CHAPTER 4

Basic Principles of Classical Conditioning

LEARNING OBJECTIVES

After reading this chapter, you should be able to

- describe the procedure of classical conditioning and some of the most common ways it is studied in the laboratory
- explain Pavlov's stimulus substitution theory, and describe its strengths and weaknesses
- describe the basic principles of classical conditioning, including acquisition, extinction, spontaneous recovery, conditioned inhibition, generalization, and discrimination
- explain how the timing of the stimuli in a classical conditioning procedure affects the results
- give examples of classical conditioning that are found in everyday life
- describe some of the main behavior therapies that are based on classical conditioning, and evaluate their effectiveness

Part of the excitement of conducting scientific research arises from the ever-present possibility that a routine experiment, conducted with a fairly mundane objective in mind, can produce an unexpected finding of great importance. The history of science records many stories of such serendipitous discoveries, and in one such story the main character was the Russian scientist Ivan Pavlov.

PAVLOV'S DISCOVERY AND ITS IMPACT

Although he eventually became one of the most famous figures in the history of psychology, Pavlov was trained as a physiologist, not as a psychologist. He conducted a substantial amount of research on the physiology of the digestive system, and in 1904 he was awarded the Nobel Prize in Medicine and Physiology for this work. Pavlov was interested in the various substances secreted by an animal's digestive system to break down the food eaten. He analyzed the chemical composition of the digestive juices, measured the times they were secreted during the course of a meal, and attempted to discover the neural mechanisms controlling these physiological responses. One of the digestive juices Pavlov studied was saliva, which is the first secretion to make contact with any ingested food. The subjects in Pavlov's studies were dogs, and he developed a surgical technique that enabled him to redirect the saliva from one of the dog's salivary ducts through a tube and out of the mouth, so that it could be measured. Figure 4-1 pictures Pavlov's experimental apparatus, which included a harness to restrain the subject and the devices for recording each drop of saliva.

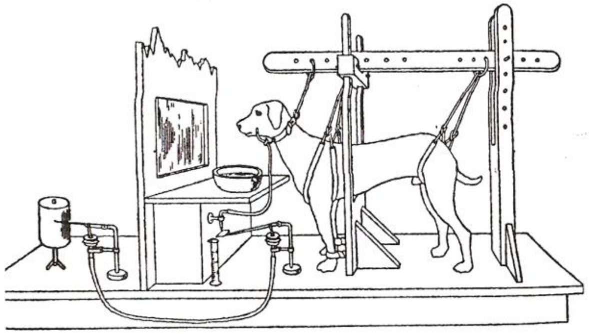


FIGURE 4-1 Pavlov's salivary conditioning situation. A tube redirects drops of saliva out of the dog's mouth so they can be recorded automatically. (From Yerkes & Morgulis, 1909)

In Pavlov's research, a single dog might be subjected to several test sessions on successive days. In each session the animal would be given food, and its salivation would be recorded as it ate. Pavlov's important observation came when studying dogs that had been through the testing procedure several times. Unlike a new subject, an experienced dog would begin to salivate even before the food was presented. Pavlov reasoned that some stimuli that had regularly preceded the presentation of food in previous sessions, such as the sight of the experimenter, had now acquired the capacity to elicit the response of salivation. Pavlov recognized the significance of this unexpected result, and he spent the rest of his life studying this phenomenon, which is now known as **classical conditioning**. He concluded that his subjects were exhibiting a simple type of learning: Salivation, which began as a reflexive response to the stimulus of food in the dog's mouth, was now elicited by a new (and initially ineffective) stimulus. Pavlov speculated that many of an animal's learned behaviors might be traced back to its innate reflexes, just as a dog's learned behavior of salivating when the experimenter appeared developed from the initial food-salivation reflex. If so, then we might be able to discover a good deal about an animal's learning mechanisms by studying the development of learned reflexes, or **conditioned reflexes**, in the laboratory. With this goal in mind, Pavlov developed a set of procedures for studying classical conditioning that are still in use today.

The Standard Paradigm of Classical Conditioning

To conduct a typical experiment in classical conditioning, an experimenter first selects some

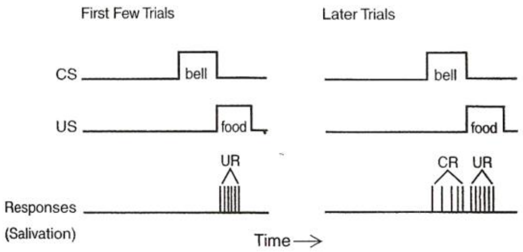


FIGURE 4-2 Events of a classical-conditioning trial both before a conditioned response is established (left) and after (right).

stimulus that reliably elicits a characteristic response. The stimulus of this pair is called the **unconditioned stimulus**, and the response is called the **unconditioned response**. The term *unconditioned* is used to signify that the connection between the stimulus and response is unlearned (innate). In Pavlov's experiments on the salivary response, the unconditioned stimulus (abbreviated US) was the presence of food in the dog's mouth, and the unconditioned response (UR) was the secretion of saliva. The third element of the classical-conditioning paradigm is the **conditioned stimulus** (CS), which can be any stimulus that does not initially evoke the UR (e.g., a bell). The term *conditioned stimulus* indicates that it is only after conditioning has taken place that the bell will elicit the response of salivation.

Figure 4-2 is a diagram of the sequence of events of a single trial of classical conditioning. In its simplest form, a classical-conditioning trial involves the presentation of the CS (say, a bell) followed by the US (e.g., the food). On the initial trials, only the US will elicit the response of salivation. However, as the conditioning trials continue, the dog will begin to salivate as soon as the CS is presented. Any salivation that occurs during the CS but before the US is referred to as a **conditioned response** (CR), since it is only because of the conditioning procedure that the bell now elicits salivation.

The abbreviations for the four basic elements of the classical-conditioning paradigm will appear repeatedly in this and later chapters, so be sure that you have no confusion about what each term represents. The two components of the initial stimulus-response pair are the US and the UR. Through the procedures of classical conditioning, a new stimulus, the CS, begins to elicit responses of its own, and these responses to the CS are called CRs (since they are learned, or conditioned, responses).

