (See Chapter 16). A few therapy sessions with the author's student were sufficient to extinguish her fear of the biology laboratory successfully.

The difference between the repeated pairing that Pavlov used on his dogs and the single experience of the young woman illustrates one way in which Pavlovian conditioning experiences may vary. The following discussions deal with other variations on the same theme, exploring both the ways in which learning is acquired and the ways in which it can be extinguished.

6.2b Acquisition of Pavlovian Conditioning

The period during which an organism learns to associate the conditioned stimulus with the unconditioned stimulus is known as the **acquisition** stage of conditioning. Each paired presentation of the two stimuli is called a trial. In cases such as Pavlov's conditioning experiments, these repeated trials strengthen, or reinforce, the association between the CS and the UCS.

Acquisition In Pavlovian conditioning, the process of learning to associate a conditioned stimulus with an unconditioned stimulus—In operant conditioning, the process of learning to associate responses with a reinforcer or punisher

Several factors influence how easily a Pavlovian conditioned response is acquired. For example, conditioning takes place more easily when the neutral or conditioned stimulus is clearly different from other stimuli. Had Pavlov signaled the arrival of food by quietly humming a Russian ballad, his dogs might never have perceived the connection since such sounds are commonplace and might not have been noticed. In contrast, Pavlov's dogs could hardly overlook a ringing bell. This property of the CS is referred to as *stimulus salience*. The more salient the CS, the more readily conditioning is acquired.

The intensity of the UCS will also influence conditioning. Typically, the more intense the UCS, the more readily conditioning takes place.

Another factor influencing acquisition is the frequency with which the CS and UCS are paired. Frequent pairings generally facilitate conditioning. If bells were only occasionally accompanied by feeding, Pavlov's dogs would have been less likely to be conditioned.

Finally, and perhaps most importantly, is the degree to which the CS and UCS are related. By this we mean the contingency between the CS and the UCS. This important issue demands extra attention (Domjan, 2010).

6.2c Stimulus Contingency and Conditioning

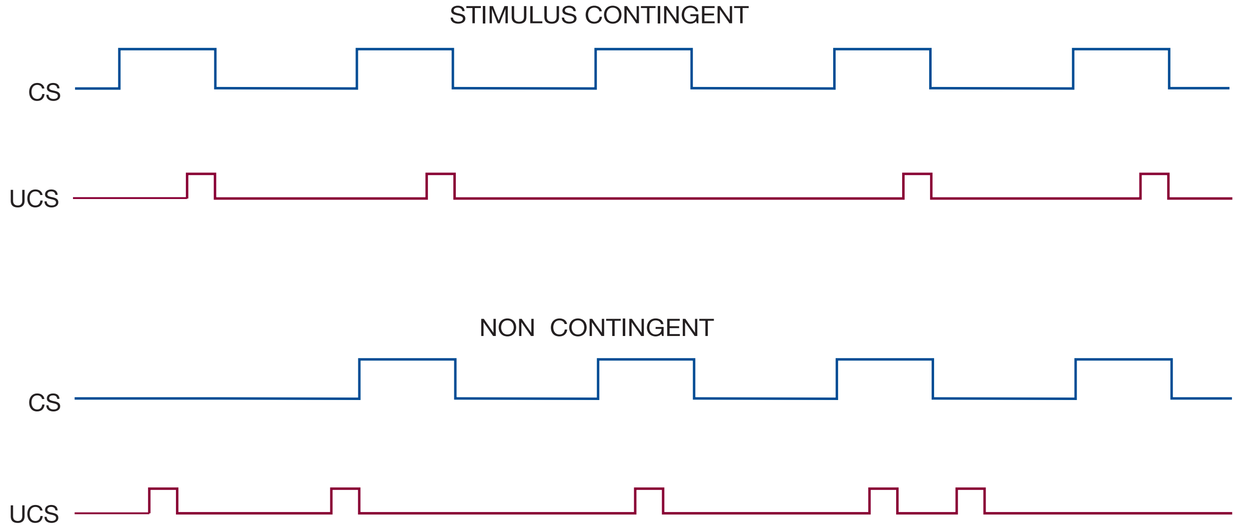
Perhaps the best way to illustrate the concept of stimulus contingency is to review a classic experiment conducted by Robert Rescorla (1968). In Rescorla's experiment rats were exposed to one of two conditioning procedures: A stimulus contingent procedure or a non-contingent procedure. In the stimulus contingent procedure a series of CSs and UCSs (tones and shocks) were presented, but a UCS (shock) never occurred unless a CS (tone) preceded it. That is, the presentation of the UCS was contingent upon a CS preceding it. Occasionally, however, CSs were presented without being followed by a UCS. This procedure is illustrated in the top part of Figure 6-3.

In the non-contingent procedure the same number of CS and UCS presentations occurred, however, the presentations of the CS and the UCS were independent. That is, the presentation of a UCS (shock) was not contingent upon the prior occurrence of a CS (tone). Occasionally in this procedure there were close pairings of the CS and the UCS, but these were random occurrences. This procedure is illustrated in the bottom part of Figure 6-3. When Rescorla tested both groups for conditioning, he found that conditioning only occurred for the rats in the stimulus contingent procedure. No learning occurred with the non-contingent procedure. Rescorla's experiment is important because it demonstrates that more than occasional CS-UCS pairings are necessary for conditioning, as Pavlov and his followers had believed. For example, Pavlov believed that occasional pairings of the CS and UCS were sufficient for conditioning, and therefore, some conditioning should have taken place during the non-contingent procedure. In summary, what is necessary for Pavlovian conditioning is that the UCS be contingent (depend) upon the prior occurrence of the CS (Rescorla, 1968).

The idea of stimulus contingency can perhaps be simplified by considering an example from weather forecasting. Imagine two forecasters—one proficient, the other not. Both predict rain on numerous occasions, but rain never occurs without a rain

Figure 6-3 Stimulus Contingency in Pavlovian Conditioning

Stimulus contingency and temporal contiguity occur in the top figure. That is, the occurrence of a UCS is always preceded by the occurrence of a CS. In the bottom figure there is no contingency. UCS presentations are occasionally paired with CS presentations, but they are not contingent (dependent) on the occurrence of a CS.



(Source: Figure of "Pairing of the CS with the USC: Four Temporal Relationships in Classical Conditioning" from *The Psychology of Learning* by S. H. Hulse, H. Egenth, and J. Deese, Copyright © 1980 by S. H. Hulce, H. Egeth, and J. Deese. Reprinted by permission of McGraw-Hill, Inc.)

forecast from the proficient weatherman. On the other hand, rain is just as likely with as without a rain forecast from the non-proficient weatherman. The proficient weatherman demonstrates a stimulus contingency because rain is contingent upon a forecast for rain. That is, rain doesn't occur unless it is forecast, even though rain doesn't occur after *every* rain forecast. Thus, upon hearing a forecast for rain, you prepare for it. The non-proficient weatherman demonstrates the lack of stimulus contingency because rain is just as likely whether or not it is forecast. As you can guess, you can't depend on the forecast so you don't prepare for rain.

There are several ways in which stimulus contingency can be presented and the ease of conditioning also depends upon them. We next consider several important examples of conditioning trials where the timing of CS and UCS presentations vary.

Delayed Conditioning
In Pavlovian conditioning, learning that takes place when the conditioned stimulus is presented just before the unconditioned stimulus is presented and continues until the organism begins responding to the unconditioned stimulus

6.2d CS-UCS Timing and Conditioning

Conditioning occurs most easily when the CS is presented just moments before the UCS appears, and it is continued until after the presentation of the UCS. For example, the bell rings before food is presented to Pavlov's dog, and it continues until the animal begins to salivate as food enters its mouth. This timing sequence is called **delayed conditioning**. The ideal CS-UCS interval in delayed conditioning depends somewhat on the associations to be learned. Typically, CS-UCS delays between 0.5 and 2 seconds are optimal.

Conditioning may still take place when timing is varied. For instance, **simultaneous conditioning** takes place when the conditioned stimulus is presented at the same time as the unconditioned stimulus. Another variation in timing is known as **trace conditioning**. Here, the conditioned stimulus begins and ends before the unconditioned stimulus is presented. Finally, in **backward conditioning** the UCS is presented prior to the CS. Figure 6-4 illustrates all four variations in timing.

Delayed conditioning with short CS-UCS intervals generally yields the most rapid rate of learning. In contrast, the least effective sequence, backward conditioning, usually results in little or no learning. An exception to the rule that the delay between CS and UCS onset must be short is conditioned taste aversions, which were briefly introduced earlier (Domjan, 2010).

Simultaneous Conditioning In Pavlovian conditioning, learning that takes place when the conditioned stimulus is presented at the same time as the unconditioned stimulus

Trace Conditioning In Pavlovian conditioning, learning that takes place when presentation of the conditioned stimulus begins and ends before the unconditioned stimulus is presented

Backward Conditioning In Pavlovian conditioning, presenting the unconditioned stimulus prior to the conditioned stimulus (backward conditioning results in little or no conditioning)

Conditional Taste Aversion A learned aversion to a relatively novel taste or smell that occurs followed by illness or nausea

Conditioned Taste Aversions

John Garcia was the first to study conditioned taste aversions (sometimes called the Garcia Effect) (1961). In his experiments rats were first exposed to a novel taste, in this case saccharin. Several hours later the rats were exposed to moderate doses of radiation, which made the rats ill. To test for conditioning, the rats were given access to two drinking spouts, one containing plain water and the other, saccharin solution. Normally rats would prefer the saccharin solution to water, but these conditioned rats do not. The lack of a saccharin preference is called a **conditioned taste aversion**. Conditioned taste aversions reliably occur with long CS-UCS intervals. In numerous experiments the interval between the CS (the taste of saccharin) and the UCS (illness) has been as long as twenty-four hours (Etscorn & Stephens, 1973).

Conditioned taste aversions are quite common for individuals who have undergone chemo or radiation therapy for cancer. Most often these aversions develop to novel or rare tastes or smells. A young child belonging to a student in one of the author's classes developed a puzzling aversion to his mother soon after he began a series of radiation treatments. Merely picking up her child would result in his pushing and squirming to get away. On a few occasions the child even vomited on his mother. It turns out this conditioned aversion was elicited by the smell of a new perfume his mother began wearing soon after his treatment began. After a few treatment sessions the perfume (a CS) began to elicit nausea and anxiety (CRs) in her child. Because these aversions can last for many years, the perfume was discarded after this author suggested avoiding its use for a few days as an experiment.

Preparedness and Selective Associations

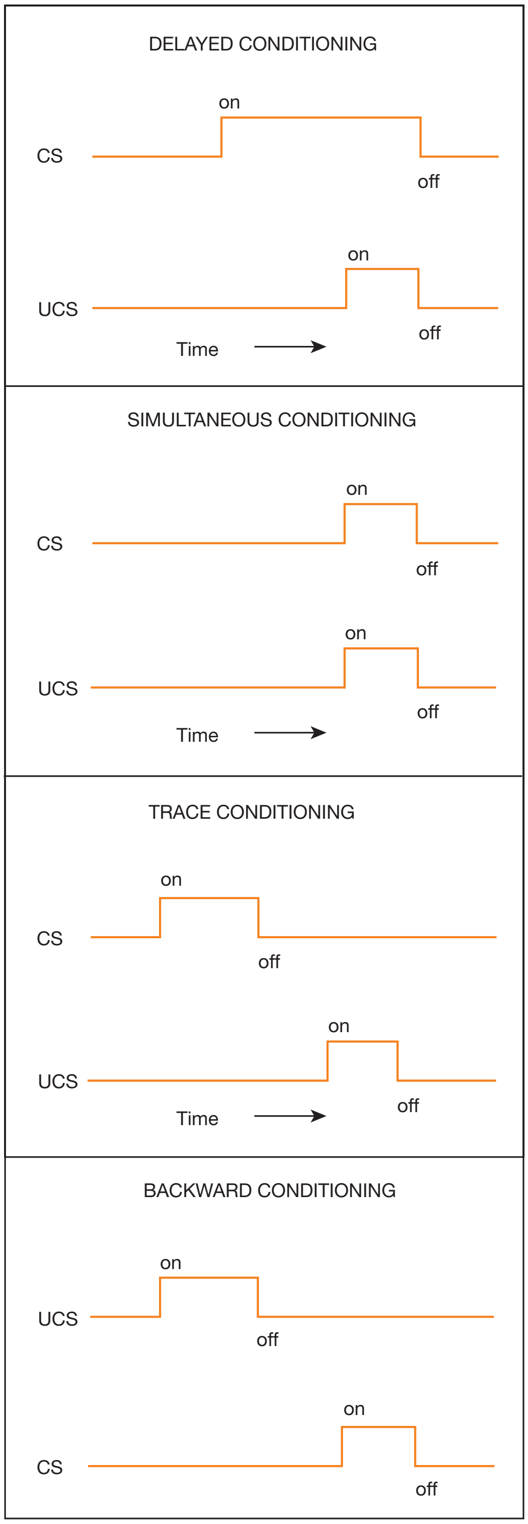
Not all associations are as readily learned as the association between a novel taste or smell and illness. In fact, most learned associations require numerous trials containing CS-UCS presentations. When associations are learned quickly, like conditioned taste aversions, they are considered to be prepared. That is, animals may be prepared biologically to learn certain associations more quickly than others. The survival advantage for animals to learn quickly to avoid foods that have made them ill is fairly clear.