The Variety of Conditioned Responses

Classical conditioning has been observed in many reflexes, including the knee-jerk reflex, the eyeblink, and others (Hull, 1934; Schlosberg, 1928). It is also possible to classically condition various organs such as the heart, the stomach, the liver, and the kidneys. Although classical conditioning can be obtained with many different responses, much of the research on this type of learning has been conducted with a small number of conditioning *preparations* (i.e., conditioning situations using a particular US, UR, and species of subject) that can be studied easily and efficiently. The following conditioning preparations are among the most commonly used.

Eyeblink Conditioning. Conditioning of the eyeblink reflex has been studied with both humans and rabbits as subjects. Figure 4-3 shows a typical procedure for eyeblink conditioning with rabbits. The US in this case is a puff of air directed at the eye, and the UR is of course an eyeblink. Eyeblinks are recorded by a potentiometer, which measures the movement of a thread attached to the rabbit's eyelid. In other eyelid-conditioning studies, the US is a mild electric shock delivered to the skin in the vicinity of the eye, which also reliably elicits an eyeblink as a UR. The CS may be a light, a tone, or some tactile stimulus such as a vibration of the experimental chamber, and the duration of the CS is typically about 1 second. Like the UR, the CR is an eyeblink, but its form may be different. Whereas the unconditioned eyeblink is a large and rapid eyelid closure, the conditioned response is often a smaller and more gradual eyelid movement. Eyeblink conditioning often requires a large number of CS-US pairings. For example, it may take well over 100 pairings before a CR is observed on 50 percent of the trials.

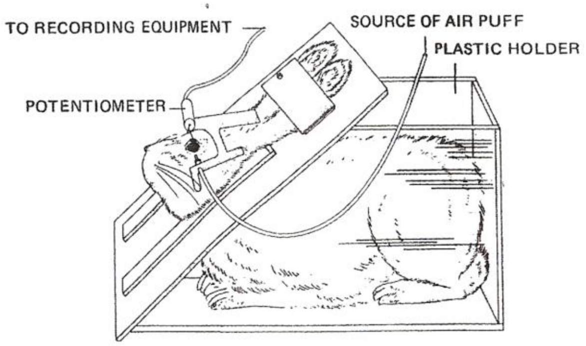


FIGURE 4-3 An eyeblink-conditioning arrangement. The potentiometer measures the movement of the rabbit's eyelid in response to either an air puff or some conditioned stimulus. (From Domjan & Burkhard, 1982)

For a long time, most of this research was conducted with rabbits, but in recent years there has been a revival of interest in human eyeblink conditioning. Research with humans has been used to map the brain areas involved in conditioning, to help diagnose psychological disorders, to study the effects of awareness on learning, and for other purposes (Steinmetz, 1999; Woodruff-Pak, 1999).

Conditioned Suppression. In the conditioned suppression procedure, which is also called the **conditioned emotional response** (CER) procedure, the subjects are usually rats, and the US is an aversive event such as a brief electric shock delivered through the metal bars that form the floor of the experimental chamber. The unconditioned response to shock may include several different behaviors; for example, the animal may jump or flinch, and temporarily stop what it was doing before the shock occurred. The measure of conditioning in this situation is the suppression of ongoing behavior when the CS (which signals that a shock is forthcoming) is presented. So that its "ongoing behavior" can be measured, the rat is given a separate task in which it can earn occasional food pellets by pressing a lever. It is fairly easy to schedule the delivery of food pellets in such a way that the animal will press the lever slowly but steadily for an hour or more, now and then earning a bit of food.

As in eyeblink conditioning, the CS may be visual, auditory, or tactile, but the duration of the CS is generally much longer in the conditioned suppression procedure—CSs of 1 minute or more are typical. When the CS is first presented, it may have little effect on the subject's lever-pressing behavior. However, after a few pairings of the CS and shock (in which the shock arrives at the end of the 1-minute CS and lasts for perhaps 1 second), the rat's rate of lever pressing suddenly decreases as soon as the CS is presented, and it may make only a few lever presses during the minute that the CS is present. The amount of suppression of lever pressing is used as a measure of the strength of conditioning. For example, if a rat was pressing the lever at a rate of 40 responses per minute before the CS and this rate dropped to 10 responses per minute in the presence of the CS, this would constitute a suppression of 75 percent.

Conditioning takes place in far fewer trials in the conditioned suppression procedure than in the eyeblink procedure, perhaps partly because the shock is more intense than the air puffs or mild shocks used in eyeblink conditioning. Whatever the reasons, strong conditioned suppression can often be observed in fewer than 10 trials, and in some cases significant suppression to the CS is found after just one CS-US pairing.

The Skin Conductance Response. The conditioning preparation called **skin conductance response (SCR)** is also referred to as the *electrodermal response*, and in the past it was known as the *galvanic skin response*. In this preparation, the subjects are usually human. The SCR is a change in the electrical conductivity of the skin. To measure a person's SCR, two coin-shaped electrodes are attached to the palm, and the electrodes are connected to a device that measures momentary fluctuations in the conductivity of the skin (caused by small changes in perspiration). The conductivity of the skin is altered by emotions such as fear or surprise, which is why the SCR is often one measure used in lie detector tests. One stimulus that reliably produces a large increase in skin conductivity is electric shock, and a similar increase in conductivity can be conditioned to any CS that is paired with shock. For instance, the CS might be a tone, the US a shock to the left wrist, and the response an increase in conductivity of the right palm. One reason for the interest in the SCR is that since it provides a response that can be quickly and reliably conditioned with human subjects, many complex stimuli (such as spoken or written words) can be examined as CSs.

Taste-Aversion Learning. The conditioning procedure called taste-aversion learning has been extensively investigated since about the late 1960s. Rats are frequently the subjects in this research, but other species (pigeons, quail, guinea pigs) have also been used. By definition, the CS in this procedure is the taste of something the subject eats or drinks. In many cases, the food is one that the subject has never tasted before. After eating or drinking, the subject is given an injection of a poison (the US) that makes the animal ill. Several days later, after the subject has fully recovered from its illness, it is again given the opportunity to consume the substance that served as the CS. The usual result is that the animal consumes little or none of this food. Thus, the measure of conditioning is the degree to which the subject avoids the food.

There are a number of reasons why taste-aversion learning has received so much attention in recent years. First, as you will see in Chapter 5, some psychologists have suggested that taste-aversion learning is not an ordinary example of classical conditioning, but that it violates some of the general principles that apply to most examples of classical conditioning. Second, a taste aversion often develops after just one conditioning trial, and this rapidity of conditioning is advantageous for certain theoretical questions. Third, a taste aversion is something that many people experience at least once in their lives. Perhaps there is some type of food that you refuse to eat because you once became ill after eating it. You may find the very thought of eating this food a bit nauseating, even though most people enjoy the food. If you have such a taste aversion, you are not unusual—one study found that more than half of the college students surveyed had at least one taste aversion (Logue, Ophir, & Strauss, 1981). A taste aversion may develop even if the individual is certain that the food was not the cause of the subsequent illness. I once attended a large dinner party where the main course was chicken tarragon. Besides passing food around the table, we evidently passed around an intestinal virus, because many of the guests became quite ill that evening. For some, the illness lasted for over a week. The result of this accidental pairing of food and illness was that several years later some of these guests still refused to eat chicken tarragon or any food with tarragon spicing. Taste aversion can be strong and long lasting!

Pavlov's Stimulus Substitution Theory

The Theory. Pavlov was the first to propose the theory of classical conditioning that is now called the **stimulus substitution theory**. On a behavioral level, the theory simply predicts the changes that supposedly take place among the observable events of conditioning—the stimuli and responses. The theory states that by virtue of repeated pairings between CS and US, the CS becomes a substitute for the US, so that the response initially elicited only by the US is now also elicited by the CS. At first glance, this theory seems to provide a perfectly satisfactory description of what takes place in many common examples of classical conditioning. In salivary conditioning, initially only food elicits salivation, but later the CS also elicits salivation. In eyeblink conditioning, both the UR and the CR are eyelid closures. In SCR conditioning, an increase in skin conductance is first elicited by a shock, and after conditioning, a similar increase in skin conductance occurs in response to some initially neutral stimulus.

Problems with the Theory. Despite these apparent confirmations of the stimulus substitution theory, today very few conditioning researchers believe the theory to be correct. The theory has several problems. First, the CR is almost never an exact replica of the UR. For instance, it was already noted that whereas an eyeblink UR to an air puff is a large, rapid eyelid closure, the CR that develops is a smaller and more gradual eyelid closure. That is, both the size and the temporal pattern of the CR differ from those of the UR. Second, not all parts of the UR to a stimulus become part of the CR. For example, Zener (1937) noted that when a dog is presented with food as a US, many responses, such as chewing and swallowing the food, occur in addition to salivation. Yet, although a well-trained CS such as a bell will elicit salivation, it will generally not elicit the chewing and swallowing responses. Therefore, not all of the components of the UR are present in the CR. Conversely, a CR may include some responses that are *not* part of the UR. For instance, using a bell as a CS, Zener found that many dogs would turn their heads and look at the bell when it was rung. Sometimes a dog would move its entire body closer to the ringing bell. Obviously, these behaviors were not a normal part of the dog's UR to food. Because of such results, it was clear that stimulus substitution theory had to be modified if it were to remain a viable theory of classical conditioning.

Hilgard (1936) suggested two ways in which the theory might be amended. First, it should be acknowledged that only some components of the UR are transferred to the CR. Hilgard noted that some components of the UR may depend on the physical characteristics of the US, and they will not be transferred to a CS with very different physical characteristics. Thus, although a dog will chew and swallow food when it is presented, it cannot chew and swallow food that is not there (when the bell is rung). Second, it should be recognized that a CS such as a bell frequently elicits unconditioned responses of its own, and these may become part of the CR. For instance, when it first hears a bell, a dog may exhibit an orienting response: The dog may raise its ears, look in the direction of the bell, and possibly approach the bell. Although such orienting responses usually habituate if the bell is inconsequential, they persist or increase if the bell is paired with food. A more recent theory of classical conditioning, called the **sign-tracking theory** (Hearst & Jenkins, 1974; Tomie, Brooks, & Zito, 1989), emphasizes precisely this aspect of an animal's response to a CS. It states that animals tend to orient themselves toward, approach, and explore any stimuli that are good predictors of important events, such as the delivery of food. It is not surprising that some components of the orienting response to the CS are retained as part of the CR. In short, the form of the CR may reflect both the unconditioned response to the US and the unconditioned response to the CS itself.

Possibly the strongest argument against stimulus substitution theory arises from the finding that in some cases the direction of the CR is opposite that of the UR. For instance, one response to an electric shock is an increase in heart rate, but in studies with guinea pigs, Black (1965) observed conditioned heart rate decreases to a CS paired with shock. Another example involves studies in which animals (usually rats) are given a morphine injection as the US. One of the URs to morphine is hyperthermia, or an increase in body temperature. In experiments where some CS is repeatedly paired with morphine, two types of CRs have been observed. Sometimes the CR is an increase in body temperature, as predicted by stimulus substitution theory, but in other cases the CR is a decrease in body temperature. Conditioned responses that are the opposite of the UR have been called **conditioned compensatory responses** (Siegel, 1982).

Examples of conditioned compensatory responses seem to demonstrate that stimulus substitution theory is inadequate as a general theory of classical conditioning. Still, some theorists (e.g., Eikelboom & Stewart, 1982) have suggested that these examples are not as damaging to stimulus substitution theory as they appear on the surface. Let us simply emphasize that one of the most widely held beliefs about classical conditioning—that it involves the simple transfer of a response from one stimulus to another—is not consistent with the following facts.

1. The sizes and temporal patterns of the CR and UR may differ.
2. Not all components of the UR become part of the CR.
3. The CR may include response components that are not part of the UR.
4. The CR is sometimes opposite in direction to the UR (or at least to the most obvious part of the UR).