In addition, not all CSs are as easily associated with a UCS as others. For instance, in a similar experiment Garcia and Koelling (1966) used two types of CSs (taste and an audiovisual stimulus) and two types of UCSs (illness and mild shock) to test for selective associations. Before reading on, consider which associations were easily learned in this experiment.

The results of the experiment clearly support the notion of selective associations. Rats easily learned the taste-illness and the audiovisual stimulus-shock associations, but they did not learn either the taste-shock or the audiovisual stimulus-illness associations. Other experiments have also demonstrated that certain CS-UCS associations are more easily learned than

Figure 6-4 Variations in CS/UCS Presentations and Pavlovian Conditioning

Delayed conditioning generally yields the most rapid conditioning. Backward conditioning rarely results in conditioning.



others. These learned associations are referred to as selective associations because certain CS-UCS combinations seem to belong together. Some psychologists have speculated that the concepts of preparedness and selective association may account for the relative ease with which people learn certain phobias (exaggerated fears of heights or insects, for example).

6.2e Extinction and Reinstatement

Would Pavlov's dogs have continued to salivate at the sound of the bell if it were no longer accompanied by food? The answer, of course, is no. They would salivate less and less at the sound until, without any additional presentations of the UCS, they eventually would cease salivating altogether.

This process is called **extinction**. Extinction occurs in Pavlovian conditioning when the CS is repeatedly presented alone, without the UCS. Extinction does not mean that a response is totally stamped out, however. Once extinguished, a conditioned response can undergo **reinstatement** in much less time than it took to acquire it in the first place. For instance, the Pavlovian conditioned response of salivating to a bell may have been established only after numerous pairings or trials. After extinction, however, the conditioned response might be reinstated after only one or two pairings of the bell and the food. In the author's laboratory, tolerance to morphine (a CR) can be extinguished by placing animals in a context (CS) where drugs have repeatedly been administered (UCS) without giving them an injection. Reinstatement of tolerance, and drug seeking behaviors, can be quickly reinstated after one drug injection. This may partially explain why it is so easy for drug addicts to return to drug use after treatment (Widholm, 2010).

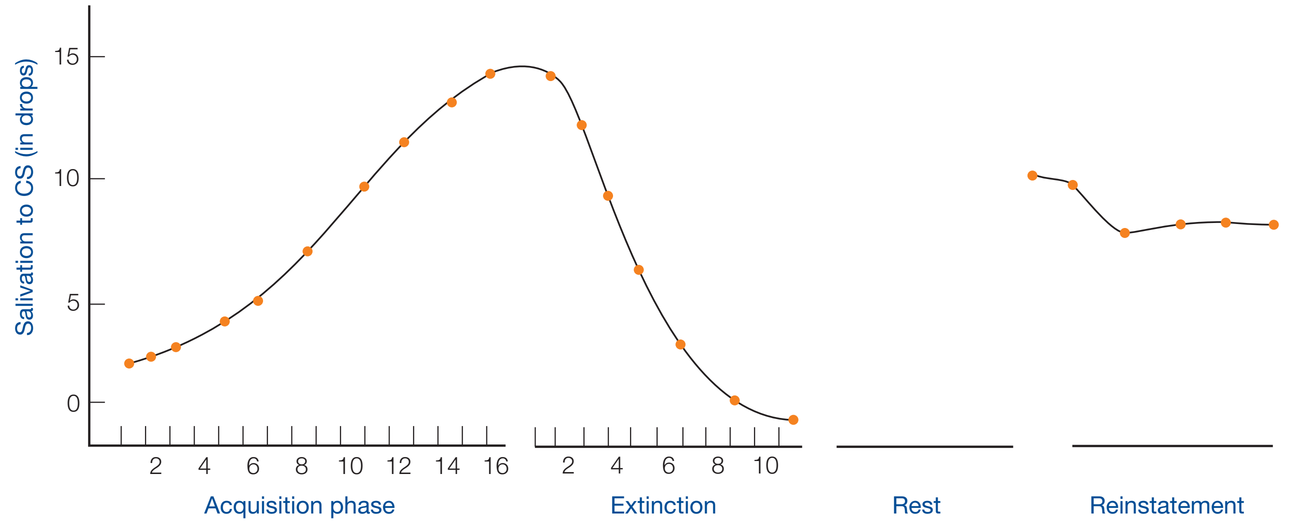
As Figure 6-5 demonstrates, reinstatement may bring the conditioned response to a higher level than before extinction.

Extinction In Pavlovian conditioning, the process by which a conditioned response is eliminated through repeated presentation of the conditioned stimulus without the unconditioned stimulus. In operant conditioning, the process of eliminating a response by discontinuing reinforcement for it

Reinstatement In Pavlovian conditioning, the reappearance of a conditioned response after extinction has taken place

Figure 6-5 Acquisition, Extinction, and Reinstatement

This figure demonstrated rapid acquisition of the CR (salvation to the bell) after several trails in which the bell (CS) was paired with food (UCS). During extinction, the UCS no longer follows the CS and the CR decreases. Later, salvation (CS) occurs following the presentation of a single CS-UCS paring. This is referred to as reinstatement.



6.2f Stimulus Generalization and Discrimination

Generalization Process by which an organism responds to stimuli that are similar to the conditioned stimulus, without undergoing conditioning for each similar stimulus

Discrimination In Pavlovian and operant conditioning, the process by which responses are restricted to specific stimuli—In social psychology, the behavioral consequence of prejudice in which one group is treated differently from another group

Second-Order Conditioning A learned association between two conditioned stimuli (CS_2–CS_1) that can occur following conditioning to CS_1 and an unconditioned stimulus (US)

When a response has been conditioned to a particular stimulus, other stimuli may also produce the same response. For example, a war veteran who has been conditioned to dive for cover at the sound of gunfire may show the same response at the sound of a car backfiring. The more similar a new stimulus is to the original CS, the more likely it is to elicit the CR.

When people and other animals respond to similar stimuli without undergoing training for each specific stimulus, it is referred to as stimulus **generalization**. For example, Pavlov's dogs may have salivated to a variety of similar bell sounds or our biology student may experience anxiety when confronted with other smells similar to the anesthetic used during her surgery; and we hope the bears associate pain with all humans, not just the rangers who administered the shocks.

Just as a learned response may generalize to similar situations, it may also be restricted through the process of **discrimination**. Early in the conditioning process, stimulus generalization may cause a learner to respond to a variety of similar stimuli. With time, however, he or she learns that only one of these stimuli, the CS, is consistently associated with the UCS. Once the learner discriminates between stimuli, he or she responds only to the CS. For example, if the war veteran experienced a variety of jarring loud noises without the accompaniment of bullets whizzing through the air, he would soon learn to discriminate between noises like a car backfiring and a gunshot.

6.2g Second-Order Conditioning

We have seen that through Pavlovian conditioning, an organism learns to respond to a previously neutral stimulus, the CS, in a similar way as to the UCS. You might wonder whether the process can be carried one step further. With its newly acquired level, can the CS now be used to condition a response to other stimuli?

The answer is yes. For example, if a salient tone (CS_1) is repeatedly paired with a mild shock (UCS), the tone will come to elicit fear (the CR). Now if a light (CS_2) is paired with the tone (CS_1) for several trials, it will elicit a fear response when presented alone. This process is called **second-order conditioning** (see Figure 6-6). In second-order conditioning, a conditioned stimulus (CS) serves as an unconditioned stimulus (UCS) for the conditioning of a second association.

Second-order conditioning can greatly extend the impact of Pavlovian conditioning on our lives. We have a virtually unlimited capacity to make associations between events. This ability is one reason why therapists treating such things as Pavlovian conditioned phobias often trace convoluted processes by which everyday stimuli come to produce an unreasonable fear in a person (Domjan, 2010).

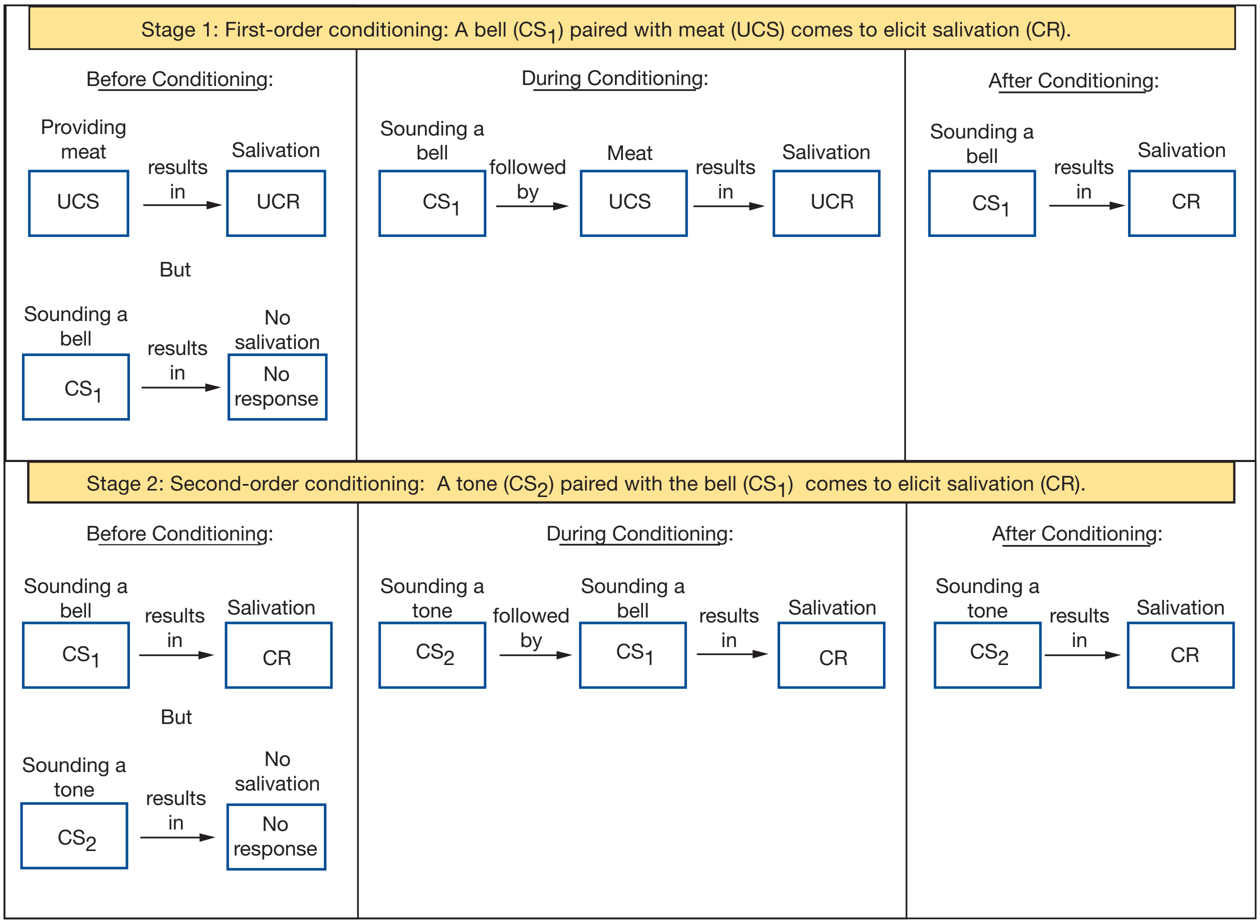
We have seen that Pavlovian conditioning is a form of associative learning that accounts for certain types of behaviors. However, Pavlovian conditioning does not explain all forms of learning. It is clearly involved in the learning of emotional and motivational states, but it does not by itself account for why you are diligently (we hope) reading this textbook. What is the UCS that automatically causes you to study? Obviously, there is none. To learn why you study and why you engage in a host of other voluntary behaviors, we must examine the second kind of associative learning, operant conditioning.

6.3 Operant Conditioning

Operant conditioning takes place when behavior is influenced by its consequences. We can trace the identification of operant conditioning to the American psychologist

Figure 6-6 Second-Order Conditioning

In Stage 1, before conditioning; sounding the bell (CS) does not elicit salivation (the CR). During conditioning, the CS_1 (bell) is paired with the UCS (food), which leads to conditioned salivation (the CR). In Stage 2, before conditioning, a tone (CS_2) does not elicit a response. During conditioning, a tone (CS_2) is paired with the bell (CS_1). After conditioning the tone (CS_2) will elicit a conditioned response.



Edward Thorndike (1911). At about the same time that Pavlov was investigating involuntary, reflexive responses, Thorndike was analyzing the effects of stimuli on voluntary, operant behavior.