For these reasons, it is often difficult to predict in advance what the CR will look like in a specific instance. It may resemble the UR, or it may be very different.

What Is Learned in Classical Conditioning? Having surveyed the arguments for and against stimulus substitution theory, let us now turn to Pavlov's speculations about what changes might take place in the brain during classical conditioning. Pavlov had limited information about the physiology of the brain, and the specific details of his theory have since been proven wrong. On a more general level, however, his speculations still constitute a viable physiological theory of conditioning.

Pavlov proposed that there is a specific part of the brain that becomes active whenever a US (such as food) is presented, and he called this part of the brain the *US center*. Similarly, for every different CS (a tone, a light), there is a separate *CS center*, which becomes active whenever that particular CS is presented. From what we know about the physiology of the sensory systems (Chapter 2), these assumptions seem quite reasonable, especially since the exact nature of CS centers and US centers is not important to Pavlov's theory. It does not matter, as far as this theory is concerned, whether a CS center or US center is a single neuron, a group of neurons with similar functions, or even a particular pattern of activity in a set of neurons. Pavlov also assumed that for every UR (say, salivation) there is part of the brain that can be called a *response center*, and it is the activation of this response center that initiates the neural commands that ultimately produce the observed response. Furthermore, since the US elicits the UR without any prior training, Pavlov assumed that there is an innate connection between the US center and the response center (see Figure 4-4). Finally, Pavlov proposed that somehow an association develops during the course of classical conditioning, so that now the CS produces activity in the response center (and a CR is observed).

As Figure 4-4 suggests, there are at least two types of new associations that would give the CS the capacity to elicit a CR. On one hand, a direct association between the CS center and the response center might develop during conditioning. Since this association is between a stimulus and a response, it is sometimes called an **S-R association**. On the other hand, the connection between the CS and response centers might be less direct. Perhaps an association between the CS center and the US center is formed during conditioning. Later, when the CS is presented, the CS center is activated, which activates the US center (through the newly formed association), which in turn activates the response center (through the innate association). This hypothesis constitutes the position that an **S-S association** is formed during classical conditioning. Pavlov tended to favor the S-S position, but he had little empirical support for this view. Later, however, experimenters devised some clever techniques to try to distinguish between these two alternatives. The next section describes one such procedure.

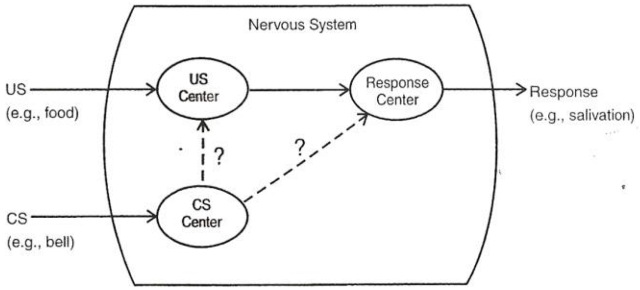


FIGURE 4-4 Two possible versions of Pavlov's stimulus substitution theory. During classical conditioning, an association might develop from the CS center to the US center, or from the CS center directly to the response center.

S-S or S-R Connections?

In the absence of physiological information about what neural changes take place during classical conditioning, how can we distinguish between the S-S and S-R positions? Rescorla (1973) used the following reasoning. If the S-S position is correct, then after conditioning, the occurrence of a CR depends on the continued strength of two associations: the learned association between the CS center and the US center, and the innate association between the US center and the response center (see Figure 4-4). If the US-response connection is somehow weakened, this should cause a reduction in the strength of the CR, since the occurrence of the CR depends on this connection. On the other hand, if the S-R position is correct, the strength of the CR does not depend on the continued integrity of the US-response association, but only on the direct association between the CS center and the response center. But how can a reflexive US-response association be weakened? Rescorla's solution was to rely on habituation.

Rescorla used a conditioned suppression procedure with rats, but instead of the usual electric shock, a loud noise was used as the US. Rescorla's previous work had indicated that a conditioned suppression of lever pressing would develop to any CS paired with the noise, but also that the noise was susceptible to habituation if it was repeatedly presented. The design of the experiment is shown in Table 4-1. In Phase 1, two groups of rats

TABLE 4-1 Design of Rescorla's (1973) Experiment

Group	*Phase 1*	*Phase 2*	*Test*
Habituation	Light→Noise	Noise (habituation)	Light
Control	Light→Noise	No stimuli	Light

received identical classical conditioning with a light as the CS and the noise as the US. In Phase 2, the habituation group received many presentations of the noise by itself, so as to habituate the subjects' fear of the noise. The technique of decreasing the effectiveness of the US after an excitatory CS has been created is called *US devaluation*. The control subjects spent equal amounts of time in the experimental chamber in Phase 2, but no stimuli were presented, so there was no opportunity for the noise to habituate in this group. In the test phase of the experiment, both groups were presented with the light by itself for a number of trials, and the subjects' levels of suppression of lever pressing were recorded. Rescorla found high levels of suppression to the light in the control group, but significantly lower levels of suppression in the habituation group. He concluded that the strength of the CR is dependent on the continued strength of the US-response association, as predicted by the S-S position but not the S-R position.

Similar studies on *US revaluation* have been conducted with human subjects, and the results have been similar. For example, in experiments using the SCR, a CS (e.g., a picture of some common object) is paired with an aversive US (either shock or loud noise); then the intensity of the US is changed. If the US intensity is decreased, skin conductance responses to the CS decrease as well, just as in Rescorla's experiment (Davey & McKenna, 1983). Conversely, the intensity of US can be increased. K. White and Davey (1989) presented subjects with a picture of a triangle followed by a 65-decibel tone. Because this tone was not very loud, subjects showed little SCR to either the triangle or the tone. Then, the tone was presented by itself, but its intensity was increased to 115 decibels, which made it aversive. Finally, the triangle was again presented (without the tone), and subjects showed a large SCR to the triangle. Once again, these results suggest that subjects had formed an S-S association (between triangle and tone in this case) because the response to the triangle could be changed by changing the value of the tone without further presentations of the triangle.