Thorndike believed that animals learn to make voluntary responses that help them adapt to their environments. To test his theory, he designed a device called a puzzle box. He placed hungry cats in wooden boxes latched from the inside. Outside he dangled a piece of fish in full view. The cats howled, meowed, clawed, and frantically explored in their attempts to get out of the box. Eventually, they accidentally tripped the latch and gained access to the food. The next time the cats found themselves inside the box, they repeated some of the same trial-and-error behavior as before, but they generally took less time to escape from the box. With each additional trial, the cats' actions became less variable until they learned to trip the latch immediately (Thorndike E., 1898).

Law of Effect Behavior followed by reinforcement will be strengthened while behavior followed by punishment will be weakened (theory originally proposed by Edward Thorndike that is the foundation of the operant conditioning theory)

Thorndike explained his results by suggesting that behavior will be strengthened if it is followed by a positive consequence. Alternatively, behavior that does not lead to a satisfying consequence will be eliminated. Thus some of the cats' behaviors, such as clawing at the walls and howling, ceased to occur because they did not produce food. On the other hand, the latch-tripping behavior was strengthened because it produced fish. On the basis of these observations, Thorndike formulated the **Law of Effect**, which held that behavior followed by a satisfying consequence (effect) would be strengthened. This law, although considerably modified over the years, is the underlying foundation of operant conditioning.

Thorndike's puzzle box illustrates why the term *operant* has been applied to this type of learning. His cats learned to *operate* on their environment in a manner that resulted in satisfaction. Another way of saying the same thing is that their behaviors were instrumental in achieving a positive outcome. Thus, this conditioning model is sometimes called *instrumental conditioning*.

Thorndike's pioneering efforts were followed by the monumental contributions of Harvard psychologist B. F. Skinner. Skinner's research spanned several decades, and it provided much of what we know about operant conditioning. Perhaps the best way to become acquainted with the principles governing operant conditioning is to take a close look at one of Skinner's basic demonstrations.

(Wikimedia Commons)

B. F. Skinner (1904–1990), founder of behavior analysis.

6.3a Operant Conditioning in a Skinner Box

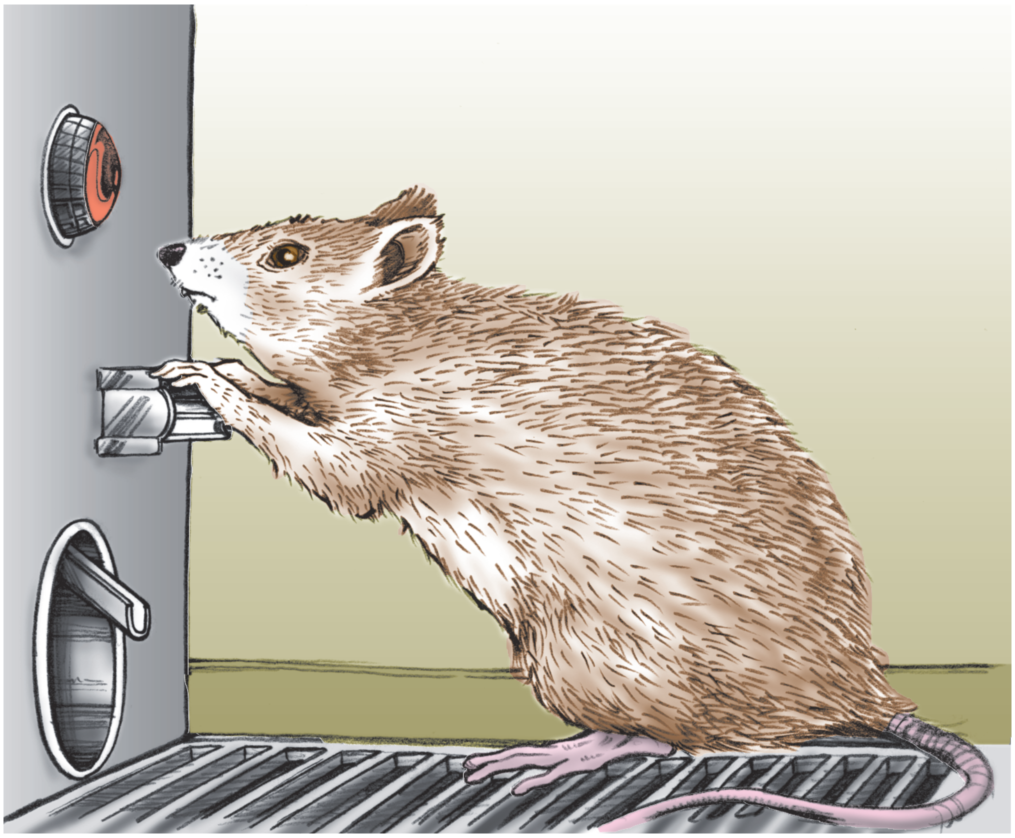
A hungry rat is placed in a box similar to that shown in Figure 6-7. This chamber, called a *Skinner box*, is empty except for a bar protruding from one wall with a small food dish directly beneath it.

After a short time in a Skinner box, the rat begins to examine its surroundings. As it explores, it eventually approaches the bar. When the rat is near the bar, a food pellet is released into the dish. The next bar approach followed immediately by food delivery occurs after some additional exploration. Soon the rat spends most of its time around the bar. Next the rat must contact and exert some force on the bar before food is delivered. As with approaching the bar, this activity soon comes to predominate. The operant response of bar pressing is "selected" by the food it produces, and the rate of pressing steadily increases.

Response Strength or Response Selection?

The concept of selection needs more elaboration because it is a part of Thorndike's original Law of Effect that has been changed considerably. Thorndike thought that reinforcement strengthened bonds or associations between behavior and the reinforcer—thus the term reinforcement. Currently psychologists view the reinforcement process as one of selection. That is, reinforcement acts to select or guide behavior (Skinner, 1981). The rat in Skinner's box spends most of its time pressing the lever not because the association between lever pressing and food was strengthened but because it is the effective response and the other ineffective responses have dropped out. A statement made by Michelangelo when asked how he produced such marvelous statues illustrates this idea: He stated that he simply removed that part of the stone that was not the statue. The concept of selection as used here shares many features with the term natural selection. While natural selection is viewed as operating over successive generations, response selection operates over the lifetime of the individual. Both result in adaptations to environmental changes.

Figure 6-7 A Skinner Box Used for Operant Conditioning



Measuring Operant Behavior

Perhaps the most common measure of operant behavior is its rate of occurrence. Skinner designed a device called a cumulative recorder that is used to measure operant behavior in a laboratory environment. A recording pen rests on paper that moves slowly at a fixed rate. Each time an animal makes an operant response, such as pressing a bar, the pen moves up a fixed distance and then continues on its horizontal path. The more frequently an animal responds, the more rapidly the pen climbs up the chart. The result, called a **cumulative record**, is a reliable measure of operant behavior.

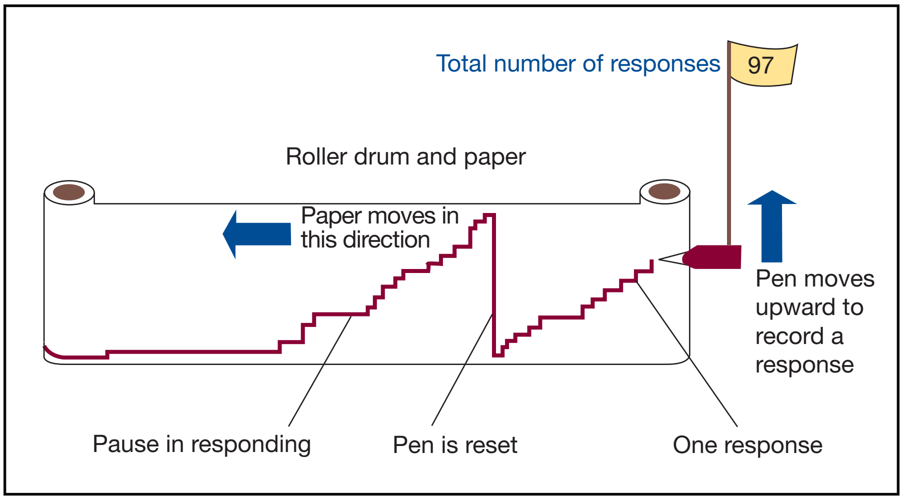
Cumulative Record A chart recording of operant responses over time—time increment is indicated along the horizontal axis (as response rate increases the slope of the record increases)

Discriminative Stimulus In operant conditioning, a stimulus that controls a response by signaling the availability of reinforcement

Discriminative Stimuli

You may have wondered about the light above the bar. Skinner used it to introduce a new variable, setting the dispenser to deliver food only when both the bar is pressed and the light is on. When the light is off, no food is delivered. Under these conditions of *differential reinforcement* (that is, reinforcement which takes place only under certain circumstances), the rat soon learns to make the appropriate discrimination: It presses the bar only when the light is on. In this circumstance, the light serves as a **discriminative stimulus**, that is, a stimulus that controls the response by signaling the availability of reinforcement.

Figure 6-8 A Cumulative Record



Skinner's experiments illustrate the primary features of operant conditioning. An animal's behavior is selected or controlled by the immediate consequences of that behavior. For Skinner's rats, bar pressing was controlled by the delivery of food. Unlike Pavlovian conditioning, in which the learner passively responds to a stimulus, operant conditioning occurs when the learner acts on the environment as a result of the consequences for that act. Sometimes response consequences are quite apparent as with Skinner's example. However, consequences may be much more subtle such as an approving nod by a parent for acting politely or a change in facial expression by a friend for a compliment.

6.3b Reinforcement

Reinforcement In operant conditioning, any procedure where an event following a specific response increases the probability that the response will occur

Positive Reinforcement In operant conditioning, any stimulus presented after a response that increases the probability of the response

Negative Reinforcement In operant conditioning, any stimulus that increases the probability of a response through its removal (for example, pounding on the wall (operant behavior) may be maintained by the termination of loud noise (negative reinforcer) in an adjoining room)

Operant conditioning stresses the effects of consequences on behavior. These consequences are described as reinforcement (or a reinforcer) and punishment (or a punisher). **Reinforcement** is defined as a stimulus whose delivery following a response leads to an increase in either the frequency or probability of that response. Punishment, on the other hand, is defined as a stimulus whose delivery following a response results in a decrease in the frequency or probability of that response. We shall first examine procedures used to study the effects of reinforcement, and then we will discuss punishment.

In studying operant conditioning, researchers have experimented with different types of reinforcers and different schedules for delivering reinforcement. Their findings help to explain how and why operant conditioning takes place.

Positive and Negative Reinforcement

Positive reinforcement is any stimulus presented following a response that increases the probability of the response. **Negative reinforcement** is a stimulus that increases the probability of a response through its removal when the desired response is made. Introductory psychology students frequently misunderstand negative reinforcement;

often confusing it with punishment by assuming that it is used to stop a behavior. In fact, quite the opposite is true: Negative reinforcement, like positive reinforcement, increases the occurrence of a desired behavior. It is important to remember that the terms positive and negative refer only to whether a stimulus is presented (positive) or removed (negative), not its hedonic value. Since the previous examples in this chapter have illustrated positive reinforcement, we look here at some examples of negative reinforcement and the procedures used to study them (Domjan, 2010).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People who live in western Oregon are accustomed to carrying umbrellas. Out-of-staters learn to always have one on hand on a cloudy day (avoidance conditioning). Much of human behavior is maintained by avoidance conditioning.

Escape and Avoidance Procedures

A rat is placed in a Skinner box, the floor of which consists of a metal grid that can be electrified. A mild current is activated. As the rat tries to escape, it bumps into a bar, and the shocking current immediately ceases. The pattern is repeated several times until the rat remains poised by the bar, ready to press it at the first jolt. This form of learning, called **escape conditioning**, clearly involves negative reinforcement. The shock, an unpleasant stimulus, may be terminated only by the appropriate operant response. The removal of, or the escape from, the shock thus acts as the reinforcer for the bar press response. Taking aspirin to alleviate headache pain is essentially escape behavior maintained by the termination of the headache.

The escape conditioning procedure can be modified slightly by introducing a warning signal which allows the rat to avoid the shock altogether. If the light goes on a few seconds prior to each shock, the rat soon learns to respond to this discriminative stimulus by pressing the bar in time to avoid the shock. This type of learning is called **avoidance conditioning**.

These examples bring to mind many parallels in our own lives. For instance, if you live in a dormitory or an apartment building, you may find that you pound on the wall of an adjoining room to get your noisy neighbor to quiet down. Your pounding behavior is thus maintained by negative reinforcement, the removal of the noise. People who live in western Oregon are accustomed to carrying umbrellas. Out-of-staters or optimistic natives have had to experience getting drenched while running back to fetch an umbrella (escape conditioning) before learning to have one always on hand on a cloudy day (avoidance conditioning). Much of human behavior is maintained by avoidance conditioning. In fact, our punitive legal system is a set of aversive consequences established to keep us in line. As long as we behave lawfully, we avoid these aversive consequences. You may attend your classes not because of positive reinforcement but to avoid the aversive consequences of failing exams. We pay taxes promptly to avoid the aversive consequences of not paying them on time, and we obtain a flu shot to avoid the consequences of getting the flu.

Escape Conditioning In operant conditioning, learning that takes place when an organism performs a response that will terminate an aversive stimulus

Avoidance Conditioning In operant conditioning, the learning of a response to a discriminative stimulus that allows an organism to avoid exposure to an aversive stimulus

Primary Reinforcer In operant conditioning, a stimulus that satisfies a biologically based drive or need (such as hunger, thirst, or sleep)

Primary and Conditioned Reinforcers

Primary reinforcers usually satisfy a biologically based need, such as hunger, thirst, sex, or sleep. However, some social events like parental contact may be primary reinforcers. It is obvious why food, water, sex, or sleep reinforce. However, why do things like money reinforce? The answer lies in the concept of conditioned reinforcement. A variety

Conditioned Reinforcer A stimulus that takes on reinforcing properties after being associated with a primary reinforcer

Continuous Reinforcement Schedule In operant conditioning, the presentation of a reinforcer for each occurrence of a specific behavior

Partial Reinforcement Schedule In operant conditioning, a schedule that reinforces behavior only part of the time, for example, a ratio or interval schedule

Partial Reinforcement Effect Behaviors that are acquired on partial instead of continuous reinforcement schedules tend to be established more slowly, but are more persistent when no reinforcement is provided

of neutral stimuli associated with primary reinforcement can also become **conditioned reinforcers**. Much of our behavior is influenced more by conditioned reinforcement than by biologically significant primary reinforcement. Words of praise, pats on the back, good grades, and money are some of the conditioned reinforcers that influence our lives.

We have seen that conditioned reinforcers acquire their reinforcing properties through association with a primary reinforcer, but what is the critical element that determines this association? For many years, psychologists believed that the strength of conditioned reinforcement depended simply on the frequency with which it had been paired with primary reinforcement (Domjan, 2010).

Research suggests otherwise. Instead of the frequency of pairings, the crucial factor seems to be the reliability with which the conditioned reinforcer predicts the availability of the primary reinforcer (Rose & Fantino, 1978). For example, a coin that always produces raisins when inserted in a chimp-o-mat quickly becomes a strong conditioned reinforcer; coins that are less predictive of raisins are much weaker conditioned reinforcers for the chimp, no matter how often they have been paired with raisins. Thus, conditioned reinforcers acquire their reinforcing properties just like Pavlovian conditioned stimuli: Through stimulus associations. Money is a powerful conditioned reinforcer for most of us because of its strong association with things we want.

Continuous versus Partial Reinforcement

In addition to the type of reinforcer used, another factor that influences the effectiveness of reinforcement is the consistency with which a behavior is reinforced.

In laboratory demonstrations of operant conditioning, a behavior may be reinforced every time it occurs. This method is called a **continuous reinforcement schedule**. For instance, a rat receives a food pellet each time it presses a bar. Outside the laboratory, particularly in the everyday lives of humans, continuous reinforcement is unusual. For example, smiling at the food server in your college cafeteria does not always produce an extra-large helping of food, nor does getting out of the house twenty minutes early always ensure your favorite parking space on campus. These behaviors persist, however, because they are sometimes reinforced. A **partial reinforcement schedule** exists when behavior is reinforced only part of the time. There are striking differences between the effects of continuous and partial reinforcement schedules on behavior.

Continuous reinforcement schedules almost always produce the highest rate of acquisition of a new behavior. For example, a rat learns to bar-press most rapidly when it receives food each time it makes the appropriate response. However, what happens when reinforcement is withdrawn? Extinction begins, and the rat quickly ceases its bar-pressing behavior.

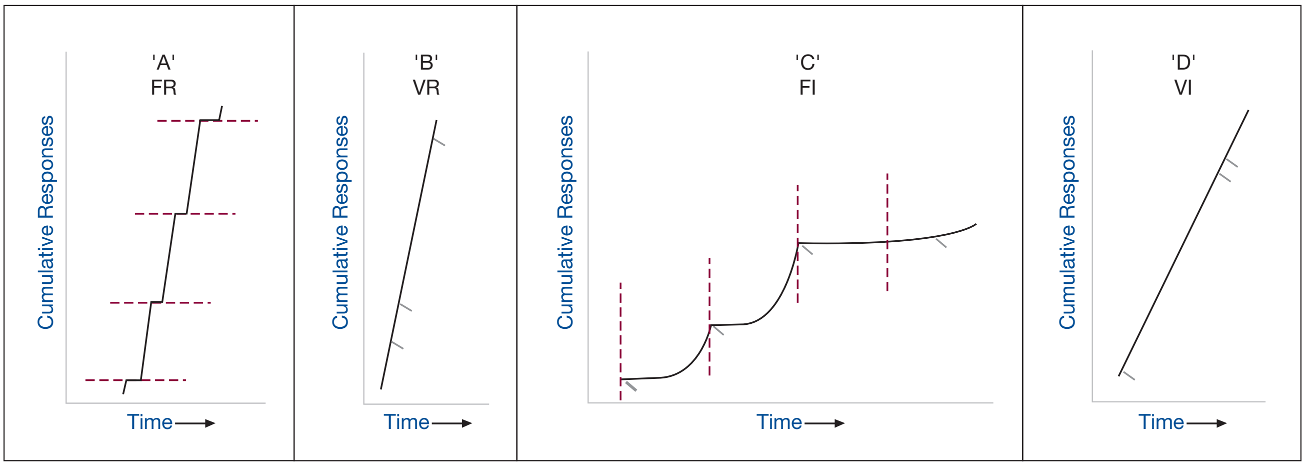
Behaviors that are acquired on partial instead of continuous schedules of reinforcement are slower to be established. However, these behaviors are remarkably more persistent when no reinforcement is provided. For example, a rat accustomed to only intermittent reinforcement for bar pressing continues to press long after the food dispenser has run dry. This is particularly true when the partial reinforcement is delivered in an unpredictable fashion. This phenomenon is known as the **partial reinforcement effect** (Domjan, 2010).

Partial Reinforcement Schedules

Partial reinforcement is typically delivered in either of two basic ways—ratio or interval schedules. On a *ratio schedule*, a certain percentage of responses receive reinforcement. For instance, a slot machine in a casino might be programmed to provide some kind of payoff on 10 percent of all plays. An *interval schedule*, in contrast, is time-based: Subjects

Figure 6-9 Schedules of Reinforcement

Stylized cumulative records from several common schedules of reinforcement: Panel A shows a fixed ratio schedule with characteristic pauses in responding; panel B illustrates a variable ratio schedule with typical high response rates; panel C illustrates the scalloped pattern of responding observed on fixed interval schedules; and panel D shows the stable pattern of responding found on variable interval schedules.



are reinforced for their first response after a certain amount of time has passed, regardless of how many responses might occur during that period. An example of an interval schedule is finally getting to speak to your friend after repeated dialing of her phone number resulted in busy signals, or cruising in a parking lot for a vacant space. In many natural environments, an animal's foraging is maintained by an interval schedule. Birds searching for food find it after the passage of variable amounts of time, not after a specific number of attempts.

Both ratio and interval schedules may be either variable or fixed. *Variable schedule* reinforcement is delivered unpredictably, with the amount of time or number of responses required varying randomly around an average. In contrast, *fixed schedule* reinforcement is always delivered after a constant number of responses or a fixed interval of time. These categories combine to form four basic partial reinforcement schedules: fixed ratio, variable ratio, fixed interval, and variable interval (see Figure 6-9).

Fixed Ratio Schedule

On a **fixed ratio (FR) schedule**, reinforcement occurs after a fixed number of responses. For example, a rat receives a food pellet after twelve bar presses, and a strawberry picker receives $1 after filling twelve small boxes with berries. Both are on an FR-12 schedule. This schedule tends to produce rather high rates of responding. The faster the rat bar-presses, the more pellets it gets; and the quicker the strawberry picker works, the more money she or he earns. Fixed ratio schedules are also used in programmed instruction where students proceed at their own pace and receive feedback after each section of work is completed. Programmed instruction is often quite successful in generating high rates of academic work (Lee & Belfiore, 1997). The fixed ratio schedule is illustrated in Panel A of Figure 6-9.

This fact explains why some factories and businesses pay workers (like the strawberry picker) on a piecework basis. However, there are some limitations to this practice.

Fixed Ratio (FR) Schedule
Partial reinforcement schedule in operant conditioning wherein reinforcement occurs after a fixed number of responses

Variable Ratio (VR) Schedule Partial reinforcement schedule in operant conditioning where reinforcement is provided after an average of a specific number of responses occur

Fixed Interval (FI) Schedule Partial reinforcement schedule in operant conditioning wherein reinforcement is provided for the first response after a specified period of time has elapsed

Variable Interval (VI) Schedule Partial reinforcement schedule in operant conditioning where opportunities for reinforcement occur at variable time intervals

For example, if workers in an automobile assembly plant were paid only according to the number of cars they ran through the assembly line, the quality of their work might suffer. Another potential limitation of the fixed ratio schedule is that people and other animals often pause briefly after reinforcement is delivered, probably because they have learned that their next few responses will not be reinforced. The pause following reinforcement on a fixed ratio schedule is termed *post-reinforcement pause*. Post-reinforcement pause may be one reason why payday typically occurs on Friday.

Variable Ratio Schedule

A **variable ratio (VR) schedule** of reinforcement also requires the occurrence of a certain number of responses before reinforcement is delivered. Unlike a fixed ratio schedule, however, the number of responses required for each reinforcer varies. For example, a rat on a VR-6 schedule receives a food pellet on the average of every six bar presses, but any given reinforcer may require fewer or more than six responses. The pattern of behavior maintained by a VR schedule is illustrated in Panel B of Figure 6.9.

Variable ratio schedules produce high response rates. Furthermore, because of the unpredictable nature of reinforcement, there is typically no post-reinforcement pause; it is possible that reinforcement will occur on the very next response. Behavior that is maintained on this schedule is often very slow to extinguish.

Gamblers are very familiar with variable ratio schedules. For example, a person who always bets on 13 at the roulette wheel is on a VR-38 schedule (the wheel has thirty-six numbers plus 0 and 00). On the average, 13 comes up every thirty-eight spins. However, during a hot streak 13 might occur three times in twenty spins (of course, it also might not occur at all). Similarly, a slot machine may be rigged to pay off once every twenty times a coin is deposited, on the average (a VR-20 schedule). The gambler does not know when it will return a few of the coins it has swallowed. It is the unpredictable, highly variable nature of these payoffs that makes gambling so compelling to some people (Haw, 2008). In fact, gamblers often put in much more than they get back—a result that doesn't occur on interval schedules. Experimental animals also show the tendency to respond at very high rates on VR schedules, sometimes at the cost of forgoing the food they've earned on previous ratios.


(Shutterstock)

A woman rubs off lottery tickets. Gamblers do not know when the lottery tickets will pay off. Their gambling behavior is maintained by a variable ratio schedule of reinforcement.

Fixed Interval Schedule

On a **fixed interval (FI) schedule**, reinforcement is provided for the first response after a specified period of time has elapsed. For example, a rat on an FI-30 schedule, whose bar press has just produced a food pellet, will receive its next reinforcer the first time it bar-presses after thirty seconds have elapsed.

The response rates of animals on FI schedules quickly adjust to this contingency. Because no reinforcements occur for a period of time, no matter how often an animal responds, it typically stops working after reinforcement is delivered and then begins to respond toward the end of the interval. Thus this pattern of reinforcement tends to produce regular, recurring episodes of inactivity followed by short bursts of responding. This is illustrated in Panel C of Figure 6-9.

Variable Interval Schedule

Finally, a **variable interval (VI) schedule** involves variable time intervals between opportunities for reinforcement. Thus an animal on a VI-45 schedule might receive reinforcement for a response after thirty seconds have elapsed, then after sixty seconds, and then after forty-five seconds. This schedule averages out to reinforcement every forty-five seconds. See Panel D of Figure 6-9.

As you might guess, the random, unpredictable occurrence of reinforcement on this schedule tends to produce more steady rates of responding than fixed interval schedules. The steady persistent pattern of behavior maintained by VI schedules makes them quite useful to researchers studying the effects of other variables on behavior. For example, a researcher interested in examining the effects of certain drugs on behavior might examine the pattern of responding on a VI schedule both before and after drug administration.

BVT *Lab*

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Applying Reinforcement Schedules

We have seen that partial reinforcement affects behavior differently from continuous reinforcement and that reinforcement schedules may further influence performance. What are the practical implications of these findings?

An Application of Reinforcement Schedules

Assume that you are the parent of a young boy who has not yet learned to clean his room each day. What type of reinforcement schedule(s) would be most effective in establishing room-cleaning behaviors? Would you use the same schedule throughout training? Think about these questions before reading on.

The best way to establish a daily room-cleaning routine would be to use a continuous reinforcement schedule. During the initial stages of training you would reinforce your son each time he completed his task, perhaps with points that could either be turned in for little payoffs (like reading a story) or accumulated for more sizable prizes like a trip to the zoo. It would also be important to praise the boy for each good job and perhaps display a chart of the child's performance. Associating the chart and praise with other reinforcers allows them to become conditioned reinforcers.