Other research on the associations formed during classical conditioning will be described in Chapter 5. For now, it is sufficient to understand how questions about the workings of the nervous system can be addressed in a meaningful way without actually tracing any specific neural connections.

BASIC CONDITIONING PHENOMENA

Acquisition

In most classical conditioning experiments, several pairings of the CS and the US are necessary before the CR becomes fully developed. On the first few trials, there may be little or no conditioned responding to the CS. With additional pairings, conditioned responding gradually increases in strength. The part of a conditioning experiment in which the subject first experiences a series of CS-US pairings, and during which the CR gradually appears and increases in strength, is called the **acquisition phase**. Figure 4-5 shows the results of an acquisition phase in an experiment on eyeblink conditioning with human subjects (Trapold & Spence, 1960). The measure of conditioning is the percentage of trials on which a conditioned eyeblink response was recorded. Subjects in Group A received 130 trials with a strong air puff as a US, and this group exhibited a typical acquisition curve. The likelihood of a CR gradually increased over the first 50 trials or so, and subsequently there was little or no additional increase in the percentage of CRs with additional conditioning. The pattern of results suggests that even if Group A received many more conditioning trials, the percentage of CRs would probably never rise above about 55 percent. This value—the stable maximum level of conditioned responding that is gradually approached as conditioning proceeds—is called the *asymptote*.

One factor that has a major influence on the asymptote of conditioning is the size or intensity of the US. In general, if a stronger stimulus is used as a US (a stronger puff of air, a larger amount of food), the asymptote of conditioning will be higher (a higher percentage of conditioned eyeblinks, more salivation). This point is demonstrated by the results from Group B in Figure 4-5. For the first 90 trials, these subjects experienced the same conditioning procedures as did Group A. However, beginning on trial 91, a weaker air puff was used as a US for Group B. You can see that shortly after this, the percentage of CRs in Group B decreased and approached a stable level of about 30 percent. Evidently, this was the asymptote, or the highest level of conditioned responding that could be maintained with the weak air puff.

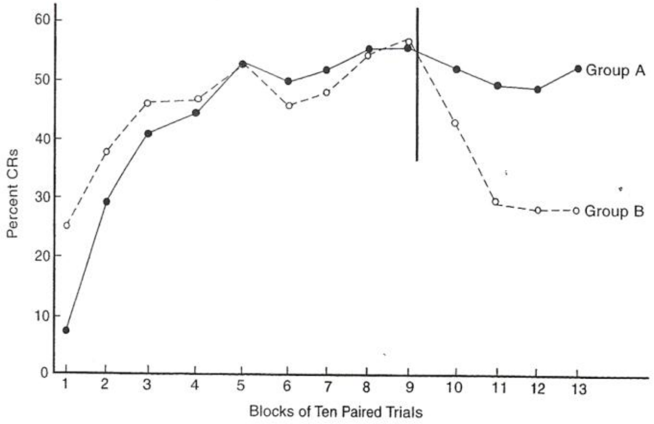


FIGURE 4-5 The acquisition of eyeblink CRs of human subjects. Subjects in Group A received 130 trials with a strong air puff as the US. Subjects in Group B received 90 trials with a strong air puff followed by 40 trials with a weaker air puff. (After Trapold & Spence, 1960)

Strong USs not only produce a higher asymptote, but they also usually result in faster conditioning; that is, it may take fewer trials for a conditioned response to appear with a strong US than with a weak one. The same is true about the intensity of the CS. Imagine one conditioning experiment in which a faint tone was used as a CS, and another with a very loud tone as a CS. It should come as no surprise that conditioning will occur more rapidly with the loud tone.

Extinction

The mere passage of time has relatively little effect on the strength of a conditioned response. Suppose we conducted an experiment in salivary conditioning, repeatedly pairing a bell and food until our subject reliably salivated as soon as the bell was rung. We could then remove the animal from the experimental chamber and allow a week, a month, or even a year to pass before returning the subject to the chamber. At this later time, upon ringing the bell, we would most likely still observe a CR of salivation (though probably not as much salivation as on the last trial of the initial training session). The point is that the simple passage of time will not cause an animal to "forget" to produce the CR once the CS is again presented.

This does not mean, however, that a conditioned response, once acquired, is permanent. A simple technique for producing a reduction and eventual disappearance of the CR is the procedure of **extinction**, which involves repeatedly presenting the CS *without* the US. For example, suppose we followed the acquisition

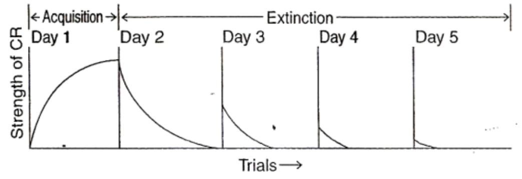


FIGURE 4-6 Idealized changes in the strength of a CR across one acquisition day followed by four days of extinction.

phase of our experiment on salivary conditioning with an extinction phase in which the bell was presented for many trials but no food was delivered. The first two panels in Figure 4-6 show, in an idealized form, the likely results of our hypothetical experiment. Like the acquisition phase, the course of extinction is usually gradual. In the beginning of an extinction phase, there are large reductions in the amount of salivation from trial to trial. Toward the end of the extinction phase, the decreases in conditioned responding occur more slowly, but eventually the CR will disappear altogether.

When the extinction phase is completed, we have a dog that behaves like a dog that is just beginning the experiment—the bell is presented and no salivation occurs. On the basis of this observation alone, we might conclude that the procedure of extinction simply reverses the effects of the previous acquisition phase. That is, if the animal has formed an association between the CS and the US during the acquisition phase, perhaps this association is gradually destroyed during the extinction phase. The simplicity of this hypothesis is appealing, but it is almost certainly wrong. At least three different phenomena show that whatever association was formed during acquisition is not erased during extinction. These phenomena are spontaneous recovery, disinhibition, and rapid reacquisition.

Spontaneous Recovery

Suppose that after an acquisition phase on Day 1 and an extinction phase on Day 2, we return our subject to the experimental chamber on Day 3 and conduct another series of extinction trials with the bell. Figure 4-6 shows that on the first several trials of Day 3, we are likely to see some conditioned responding to the bell, even though no CRs were observed at the end of Day 2. Pavlov called this reappearance of conditioned responding **spontaneous recovery** and treated it as proof that the CS-US association is not permanently destroyed in an extinction procedure. Pavlov's conclusion was obviously correct: If extinction serves to undo or erase the learning that occurred in acquisition, why would CRs spontaneously reappear without further conditioning trials? Whatever happens during extinction, it is not a simple erasure of the previous learning, and the passage of time seems to be an important variable. If more time elapses between the first and second extinction sessions, more spontaneous recovery is observed (Brooks & Bouton, 1993).

Several different theories about spontaneous recovery have been developed. One popular theory, which we can call the *inhibition theory*, states that after extinction is complete, the subject is left with two counteracting associations (Konorski, 1948). The CS-US association formed during acquisition is called an *excitatory association* because through this association the CS now excites, or activates, the US center. According to this theory, a parallel but *inhibitory association* develops during extinction. When extinction is complete, the effects of the excitatory and inhibitory associations cancel out, so that the US center is no longer activated by the presentation of the CS. However, inhibitory associations (or at least newly formed ones) are more fragile than excitatory associations, and they are therefore more severely weakened by the passage of time. With respect to Figure 4-6, this theory would say that at the end of Day 2, the inhibitory CS-US association is strong enough to counteract completely the excitatory association, so no CRs are observed. However, between Day 2 and Day 3 the inhibitory association is

weakened because some time has passed, so at the beginning of Day 3 it can no longer fully counteract the excitatory association, and some CRs are therefore observed. Further extinction trials on Day 3 strengthen the inhibitory association (just as they did on Day 2), and so conditioned responding once again disappears.

If we were to conduct further extinction sessions on Days 4, 5, 6, and so on, we might again observe some spontaneous recovery, but typically the amount of spontaneous recovery would become smaller and smaller until it no longer occurred (see Figure 4-6). According to the inhibition theory, this happens because the inhibitory association becomes progressively less fragile with repeated extinction sessions, until it can withstand the passage of time as well as the excitatory association.

The inhibition theory is just one of several theories about why spontaneous recovery occurs (Boakes & Halliday, 1975; Estes, 1955; Skinner, 1950). Some experiments by Robbins (1990) supported a theory that, during extinction, the subject stops "processing" or "paying attention to" the CS. Conditioned responses then disappear, because when the animal stops paying attention to the CS, it stops responding to the CS. Later, when the animal is brought back to the conditioning chamber after some time has passed (e.g., at the start of Day 3 in Figure 4-6), the animal's attention to the CS is revived for a while, leading to a spontaneous recovery of CRs.

Another theory of spontaneous recovery states that the CS becomes an ambiguous stimulus because it has been associated both with the US and then with the absence of the US (Capaldi, 1966). Referring again to Figure 4-6, after Day 2, the dog has experienced one session in which the bell was followed by food and one session in which it was not. At the start of Day 3, the dog cannot know whether this session will be like that of Day 1 or like that of Day 2, and its behavior (some weak CRs at the start of the session) may be a reflection of this uncertainty. As Bouton (2000) has put it, the CS "is ambiguous, and like an ambiguous word, its current meaning—or the behavior it currently evokes—is determined by the context. . . . Instability, lapse, and relapse are to be expected from a modern understanding of behavioral change" (pp. 57–58). Consistent with this theory, rats in one experiment displayed less spontaneous recovery of a taste aversion when a specific stimulus (a buzzer) was presented throughout every extinction session. The rats may have learned that the CS presented in a quiet environment was followed by the US, but the CS presented with the buzzer was not (Brooks, Palmatier, Garcia, & Johnson, 1999). In other words, the presence of the buzzer may have helped to reduce the ambiguity of the CS.

If the different theories of spontaneous recovery seem confusing to you, it may be reassuring to know that there is confusion and disagreement among the experts about this topic. Surprisingly, psychologists still do not fully understand the causes of extinction and spontaneous recovery, two of the most basic phenomena of classical conditioning.

Disinhibition

Suppose that an extinction phase has progressed to the point where the CS (a bell) no longer evokes any salivation. Now, if a novel stimulus such as a buzzer is presented a few seconds before the bell, the bell may once again elicit a CR of salivation. Pavlov called this effect **disinhibition** because he believed that the presentation of a distracting stimulus (the buzzer in this example) disrupts the fragile inhibition that supposedly develops during extinction. According to the inhibition theory, the more stable excitatory association is less affected by the distracting stimulus than is the inhibitory association. The net result is a slight excitatory tendency manifested in the reappearance of the conditioned salivary response.

As in the discussion of spontaneous recovery, let us be sure to separate data from theory. On one hand, we can be confident that disinhibition is a real phenomenon, because it has been observed a number of times in different experiments (Bottjer, 1982; Winnick & Hunt, 1951). On the other hand, the inhibition theory may or may not be the correct explanation of why disinhibition occurs.

Rapid Reacquisition

The phenomenon of rapid reacquisition is similar to the "savings" that are found in experiments on list learning (Chapter 2) or habituation (Chapter 3). In classical conditioning, if a subject receives an acquisition phase, an extinction phase, and then another acquisition phase with the same CS and the same US, the rate of learning is substantially faster in the second acquisition phase—the *reacquisition phase.* Furthermore, the rate of learning tends to get faster and faster if a subject is given repeated cycles of extinction followed by reacquisition (Hoehler, Kirschenbaum, & Leonard, 1973). The speed of reacquisition is probably due in part to the presence of spontaneous recovery, or to some residual but hard-to-detect association between CS and US, which gives the subject a head start at the beginning of the reacquisition phase. However, even if steps are taken to control for these factors, the rate of reacquisition is still faster than original acquisition (Napier, Macrae, & Kehoe, 1992; Rescorla, 2003).