You cannot monitor and reinforce this behavior indefinitely, however. Once the room-cleaning behavior is established, you could begin shifting to a partial reinforcement schedule, reinforcing the behavior only some of the time. A variable ratio schedule would be the logical choice since it is very resistant to extinction and it is response, not time dependent. Gradually, you would make the schedule more demanding until just a few words of praise delivered now and then would be sufficient.

Partial reinforcement can be a good way to maintain a child's room cleaning, but it may contribute to less desirable behavior in some circumstances. Consider the case in which a father tells his young daughter that she cannot leave their yard unless accompanied by an adult. Since children typically test the limits, the little girl sneaks over to her friend's house at the first opportunity, a lapse that the father overlooks because he is too busy. In this manner, a pattern of inconsistency is established, with the child discovering she can get away with inappropriate behavior at least some of the time. These unpredictable victories over the system can be powerfully reinforcing. In essence, parents who inconsistently enforce rules are training their children to be gamblers. Like Atlantic City slot machine players, these children are conditioned to keep pushing the button until the inevitable payoff is provided.

The reinforcement schedules we have been discussing share a common assumption: The learner will produce the desired behavior so that it can be reinforced. In operant conditioning, however, it is sometimes difficult to get an animal (humans included) to make the initial correct response so that it can be reinforced. The next section discusses methods for increasing the probability that a desired response will occur.

6.3c Reinforcing the Initial Operant Response

Shaping In operant conditioning, a technique in which responses that are increasingly similar to the desired behavior are reinforced, step by step, until the desired behavior occurs

In operant conditioning, many responses occur spontaneously. For example, rats placed in Skinner boxes invariably get around to pressing the bar during the course of their explorations. In other circumstances, however, the behavior may not occur without some additional help. For instance, no matter how many times you say "roll over" to your untrained dog, the odds are remote that it will perform the trick so that you can reinforce it. Some special techniques can be used to encourage the desired response, however.

Verbal Instruction

Sometimes desired behavior could be established by simply describing the appropriate response. Parents and educators often use this method. When you learned to drive, most of your instruction was probably verbal: Someone sat next to you and told you when to turn, brake, and accelerate. Verbal instruction is also provided in writing. Perhaps you first learned to operate a computer from a set of instruction manuals.

Shaping

You may have wondered how researchers trained rats to press levers in several of the experiments already discussed in this chapter. The procedure used is referred to as shaping. **Shaping** involves a systematic process whereby responses that are increasingly similar to the desired behavior are reinforced step by step until finally the desired behavior occurs. For example, hungry rats are first reinforced for being near the lever. Later they must touch it, and finally they are required to exert sufficient force on the lever to operate it.

Shaping is especially effective for establishing novel behaviors. For instance, the learning of speech by a young child is shaped from nonsensical babbling to closer and closer approximations of the appropriate sounds of words. The reinforcement during this process may be as subtle as a change in facial expression of the parent. Later, reinforcement may be the appropriate response of the listener to a command.

Many therapists use shaping to obtain desirable behavior in emotionally disturbed children and adults. An example of this is the case of a nine-year-old boy with autism, a profound emotional disability that blocks normal patterns of social interaction. His parents consulted a behavior therapist, who used shaping to establish social behavior. At first the boy learned to obtain candy from a machine that was activated remotely. (Since no social pressures were imposed, this procedure was nonthreatening.) The next step was more complex. The boy was placed in a room that contained a variety of toys, the candy machine, and another boy about his age, a confederate of the therapist. The ensuing behavior was viewed through a one-way glass.


(Shutterstock)

Modeling involves demonstrating the desired behavior to the learner. Many athletic skills, such as diving, hitting a tennis ball, or skateboarding, are more easily learned by watching someone else.

The disturbed youth made no overtures to the other boy. However, each time he looked at him, the therapist activated the candy dispenser. Once this behavior was established, the next step was to reinforce the boy when he took a step toward the other boy. In this fashion the autistic boy gradually learned to stand next to his would-be playmate and then to interact with him. (Even a normally undesirable act like grabbing a toy from him was acceptable at first because it represented an interaction.) Gradually, over a period of weeks, a number of social behaviors were shaped, and eventually the candy machine became a less important reinforcer than the other boy. Shaping is commonly used to teach autistic children a variety of new behaviors as well as to enhance their social skills (Noell, Call, Ardoin, & Fisher, 2011).

Modeling Learning process wherein an individual acquires a behavior by observing someone else performing that behavior (also known as observational learning)

Punishment A procedure in which the presentation of a stimulus following a response leads to a decrease in the strength or frequency of the response

Modeling

Another technique for producing a new operant response is through modeling. **Modeling** involves demonstrating the desired behavior to the learner. Many athletic skills, such as diving, hitting a tennis ball, or riding a skateboard, are more easily learned by watching someone else or watching your own performance on video. Videotape has been successfully used with both adults and children to model a variety of skills including reading (Dowrick P. W., 1999; Dowrick, Kim-Rupnow, & Power, 2006). Modeling can teach a wide range of behaviors, undesirable as well as desirable. For instance, a young child who observes a parent using physical punishment may behave more aggressively, even when punished for it.

Physical Guidance

The best strategy for training a dog to roll over is to guide compliance to the command by gently manipulating the animal. As the dog scrambles back on its feet, you can then provide a reinforcer such as a piece of meat or a pat on the head. After several sequences of command, manipulation, and reinforcement, the animal should begin to roll over on command without any manipulation.

This same technique might be used to train a child to drink from a cup. A parent's hand over a child's hand holding a cup can guide the child through the appropriate sequence of lifting the cup to the mouth. Each response is then reinforced by both the parent's praise and the act of drinking (it is a good idea to offer an especially tasty liquid in this initial training).

So far we've discussed the application of reinforcement to shape and increase rates of behavior; now we turn our attention to the use of punishment. From the very earliest experimental studies, its use and effectiveness have been controversial; however, because punishment is so frequently applied as a learning procedure, it deserves our careful consideration here.

6.3d Punishment and Operant Behavior

Certainly punishment is widespread—from spanking misbehaving children to keeping students after school, meting out traffic fines, and incarcerating people in prisons. However, the fact that many people and institutions rely on punishment to control behavior does not necessarily mean that it is more effective than reinforcement. People have long debated the relative advantages and disadvantages of reinforcing desirable behavior versus punishing undesirable acts. There is no simple answer. Nevertheless, research has provided ample data that can help us make better informed choices as we confront this issue in our own lives. We begin by defining punishment.

Punishment (or a *punisher*) is defined as a stimulus whose delivery following a response results in a decrease in the frequency or probability of that response. We often think of punishment as an unpleasant or aversive stimulus, such as a spanking. However, punishment may also involve the withdrawal of positive reinforcers—such as playtime, watching TV, money, or the use of the family car. Students sometimes confuse this second form of punishment with the process of extinction discussed earlier. The two are quite different. For example, if we wished to stop a child's temper tantrums through extinction, we would simply withhold our attention (which presumably is the reinforcer of this behavior). In contrast, modifying this behavior through punishment might be accomplished by withdrawing TV-watching privileges each time a temper tantrum occurred.

6.3e Limitations of Punishment

Extinction of Punished Responses

One limitation of punishment is its long-term effectiveness. In some cases, punishment suppresses the unwanted behavior for a short time, but does not eliminate it. In fact, there is ample evidence that suppressed behavior may reemerge when the prospect of punishment is gone or sharply curtailed. To eliminate a response with punishment, the contingency between the response and punishment must be maintained. When punishment is discontinued, the response emerges. This is referred to as *extinction* of punishment. This is also true for reinforcement. When either reinforcement or punishment is discontinued, responding returns to its pre-reinforcement or pre-punishment level (Domjan, 2010).

For example, a child who is punished by a parent each time she raids the cookie jar will probably learn to suppress this behavior. However, if punishment hasn't occurred for some time, she is likely to raid again.

Emotional Side Effects of Punishment

Another potential problem is that punishment may produce undesirable emotional side effects such as fear and aggression. This outcome is particularly true when punishment is severe. For example, a child who receives constant, severe punishment from a parent may learn to fear that parent. The process by which this fear response is learned is Pavlovian conditioning. In this case a parent who consistently punishes may become a conditioned stimulus for fear. The subject will learn to withhold the punished behavior but also learns to fear the punishing situation. This could lead to problems interacting with the parent that may generalize to other relationships. In fact, punishment may induce aggression against the punisher (Gershoff & Bitensky, 2007).

The negative emotional effects of punishment are often generalized to related behaviors. Thus, a child who is singled out for harsh punishment in one class may begin to react negatively to school in general. In contrast, people who are reinforced for desirable behavior generally feel good about themselves, are motivated to perform well, and are optimistic about future endeavors that they anticipate will lead to additional positive consequences. Similarly, the child who is punished by being sent to his or her room, having to write repeatedly on the chalkboard, or having to run extra laps on the track may actually be learning to associate these events and places with punishment and react negatively to them on later occasions.

Physical Punishment and Modeling

Children are often punished by physical means, such as slapping or spanking. Considerable evidence suggests that youngsters who are punished physically learn to model or imitate these aggressive acts and often become more aggressive in their interactions with others

(Bandura & Walters, 1959; Kuppens, Grietens, Onghena, & Michiels, 2009). Thus parents who spank or hit misbehaving children may be teaching them more than is intended, namely, that physical aggression is acceptable and that it typically gets the aggressor what they want.

6.3f Advantages of Punishment

While it is important to be aware of the limitations of punishment, most psychologists do not advocate total abolition of all punishment for controlling or modifying behavior. Although reinforcement is preferable in most cases, punishment is sometimes essential as a way to suppress undesirable actions so that a desirable alternative behavior may occur.

For instance, assume you are the parent of a young child who constantly strays out of your yard. To avoid establishing a pattern of partial reinforcement caused by inconsistent punishment, you might decide to wait until the day occurs when she stays home, so you can reinforce her. Theoretically, this idea is a good one. However, the behavior might not occur spontaneously, and in the meantime your child might get lost or hit by a car.

In other instances, punishment is desirable because reinforcement of an alternative behavior is impractical. For example, punishment may be the only practical method to train your dog to refrain from barking at night. The immediate and consistent application of punishment can be very effective here.

In such cases, it is necessary to apply sufficient punishment to suppress an unwanted behavior. At the same time, you would also reinforce the desired behavior with appropriate reinforcement.

Immediate Application of Punishment

Punishment, like reinforcement, works best when it immediately follows behavior. Perhaps one of the more common violators of this rule is the parent who says to a misbehaving child, "Wait until Dad (or Mom) comes home." This long delay dramatically reduces the effectiveness of punishment.

Sometimes, however, punishment cannot be delivered immediately. For instance, punishing a child who intentionally emits distracting noises during a church service would disrupt the service for everyone. In cases like this, it would be valuable to have established a verbal command such as "stop", as a conditioned punisher. Conditioned punishment is discussed below.

Consistent Application of Punishment

A second point that should be remembered in applying punishment is that it loses effectiveness if it is inconsistent. Inconsistencies may occur over time or from one person to another. In the first case, inappropriate behavior may be punished in one instance and ignored the next. As we noted earlier, such inconsistencies place the learner on a variable ratio schedule of reinforcement (not punishment), a practice that can produce remarkable persistence of undesirable behavior. The dog owner who only occasionally punishes his barking dog, or the parent who only punishes nagging inconsistently, may be doing just this.

Inconsistencies from person to person are quite common. Two parents often have differing concepts of discipline. Children in this type of home environment frequently learn to play one parent against the other, a situation that can teach the child to manipulate others for personal gain.

Intensity of Punishment

Punishment needs to be strong enough to accomplish the desired goal of suppressing undesirable behavior, but it should not be too severe. You probably know some people who believe that if a little bit of punishment works, a lot will work even better. Unfortunately, this philosophy often results in negative side effects such as fear and aggression. Moderate punishment, especially when it is designed to be informative, can redirect behavior so that new responses can be reinforced. When punishment is severe, however, the intent is more likely to be retribution than a redirection of behavior.

In most circumstances, physical punishment should be avoided. Instead of getting a spanking, a misbehaving child could be sent to a time-out room for five minutes. (A time-out room is a boring but safe place, such as a laundry room with nothing but a stool for the child to sit on.) Note that even this type of punishment can be overdone, however. Whereas five minutes is usually ample time for a young child to be alone in a time-out room, one or two hours is probably unreasonable.

Conditioned Punishment

As with reinforcement, stimuli associated with punishment can become powerful conditioned punishers when they reliably predict punishment. If the command NO reliably predicts a slap on the rear of your barking dog, the command alone on later occasions may be sufficient to suppress barking. However, the effects of a conditioned punisher, like a conditioned reinforcer, will extinguish if they are no longer occasionally paired with a primary punisher. The author used an electric shock collar occasionally to punish his dog for running away. Can you use what you have learned so far to describe an effective method for establishing a verbal command such as "No" as a conditioned punisher?

Conditioned punishers are established in the same way as conditioned reinforcers, and they can more easily be delivered immediately. To condition the command "No", it needs to be reliably paired with a primary punisher. Saying the command "No" as his dog begins to escape and following this with a brief shock has conditioned the dog to associate the command "No" with an aversive event. After a few pairings, the command can be delivered immediately and quite effectively. However, the effects of a conditioned punisher, like a conditioned reinforcer, will extinguish if they are no longer occasionally paired with a primary punisher (Domjan, 2010).