As with spontaneous recovery and disinhibition, we do not yet have a complete explanation for the phenomenon of rapid reacquisition. Nevertheless, these three phenomena make it abundantly clear that there is no simple way to get a subject to "unlearn" a conditioned response, and that no amount of extinction training can completely wipe out all the effects of a classical conditioning experience. Extinction can cause a conditioned response to disappear, and after repeated extinction sessions, spontaneous recovery may disappear, but the subject will never be exactly the same as before the conditioning began.

Conditioned Inhibition

Although disagreement still exists over whether inhibition plays an important role during extinction, there is general agreement that a CS can develop inhibitory properties as a result of certain conditioning procedures (see R. R. Miller & Spear, 1985). If it can be shown that a CS prevents the occurrence of a CR, or that it reduces the size of the CR from what it would otherwise be, then this CS is called an *inhibitory CS* or a **conditioned inhibitor** (sometimes designated as a CS$^-$). Pavlov discovered what is probably the simplest and most effective procedure for changing a neutral stimulus into a conditioned inhibitor. This procedure involves the use of two different CSs, such as a buzzer and a light. Suppose that in the first phase of an experiment, we repeatedly pair the sound of the buzzer with the presentation of food until the dog always salivates at the sound of the buzzer. The buzzer can now be called an **excitatory CS** (or CS$^+$), because it regularly elicits a CR. In the second phase of the experiment, the dog receives two types of trials. Some trials are exactly like those of phase one (buzzer plus food). However, on occasional trials both the buzzer and the light are presented simultaneously, but no food is delivered (see Figure 4-7). The simultaneous presentation of two or more CSs, such as the buzzer and the light, is called a **compound CS**. At first, the dog may salivate both on trials with the buzzer and on trials with the compound CS. As phase two continues, however, the animal eventually learns that no food ever appears on trials with the compound CS. The result is that the dog continues to salivate on trials with the buzzer alone, but little or no salivation occurs on trials with both the buzzer and the light.

	CS	US	CR
Training:			
	Buzzer	Food	Salivation
	Buzzer and Light	No Food	No Salivation
	Fan	Food	Salivation
Testing:			
	Fan and Light		No Salivation

FIGURE 4-7 A summation test for conditioned inhibition. After training in which the light appears to inhibit salivation to the buzzer, the light can also inhibit salivation to a different excitatory CS, a fan.

One way to give a convincing demonstration that the light has become a conditioned inhibitor is to show that it can prevent salivation to some other CS, not just to the buzzer with which it was trained. Suppose that a third stimulus, a fan blowing air into the chamber, is paired with food until it reliably elicits salivation. Now suppose that, for the first time, the animal receives a trial with a compound CS consisting of the fan and the light. This procedure of testing the combined effects of a known excitatory CS and a possible inhibitory CS is called a *summation test.* If the light is truly a conditioned inhibitor, it should have the capacity to reduce the salivation produced by any CS, not just by the buzzer with which it was originally presented. In this test, we would find that the light reduced or eliminated the CR to the fan, even though these two stimuli were never presented together before. This type of result indicates that the light is a general conditioned inhibitor, because it evidently has the ability to block or diminish the salivation elicited by any excitatory CS.

A second method for determining whether a stimulus is inhibitory is to measure how long it takes to turn the stimulus into an excitatory CS. Suppose that one group of dogs, the experimental group, has received the training with the buzzer and light described earlier, so we believe the light is a conditioned inhibitor. A second group of dogs, the control group, has not been exposed to the light before, so it is presumably a neutral stimulus for this group. Now suppose that both groups receive a series of trials with the light paired with food. Since the light is supposedly a conditioned inhibitor in the experimental group, this group should be slower to develop a CR of salivation to the light. This is because the training with the light and food must first offset the inhibitory properties of the light before a CR is observed. This technique of testing for the inhibitory properties of a CS is called a *retardation test* (Rescorla, 1969) because the development of conditioned responding should be retarded with a CS that is initially inhibitory. The retardation test and the summation test are the two most common techniques for showing that a CS is a conditioned inhibitor.

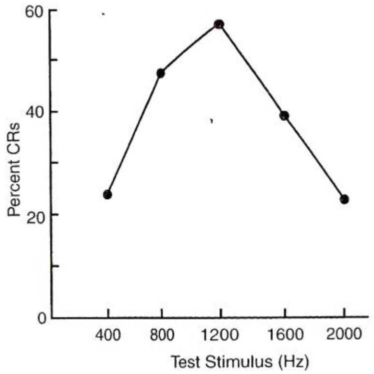
Why does the light become a conditioned inhibitor in this procedure? The following rule of thumb may make this phenomenon easier to understand: A stimulus will become a conditioned inhibitor if it reliably signals the absence of the US in a context where the US would otherwise be expected to occur. In our example, the buzzer was normally followed by food, but not when the light was normally presented. Because the light signaled the absence of an otherwise imminent US, it became an inhibitory CS.

Generalization and Discrimination

After classical conditioning with one CS, other, similar stimuli will also elicit CRs, although these other stimuli have never been paired with the US. This transfer of the effects of conditioning to similar stimuli is called **generalization**, which is illustrated in Figure 4-8. In this experiment on eyeblink conditioning, rabbits received a few hundred trials with a 1200-Hz tone as the CS and a shock near the eye as a US.

The data shown in Figure 4-8 were collected on a test day when tones of five different frequencies were repeatedly presented in a random sequence, but no US occurred on any trial. In

FIGURE 4-8 A typical generalization gradient. Rabbits in an eyeblink conditioning experiment received several hundred pairings of a 1200-Hz tone and a shock. The graph shows the results from a subsequent generalization test in which the 1200-Hz tone and four others were presented but never followed by the US. (From J. W. Moore, 1972)



other words, these tests were conducted under extinction conditions. As can be seen, the 1200-Hz tone elicited the highest percentage of CRs. The two tones closest in frequency to the 1200-Hz tone elicited an intermediate level of responding, and the more distant tones elicited the fewest responses. The function in Figure 4-8 is a typical **generalization gradient**, in which the x-axis plots some dimension along which the test stimuli are varied and the y-axis shows the strength of conditioned responding to the different stimuli. In general, the more similar a stimulus is to the training stimulus, the greater will be its capacity to elicit CRs.