In all, it seems that punishment can be useful for modifying behavior under certain circumstances. When punishment is used, however, it should be applied in moderation and in combination with incentives for desirable behavior.

6.4 Comparing Pavlovian and Operant Conditioning

As we have seen, both Pavlovian and operant conditioning involve learning relationships or associations between two events. Pavlovian conditioning involves learning associations between a conditioned stimulus (CS) and an unconditioned stimulus (UCS). Operant conditioning involves learning associations between behavior and its consequences, reinforcement or punishment. Each learning process produces a change in response, whether it is the conditioned response of anxiety to medicinal smells or an operant response such as playing a video game. However, Pavlovian and operant conditioning involve very different procedures and result in different kinds of responses. These two differences will be examined more closely.

First, the procedures for Pavlovian and operant conditioning differ. In Pavlovian conditioning experiments the researcher typically presents two stimuli: A novel CS immediately preceding the UCS, which naturally elicits some response. After several paired presentations of these stimuli, the researcher can test for a conditioned response by presenting the CS alone. If learning occurred, the CS will now elicit a conditioned response. In operant conditioning experiments the researcher shapes a particular response by closely following approximations to that response with reinforcement. Learning has occurred when the new response is demonstrated.

Two-Factor Theory of Learning A theory of avoidance learning that involves both Pavlovian and operant conditioning

Second, and perhaps more important, the kinds of responses for operant and Pavlovian conditioning are different. Pavlovian conditioned responses are typically reflexive responses or changes in emotional or motivational states, not voluntary behavior. Salivation is not a voluntary response by dogs but rather a reflexive response, which occurs during and prior to the ingestion of food. The anxiety you may experience while waiting at your dentist's office is also a change in behavior, but it is emotional behavior, not a voluntary response. Operant responses on the other hand are typically voluntary responses such as lever pressing, riding a bicycle, verbal behavior, and covert behavior like thinking.

Although it is possible to dissociate Pavlovian and operant conditioning in the laboratory, rarely in nature is there so clean a distinction between the two processes. In fact, both are typically involved in the adaptive behavior of most animals, including people. Consider a squirrel foraging for nuts among several species of deciduous trees, some dropping nuts, others not. At first the behavior of the squirrel might appear somewhat random as it scrambles among the leaves under the different trees. When nuts are located under a leaf of a certain color and size, this increases the likelihood that similar color and shaped leaves will be approached and turned. Finally, the squirrel attends primarily to the leaves with nuts among them and no longer forages near the others. In this example, both Pavlovian and operant conditioning lead to the adaptive behavior of the squirrel. Pavlovian conditioning was involved in learning the association between leaves of a certain color and shape, and the nuts found under them. Operant behavior was involved in learning the association between approaching and turning these particular leaves and finding nuts. This is referred to as **two-factor learning**. Without both types of learning, the squirrel's foraging behavior would be far less successful.

6.4a Two-Factor Theory of Avoidance Learning

Many learning situations, like the example above, involve both Pavlovian and operant conditioning. Let us return to the case of avoidance learning demonstrated by the biology student, discussed earlier in this chapter. This example was originally presented to illustrate Pavlovian conditioning, and Pavlovian conditioning was most likely the first learning process that took place. Through pairing with the frightening experience at the hospital, the medicinal odors became the CS that triggered a fear response.

Operant conditioning also occurred, however. Since fear is unpleasant, any responses that reduce or eliminate fear are strengthened through negative reinforcement. When the young woman avoided the biology lab, she was operating on her environment to alleviate her fear. The student's avoidance behavior kept her far from the biology lab; and since she was never exposed to the laboratory long enough to find out that the UCS would not occur, her conditioned fear was maintained. Thus her avoidance behavior involved two factors: The first being the acquisition of conditioned fear to the medicinal odors (Pavlovian conditioning), the second being the operant avoidance response that was maintained by negative reinforcement (Domjan, 2010).

Many human phobias are products of two-factor learning. An understanding of the principles underlying this kind of conditioning provides a clue for treating such fear responses. In order to extinguish conditioned phobias, a person must be exposed to the CS in the absence of the UCS. To do this, the operant avoidance behavior must be prevented. One possible way to accomplish this would be initially to expose a relaxed subject to a very mild version of the feared stimulus (for example, a mildly medicinal odor in a nonthreatening situation). Gradually, more intense versions of the conditioned fear stimulus would be introduced. This technique, called systematic desensitization, is discussed in Chapter 16. Conditioned fear responses and anxiety are discussed in more detail in Chapter 15.

6.5 Cognitive Influences on Learning

To this point, we have focused on associative learning through either Pavlovian or operant conditioning. Many contemporary psychologists (including learning theorists) have argued that associative learning may provide too mechanistic an interpretation for all forms of learning. As conditioning was originally proposed by Pavlov, Thorndike, Skinner, and others, it did not take into account cognitive processes that cannot be observed. Another theoretical perspective, **cognitive learning theory**, attempts to identify the role that cognitive processes play in learning. Not all learning theorists agree that internal cognitive processes are necessary to account for learned behavior, however. As you read this final section, keep in mind that the examples discussed can also be explained without reference to cognitive processes.

As you might guess, cognitive theorists stress the individual's active participation in the learning process. They suggest that we learn by forming a cognitive structure in memory that preserves and organizes information pertaining to the key elements in a situation. Thus, in addition to forming conditioned associations between stimuli (Pavlovian conditioning) and behavior and reinforcement (operant conditioning), we form mental representations of our environments. These representations, along with external stimuli, guide behavior. Although learning is involved in the formation of these representations, the roles of Pavlovian and operant conditioning in the formation of internal representations are just beginning to be systematically explored (Fiser, 2009).

Cognitive learning theories did not become an important force in psychology until the late 1960s, but their roots go back many years. One important early influence was Edward Tolman's research on latent learning in rats.

6.5a Latent Learning

A fundamental principle of operant conditioning is that reinforcement is essential for learning new behavior. However, over fifty years ago psychologist Edward Tolman and his associates demonstrated that rats would learn a maze even when they were not reinforced. Tolman called this phenomenon **latent** (or hidden) **learning** because it is not demonstrated by an immediately observable change in behavior at the time of learning. Such learning typically occurs in the absence of a reinforcer, and it is not demonstrated until an appropriate reinforcement appears.

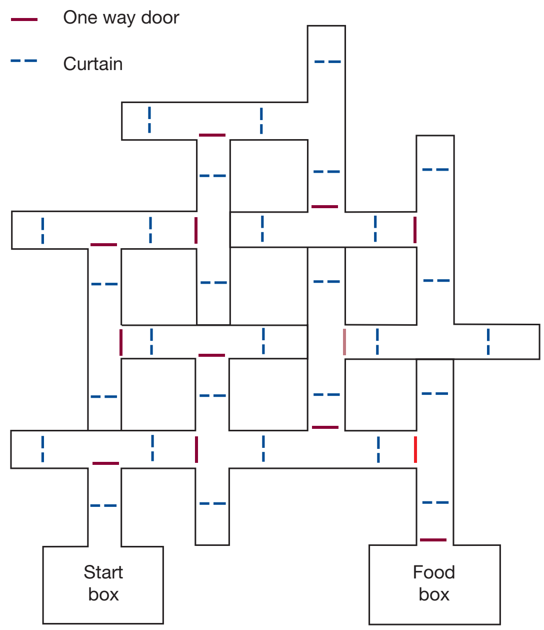
In a classic latent-learning experiment, three groups of rats were run for sixteen consecutive days in the complex maze shown in Figure 6-10. An error was recorded each time a rat entered a blind alley in the maze. Rats in one group, the reinforcement group, received food when they reached the goal box at the end of the maze on each of the sixteen days. A second group, the non-reinforcement group, also explored the maze each day; however, they did not receive food when they reached the end. Rats in a third group, the latent-learning group, received no reinforcement for the first ten days and then were reinforced for the remaining six days.

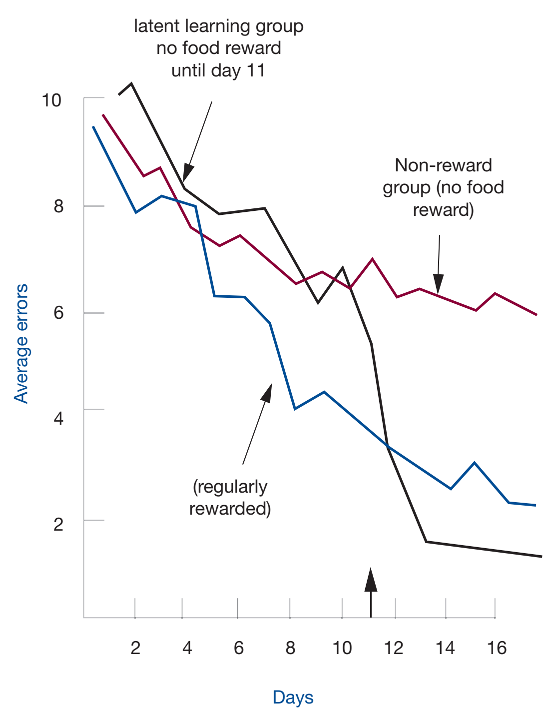
Cognitive Learning Theory Theoretical perspective that attempts to study the role of thinking and memory processes in learning

Latent Learning Learning that is not demonstrated by an immediately observable change in behavior

Figure 6-10 Classical Latent Learning Experiment

In Tolman's experiment, three groups of rats were run for 16 consecutive days in the maze shown in the top part of the figure. Results for the three groups are shown at figure bottom. Notice that the rats in the latent learning group (solid black line) that received rewards beginning on day 11 performed as well as rats that received rewards beginning on day one (solid blue line).





(Adapted from Tolman & Honzik, 1930.)

Cognitive Map Internal representation of the relationship between events or spatial elements

Over the first ten days, rats in the reinforcement group showed considerably more improvement than animals in either of the other groups. In fact, the animals in the nonreinforcement group showed very little improvement in performance over the entire sixteen days. However, after food was introduced on day 11 for rats in the latent-learning group, they immediately began to perform as well as animals in the reinforcement group. This occurrence clearly demonstrated that Tolman's rats were learning something about the maze even with no reinforcement (Tolman & Honzik, 1930).

This latent-learning experiment demonstrates the distinction between learning and performance, for learning can take place even when it is not demonstrated by performance. The experiment also poses a question: If no responses can be observed, what is being learned? Tolman answered this question by claiming that his rats were developing a **cognitive map**, or mental representation, of the maze in the absence of reinforcement. Later, when, reinforcement was introduced, the map allowed the animals to reach a high level of performance quickly.

Tolman and his associates conducted a number of additional experiments that demonstrated how cognitive maps work in problem solving. For example, once rats had learned how to get through a complex maze to reach food, obstructions were placed in their way and new routes introduced. Tolman suggested that these complications were quickly mastered because the rats were able to re-sort and rearrange the mental picture of the maze, and thereby find the new route with ease (Tolman, Ritchie, & Kalish, 1946).

Cognitive maps have become a very important concept in contemporary learning theory. Research suggests that a variety of organisms—including rats, chimpanzees, birds, and bees—use cognitive maps in adapting to their environments (Gould & Marler, 1987; Shettleworth, 1983). Humans also create mental representations of their environments that allow them to function more effectively. For instance, you can easily navigate your college campus and use shortcuts without ever having used them previously. To do this you rely on a cognitive map, a mental representation, of your campus.

6.5b Cognitive Processes in Learning

We have presented cognitive learning as separate from the associative types of learning, which is the traditional way of viewing learning. Pavlov, for instance, stressed that *temporal contiguity* (that is, closeness in time) of the CS and the UCS is essential for Pavlovian conditioning. Indeed, most learning theorists after Pavlov continued to view Pavlovian conditioning as a relatively automatic form of learning that is strengthened through repeated pairings of the CS and the UCS.

Recent evidence has caused some psychologists to question this view, however. According to their interpretation, cognitive processes are involved even in Pavlovian conditioning (Rescorla, 1988; Rescorla, 1988; Rescorla, 1999; Turkkan, 1989).

According to this cognitive perspective, the learner during Pavlovian conditioning first observes that the CS and UCS typically occur together and stores this information in memory. Later, when the CS appears by itself, the learner retrieves the information from memory; and the conditioned response occurs in anticipation that the UCS will occur. In other words, it appears that the CS and UCS become associated not simply because they occur contiguously in time but rather because the CS provides information about the UCS (Rescorla, 1987). Indeed this view is supported by Rescorla's experiment described earlier where he demonstrated that mere contiguity between a CS and UCS is not sufficient. Rather, it was stimulus contingency that was essential. Recent interpretations of Rescorla's experiments stress the importance of how much information the CS conveys about the UCS. That is, the more informative or predictive the CS, the better conditioning will be.

Studies of a phenomenon known as *blocking* also support this interpretation. In such experiments, subjects are exposed to repeated CS-UCS pairings (for example, a light with a shock). Later, after conditioning is established, a second stimulus (such as a tone) is added to the original CS so that both stimuli now occur prior to the UCS. According to Pavlov, the second stimulus should quickly become conditioned since it is regularly paired with the UCS. However, this outcome does not occur (Halas & Eberhardt, 1987; Kamin, 1969). Apparently, the previous conditioning of the response to the light somehow interferes with or blocks the tone from becoming an effective CS.

Learning theorists refer to the information concept to explain these results. They argue that since the original stimulus already predicts the occurrence of the UCS, the new stimulus is irrelevant because it provides no new information about the occurrence of the UCS. If the UCS is now changed in some way, for example its intensity is increased, learning will occur to the second CS (the tone) because now tone predicts larger shocks than did the light alone. Learning theorists believe that the predictability of the relationship between the CS and UCS is probably more important than either the timing or the frequency of pairings. We now know that CS-UCS pairings, while necessary for Pavlovian conditioning, are not sufficient by themselves to ensure that learning will occur.

Cognitive factors may be important in operant as well as Pavlovian conditioning. Although the operant conditioning emphasizes the consequences of behavior, those consequences do not automatically strengthen or weaken responses. Rather, they provide the learner with important information about the probable consequences of a given behavior under certain circumstances. Cognitive theorists view individuals as information-processing systems that store this relevant information about consequences. Later, when confronted by similar circumstances, the learner retrieves this information from memory and acts accordingly. Thus, from the cognitive perspective, operant behavior is guided by expectations of probable outcomes (Colwill & Rescorla, 1986; Rescorla, 1987; Rescorla, 1999; Williams, Buder, & Overmier, 1990).

The cognitive theorists stress the argument that events occurring in Pavlovian and operant conditioning do not automatically stamp in behavior. Instead, they provide relevant information that helps to establish expectancies, and it is these expectancies that form the basis for subsequent behavior.

6.5c Observational Learning

Much of human as well as other animal learning occurs by watching or listening to others. This is referred to as **observational learning**, and it involves both the Pavlovian and operant processes already discussed.

One of the major findings of observational-learning research is that children tend to behave in a manner similar to their parents, both during their childhood and later on in life. Thus child abuse and other maladaptive behaviors are often passed on from one generation to the next just as are warm, nurturing behaviors.

There are strong cognitive components in learning by observation. People observe the behaviors of others and then store cognitive representations of these acts in memory, where they remain until the right influence triggers the individual to enact that behavior.

The role of observation and imitation in learning is explained in **social learning theory**, and Albert Bandura (1977; Bandura A., 1992) of Stanford University is probably its leading proponent. Bandura and his colleagues have performed a number of studies that demonstrate the importance of observational learning in our lives. In one widely cited experiment, children observed adults beating on a five-foot inflated BoBo doll and were then placed in a similar situation. The researchers found that children who had observed this aggressive

Observational Learning
Learning process wherein an individual acquires a behavior by observing someone else performing that behavior. (also known as modeling)

Social Learning Theory
Theory that emphasizes the role of observation in learning

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behavior were more likely to act aggressively when placed in the same situation than did children in control conditions who had observed a quiet model (Bandura, Ross, & Ross, 1963).

Social learning theorists use the term *models* to describe the people whose behaviors we observe and often imitate. These models can range from parents (usually the most influential models in our lives) to people we see on television or in movies. Humans have a great capacity to store mental representations. In this fashion we learn from the examples of others.

Some of the behaviors we observe become part of our own behavioral repertoire, but we also observe many responses that we never imitate. (Watching another diner chew gum at an elegant restaurant, for instance, may cause you to resolve never to do such a thing.) Our brains process all these stored memories of previously observed behaviors, selecting out those that seem appropriate in a given situation. Once an observed behavior becomes part of our own response system, it becomes subject to the rules of reinforcement discussed earlier. In this fashion, imitative behaviors become either strengthened or weakened.

Bandura has identified four key steps in observational learning. The first is simply having our attention drawn to a modeled behavior. (As you recall modeling was already discussed as a procedure to produce an initial operant response.) Second, we store a mental representation of the behavior in our memories. Third, a specific type of situation triggers us to convert the remembered observation into actions. Finally, if our actions are reinforced, we add the behavior to our repertoire of responses.

Learning by observation, or modeling, can exert a powerful influence on our lives. Being able to learn by watching, listening, and even reading is extremely useful. Can you imagine how tedious it would be to acquire all our behaviors by trial and error or shaping? Modeling allows us to profit from the experiences of others. For example, in one study researchers tried a variety of strategies to increase the sociability of nursery school children who normally kept to themselves. The most effective strategy turned out to be to have these youngsters watch a film showing sociable children. The film was even a faster agent of social change than a shaping procedure that involved praising and paying attention to children when they behaved sociably.

Observational learning and modeling also contribute significantly to the problem of bears foraging in neighborhoods and campgrounds as described in the chapter opening. Cub bears that are reared in wild foraging environments remain in wild habitats for much of their adult lives. On the other hand, cub bears that forage with their mothers in human habitats continue this pattern well into adulthood (Mazur & Seher, 2008)

6.6 Biological Bases of Learning

You now appreciate that learning involves relatively permanent changes in the behavior of the learner. You may wonder what kinds of changes actually occur to represent this learning. Searching for these changes has been a long and exciting endeavor. As you will see, even though these findings have important implications for human learning, we have yet to observe the neuronal changes that represent learning in people.

Investigating the biological mechanisms of learning in humans, or even rats, is not practical at present because of the extremely large number of neurons involved. As you recall from Chapter 3, the human brain contains more than one hundred billion neurons. Thus researchers interested in the cellular changes that represent learning have focused on another species with a relatively simple nervous system. The species that has proven to be most valuable for this research is the Aplysia, a shell-less marine snail. The Aplysia has about twenty thousand neurons, many connections (synapses) of which have been well studied.

6.6a Pavlovian Conditioning of the Aplysia

Investigations by Eric Kandel of Pavlovian conditioning in Aplysia have focused on a protective reflex of the gill, which is the respiratory organ of the Aplysia (Kandel E., 1983). For instance, when the Aplysia is touched strongly on the tail or the siphon, the gill withdraws into the mantle. Refer to Figure 6-11 for a diagram of the Aplysia. Because this protective response is easily observed and occurs reliably, it is an ideal response for Pavlovian conditioning. To condition a gill withdrawal response, a mild touch (squirt of water) is applied to the siphon. This mild touch (the CS) by itself does not cause a gill withdrawal response. Immediately following the CS, a shock is applied to the tail (the UCS), and this does cause the gill to withdraw. After a number of paired CS-UCS (touch-shock) trials, the siphon squirt (CS) results in a conditioned gill withdrawal response (the CR).

What kinds of changes in the nervous system of the Aplysia mediate this conditioning? Kandel and others have recently identified several cellular changes that occur. The neurons involved are illustrated in Figures 6-11 and 6-12. When stimulated, the UCS neuron (the sensory neuron receiving shock) transmits a strong signal to the modulatory neuron, which in turn activates the motor neuron to cause the gill to withdraw.

In Figure 6-12 you can see that the modulatory neuron also has contact with the CS neuron (the sensory neuron receiving touch). Notice, however, that this synapse is at the end of the axon before its synapse with the motor neuron. If the CS neuron was recently active (because the CS was presented before the UCS), chemical events involving the neurotransmitter serotonin occur on both the presynaptic membrane of the CS neuron and on the postsynaptic motor neuron. After several conditioning trials, this chemical activity leaves the CS neuron facilitated and the postsynaptic motor neuron strengthened, or potentiated. That is, the CS nerve terminal is now more permeable to calcium ions (Ca^{++}) and the postsynaptic motor neuron fires more easily. As you recall from Chapter 3, calcium is involved in the release of the neurotransmitter into the synapse.

Figure 6-11 Marine Animal Aplysia Used to Study the Biology of Learning

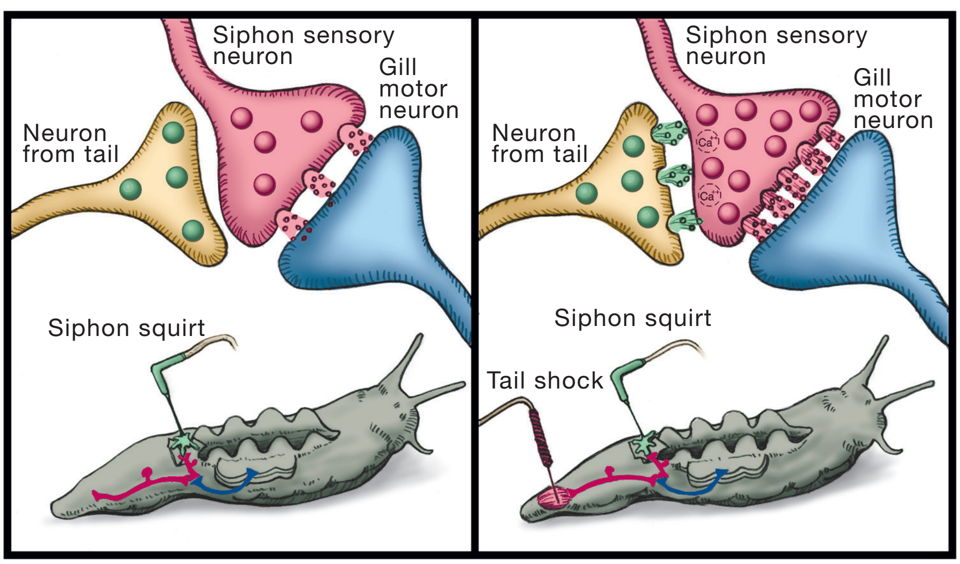
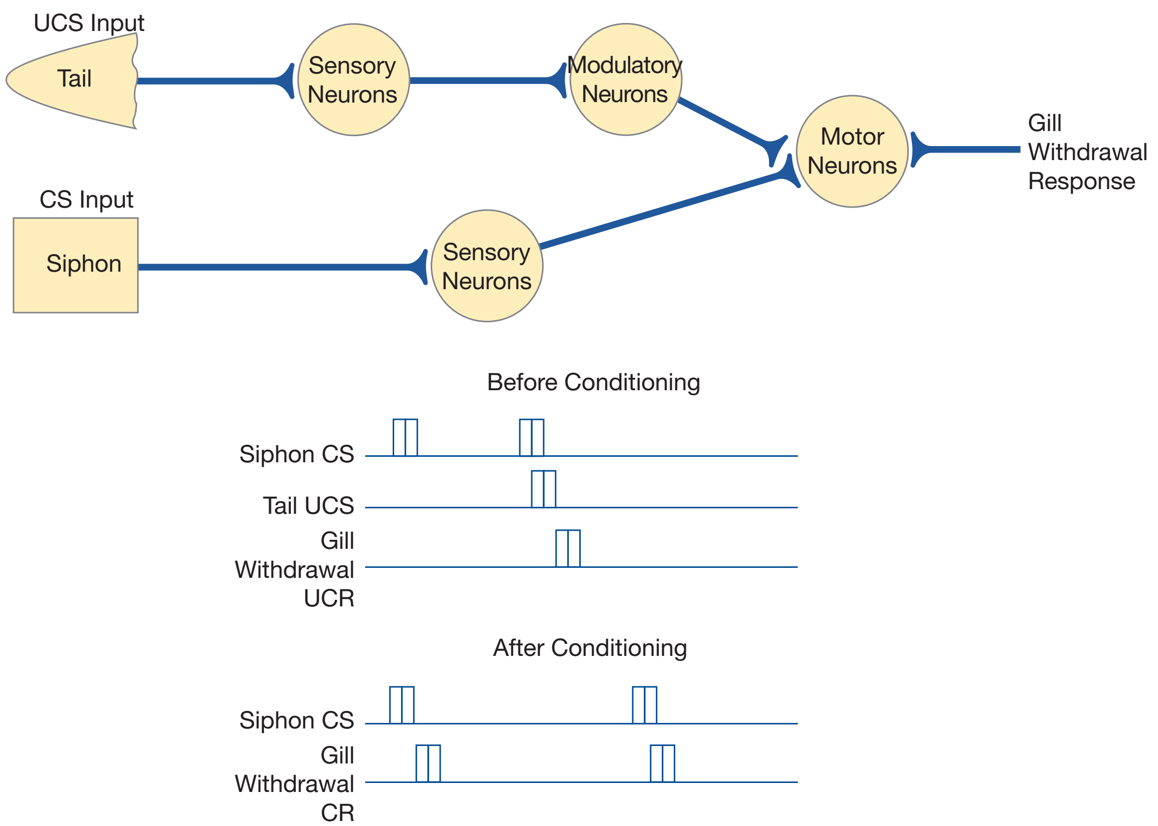


Figure 6-12 Model of Neuronal Connections in Aplysia



When more calcium flows into the nerve terminal, more neurotransmitter is released. Therefore, the next time the CS occurs (without the UCS), the activity of the CS neuron results in more neurotransmitter being released at the motor neuron synapse. If sufficient neurotransmitter is released from the CS neuron, the motor neuron will now fire causing the gill withdrawal response. The withdrawal response to the mild siphon touch is now a conditioned response.

In summary, paired presentations of the CS and the UCS leave the CS neuron facilitated and the postsynaptic neuron potentiated. **Synaptic facilitation** and **long-term potentiation** allow the CS to activate the motor neuron for the gill response. These synaptic changes are relatively permanent (thus the term long-term potentiation), and they will not occur if the delay between the CS and the UCS is much longer than 0.5 seconds. Likewise, they will not occur if the CS follows the UCS as in backwards conditioning (Kandel E., 1983; Kandel & Hawkins, 1992; Antonov, Antonova, Kandel, & Hawkins, 2003).

Synaptic Facilitation An increase in the size of a postsynaptic potential to a weak stimulus resulting from neuronal changes that underlie learning and memory

Long-Term Potentiation (LTP) An increase in a neuron's sensitivity to fire following a burst of signals to that neuron's dendrites

Chemical changes like this are believed to underlie all of the learning processes discussed in this chapter. In fact, as you read this text or perfect your tennis serve, similar changes are occurring throughout your brain. Without additional memory processes, however, learning would clearly be of little value. In the next chapter we discuss the processes of memory that allow our experiences, as represented, to influence our behavior. We conclude the next chapter with more discussion of these biological processes.

Health, Psychology, and Life

Pavlovian Conditioning

A few years ago, researchers Robert Ader and Nathan Cohen (1982) observed a curious effect as they were studying Pavlovian conditioned taste aversion. In their experiment, rats were given drinks of a saccharin-flavored water (the CS), followed immediately by injections of a drug that made them nauseous (the UCS). As you might predict, the animals immediately acquired a taste aversion that caused them to avoid or reduce their consumption of the sweet solution. The rats were then exposed to several extinction trials in which they were presented with the sweet solution but no toxic drug. (Extinction is a process designed to reduce the strength of the association between the CS and UCS through repeated presentations of the CS alone without the UCS.)

During this stage of the study, something unexpected happened. For no apparent reason, some of the rats died. Ader and Cohen considered a variety of possibilities to explain what had happened. One of their primary clues was that the drug they used to induce nausea, cyclophosphamide, is also known to suppress the body's immune system.

Ader and Cohen reasoned that perhaps the saccharin water had become a conditioned signal that suppressed the rats' immune systems in the same way as the drug with which it had been paired. If this were the case, the repeated exposures to the sweetened water alone during the extinction trials may have suppressed their immune systems so much that they fell victim to disease-bearing microorganisms in the laboratory.

To test this possibility, they conditioned other rats, using the original design with one modification. Before the extinction trials in which rats received only the CS of sweet water, they were injected with red blood cells from sheep that would normally trigger the rats' immune systems to produce high levels of defensive antibodies. The researchers' hypothesis was supported: The conditioned animals produced significantly fewer antibodies than their control animals. Ader and Cohen also tested the immune-system responses of mice that had been classically conditioned to respond to the sweet water. They found that if these conditioned mice received only half the usual dosage of cyclophosphamide, together with exposure to the CS, their immune systems were suppressed as completely as if they had been given a full dosage of the toxic drug.

Other researchers have confirmed and extended Ader and Cohen's findings. For instance, Grochowicz et al., (1991) demonstrated that conditioned immunosuppression effectively prolonged the survival of transplanted heart tissue in rats. Immunosuppression in tissue transplant procedures is necessary to prevent the immune system from attacking the newly transplanted tissue. In experiments with humans, researchers recruited 34 healthy male volunteers to participate. Twenty-four of the subjects received five days of conditioning using strawberry milk as the CS and the immunosuppressive drug, cyclosporine, as the UCS. The control group consumed the strawberry milk, but was given a placebo. Neither the researchers nor the subjects were informed as to which group they were subject. After 5 days of conditioning, both groups consumed strawberry milk (CS) before receiving identical-looking placebo tablets. The researchers then measured lymphocyte production in both groups. The conditioning group had significantly suppressed immune responses compared to the control group (Goebel, Trebst, Steiner, Yu, & Exton, 2002). These results not only confirm earlier work by Ader but also demonstrate conditioned immune suppression in humans. It is anticipated that conditioning of the immune system will be applied to treat human lupus and arthritis, as well as other autoimmune disorders.

Health, Psychology, and Life

Health Implications

Certainly, these findings extend our knowledge as to how the mind and body interact to reduce or increase our vulnerability to disease. Beyond this, they may lead to a practical medical application in the future. For instance, one major problem associated with many drugs used to combat disease is that they often produce serious side effects. Although cyclophosphamide is toxic enough to have been selected as the nausea-inducing UCS in Ader and Cohen's experiment, it has a legitimate and very valuable medical use as treatment for lupus, an immune-system disorder in which the body turns against itself. If Pavlovian conditioning could be used to condition the body of a lupus victim into responding to a significantly lowered dosage of the drug, a diseased person might be able to benefit from cyclophosphamide without having to experience its debilitating side effects. Experiments are currently being conducted with lupus patients to determine whether conditioned immunosuppression can effectively augment drug therapy.

The same kinds of benefits might also be obtained with drugs used to treat cancer and MDS. Hopefully, in the years to come these conditioning principles can be applied to alleviate suffering and improve the treatment of many victims of disease.

CHAPTER REVIEW

Defining Learning

1. Learning may be defined as a relatively permanent change in potential behavior that results from experience.
2. Associative learning, the process by which connections or associations are made between two events, may take place in two primary ways: Pavlovian conditioning and operant conditioning. Pavlovian conditioning involves learned associations between two stimuli. In operant conditioning, people or other animals learn to associate their own behavior with its consequences.

Pavlovian Conditioning

3. The four key elements in Pavlovian conditioning are the unconditioned stimulus (UCS), the unconditioned response (UCR), the conditioned stimulus (CS), and the conditioned response (CR). After pairing a previously neutral stimulus (CS) with a stimulus (UCS) that automatically elicits an unlearned response (UCR), the CS will cause a response on its own.
4. Factors which facilitate the acquisition of a Pavlovian conditioned response include a CS that is clearly different from other stimuli, frequent pairings of the CS and the UCS, and the order and timing with which the CS is paired with the UCS.
5. The acquisition of Pavlovian conditioning depends on a predictive relation between the CS and the UCS called stimulus contingency.
6. When certain associations are acquired very quickly, they are called selective associations. Conditioned taste aversions are examples of selective associations.
7. Extinction, or cessation of the CR, occurs in Pavlovian conditioning when the CS is repeatedly presented alone, without the UCS.
8. A CR can be reinstated following extinction with one or two conditioning trials. In some cases, reinstated CRs are stronger than their pre-extinction levels.
9. When a response has been conditioned to a particular stimulus, other stimuli may also produce the same response. This principle is called generalization.
10. Early in the conditioning process, a learner may respond to a variety of similar stimuli (generalization). However, with time, he or she learns that only one of these stimuli, the CS, is consistently associated with the UCS. This process of learning to make distinctions between the CS and similar but not identical stimuli is called discrimination.
11. A Pavlovian conditioning variation in which a neutral stimulus becomes a CS through association with an already established CS is referred to as second order conditioning.

Operant Conditioning

12. In operant conditioning humans and other animals learn to associate their behavior with either reinforcing or punishing consequences.
13. Reinforcement is defined as a procedure that increases the probability that a response will occur.
14. A positive reinforcer is any stimulus presented following a response that increases the probability of the response. A negative reinforcer is a stimulus that increases the probability of a response through its removal when the desired response is made.
15. In escape conditioning, an organism learns to produce a response that will allow termination or escape from an aversive stimulus (negative reinforcer). In avoidance conditioning, the individual learns to emit an appropriate avoidance response, thereby averting any exposure to the aversive stimulus.
16. A primary reinforcer is a stimulus that satisfies a biologically based drive or need. Secondary reinforcers are stimuli that acquire reinforcing properties through association with primary reinforcers.
17. A continuous reinforcement schedule exists when behavior is reinforced every time it occurs. A partial reinforcement schedule exists when behavior is reinforced only part of the time.
18. Behaviors that are acquired on partial instead of continuous schedules of reinforcement are slower to be established, but they are remarkably more persistent when no reinforcement is provided.
19. Four varieties of partial reinforcement schedules include those based on a percentage of responses that are reinforced (fixed ratio and variable ratio) or passage of a certain amount of time before a response is reinforced (fixed interval and variable interval).
20. Methods used to encourage the occurrence of an initial desired operant response include physical guidance, shaping, modeling, verbal instruction, and increasing motivation.
21. Punishment can be defined as a procedure that decreases the probability that a given behavior will occur.
22. The effectiveness of a punisher in producing a desired change in behavior depends upon its intensity, consistency, and the delay between a response and punishment.
23. Principles that may improve the effectiveness of punishment include immediacy, consistency, moderation, and combining it with positive reinforcement (always reinforcing acceptable alternatives to the punished behavior).

Comparing Pavlovian and Operant Conditioning

24. Pavlovian conditioning involves learning associations between a CS and a UCS. Operant conditioning involves learning associations between behavior and its consequence.
25. Most learning situations combine both Pavlovian and operant conditioning in what is called two-factor learning.
26. Many human phobias are a result of two-factor learning. First, an individual acquires a fear of a neutral stimulus (Pavlovian conditioning), and then the individual acts to reduce or eliminate this fear by learning to avoid the frightening stimulus (operant avoidance conditioning).

Cognitive Influences on Learning

27. Cognitive theorists suggest that we learn by forming a cognitive structure, or representation, in memory that preserves and organizes information relevant to a given situation.
28. The roots of cognitive learning theories go back many years to studies of latent learning in rats.
29. Cognitive theorists suggest that what is learned in Pavlovian conditioning is not a mere contiguity between the CS and UCS but rather an expectancy that the UCS will follow the CS.
30. From the cognitive perspective, operant behavior is also viewed as being guided by expectations of probable outcomes.
31. Cognitive theorists believe that there are strong cognitive components in learning by watching and imitating others, a process called observational learning.
32. The role of observation and imitation in learning is explained in social learning theory. In some circumstances, teaming by observation, or modeling, may be even more effective than operant conditioning in shaping our behavior.

Biological Bases of Learning

33. Learning involves structural and chemical changes at synapses within the brain.
34. Researchers have identified these changes in the marine snail, Aplysia.
35. In the Aplysia, learning involves both presynaptic facilitation and postsynaptic potentiation of motor neuron synapses.

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POP QUIZ

True or False

___ 1. A new behavior that is acquired as a result of an individual's maturation is considered a learned behavior.

___ 2. When a CR that has been extinguished suddenly returns after an interval of rest, we say spontaneous recovery has occurred.

___ 3. Shaping involves the physical guidance of the subject to make the desired response.

___ 4. Bandura's study involving children and a Bobo doll demonstrated modeling.

___ 5. Research interested in the biological mechanisms of learning has focused on operant conditioning in the marine snail Aplysia.

Multiple Choice

6. Associative learning describes the process by which a connection or association is made between which of the following?
   a. Two stimuli
   b. A behavior and the consequences of that behavior
   c. A problem and the solution to that problem
   d. Both a and b are correct.
7. Young children frequently cry when their mothers leave them. Sometimes they start to cry as soon as the babysitter arrives. Why does this occur?
   a. Babysitter is a UCS associated with the mother leaving.
   b. Babysitter uses negative reinforcement.
   c. Babysitter is a CS associated with the mother leaving.
   d. Child dislikes the babysitter.
8. Which of the following is not an important factor in the initial acquisition of a CR?
   a. The motivation of the individual to perform the CR
   b. The timing of the presentation of the CS and UCS
   c. That the CS is clearly different from other stimuli
   d. How frequently the CS and UCS have been paired
9. What should one do to extinguish a CR?
   a. Pair the CS with a second order stimulus
   b. Repeatedly present the CS while not presenting the UCS
   c. Withhold the UCR
   d. Not present the CS for a period of several days

10. What is teaching an organism to respond to only one of a series of similar stimuli called?
    a. Operant conditioning
    b. Generalization
    c. Extinction
    d. Discrimination training
11. What is the most commonly used measure of the strength of an operant response?
    a. The rate of response
    b. The calculation from the Law of Effect
    c. The variety of stimuli that elicit the response
    d. How much generalization is shown
12. Your child gets a gold star on her perfect spelling test. After accumulating several stars, the child may trade them for play time. What does the gold star represent?
    a. A conditioned reinforcer
    b. A primary reinforcer
    c. An UCS
    d. A discriminative stimulus
13. Immediately after being reinforced, a rat on which schedule of reinforcement would show the longest pause before its next bar press?
    a. FR
    b. VR
    c. FI
    d. VI
14. Which of the following is ***not*** a limitation or undesirable side effect of punishment?
    a. It may induce counteraggression against the punisher.
    b. Fear or anxiety may develop.
    c. Positive reinforcers lose their reinforcing properties.
    d. The results are often temporary.
15. What is the basic premise of observational learning?
    a. Behavior learned through observational learning is never extinguished.
    b. Insight into the model's motivation is gained.
    c. Learning may occur without physical responses or reinforcement.
    d. All learning results from modeling.

Answer Key: 1.F 2.T 3.F 4.T 5.F 6.d 7.c 8.a 9.b 10.d 11.a 12.a 13.c 14.c 15.c