Generalization can be used by advertisers to help them sell their products. Till and Priluck (2000) found that if consumers have a favorable attitude toward a particular brand name of a product, this favorable attitude generalizes to other brands that have similar names, and to other products with the same brand name. This can help to explain why many products you see in supermarkets and department stores have names and package designs similar to those of well-known brands.

The opposite of generalization is **discrimination**, in which a subject learns to respond to one stimulus but not to a similar stimulus. We have seen that if a rabbit's eyeblink is conditioned to a 1200-Hz tone, there will be substantial generalization to an 800-Hz tone. However, if the 800-Hz tone is never followed by food, but the 1200-Hz tone is always followed by food, the animal will eventually learn a discrimination in which the 1200-Hz tone elicits an eyeblink and the 800-Hz tone does not. This type of discrimination learning is important in many real-world situations. For instance, impala and other species of prey on the African plains can learn to discriminate between wild dogs that have just eaten (and will not attack again) and wild dogs on the hunt (which are very dangerous). The latter will elicit an obvious fear reaction in the prey, whereas the former will not.

Although the concepts of generalization and discrimination are easy to describe, a number of theoretical problems have puzzled psychologists since the time of Pavlov. Why does conditioning with one stimulus cause a "spread of excitation" to similar stimuli? Can we predict, in advance, what stimuli a subject will treat as similar? How does experience affect the shape of a generalization gradient? What types of training will produce the most accurate levels of performance in a task where a difficult discrimination is required? These and other questions about generalization and discrimination will be examined in Chapter 10.

WWW

The Encyclopedia of Psychology has links to many articles on classical conditioning and other types of learning at *http://www.psychology.org/links/Environment_Behavior_Relationships/Learning.*

PRACTICE QUIZ

1. In eyeblink conditioning, a tone could be used as the ________, and an air puff as the ________; an eyeblink is the ________.
2. A problem with Pavlov's stimulus substitution theory is that the ________ does not always resemble the ________.
3. Rescorla's (1973) experiment supported the theory of S-S associations because after responding to the US (loud noise) was reduced through habituation, responding to the CS ________.
4. Three phenomena that show that extinction is not the complete elimination of a learned association are ________, ________, and ________.
5. After classical conditioning with one CS, the appearance of conditioned responses to new but similar stimuli is called ________.

Answers

1. conditioned stimulus, unconditioned stimulus, conditioned response
2. conditioned response, unconditioned response
3. decreased
4. spontaneous recovery, disinhibition, rapid reacquisition
5. generalization

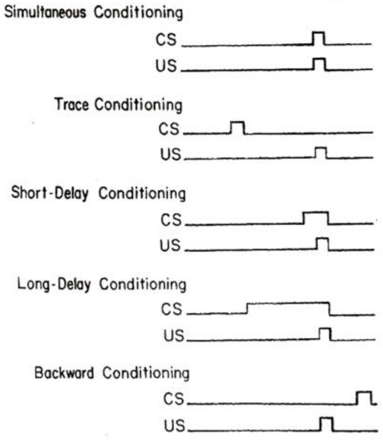
THE IMPORTANCE OF TIMING IN CLASSICAL CONDITIONING

In any experiment on classical conditioning, the precise timing of the CS and the US can have a major effect on the results. All of the experiments discussed so far involved what is called **short-delay conditioning** (Figure 4-9) in which the CS begins a second or so before the US. It is well established that this temporal arrangement produces the strongest and most rapid conditioning. The optimal delay depends on what conditioning preparation is used, who the subjects are, and other factors. For example, in human eyeblink conditioning, the fastest acquisition occurs with a delay of about 0.4 seconds if the subjects are young adults, but with older adults, conditioning is faster with a delay closer to 1 second (Solomon, Blanchard, Levine, Velazquez, & Groccia-Ellison, 1991).

Studies have shown that the early onset of the CS is important: In **simultaneous conditioning**, where the CS and US begin at the same moment (see Figure 4-9), conditioned responding is much weaker than in short-delay conditioning (M. C. Smith & Gormezano, 1965). This may be so for a number of reasons. For one thing, if the US begins at the same moment as the CS, the subject may be so busy responding to the US that it fails to notice the CS. Furthermore, if the CS does not precede the US, it cannot serve to signal or predict the arrival of the US. As we will see again and again, the predictiveness of a CS is an important determinant of the degree of conditioning the CS undergoes and of whether this conditioning is excitatory or inhibitory. The following rules of thumb, though not perfect, are usually helpful in predicting the outcome of a conditioning arrangement:

- To the extent that a CS is a good predictor of the presence of the US, it will tend to become excitatory.
- To the extent that a CS is a good predictor of the absence of the US, it will tend to become inhibitory.

FIGURE 4-9 The temporal relationships between CS and US in five types of classical conditioning.



Keep these rules in mind when examining the other conditioning arrangements discussed in this section.

As shown in Figure 4-9, **trace conditioning** refers to the case in which the CS and US are separated by some time interval in which neither stimulus is present. The term *trace conditioning* is derived from the notion that since the CS is no longer physically present when the US occurs, the subject must rely on a "memory trace" of the CS if conditioning is to occur. In a number of studies, the amount of time elapsing between CS and US presentations, or the **CS-US interval**, was systematically varied. That is, one group of subjects might receive a series of conditioning trials with a 2-second CS-US interval, another group with a 5-second CS-US interval, and so on. The results of such studies showed that as the CS-US interval is increased, the level of conditioning declines systematically (Ellison, 1964; Lucas, Deich, & Wasserman, 1981). In some cases, the decreases in conditioning are quite dramatic. For instance, in eyeblink conditioning there is virtually no evidence of conditioned responding if the CS and US are separated by as little as 2 seconds (Schneiderman, 1966).

A similar pattern emerges in **long-delay conditioning** where the onset of the CS precedes that of the US by at least several seconds, but the CS continues until the US is presented (see Figure 4-9). In long-delay conditioning, CS-US interval refers to the delay between the onsets of the CS and US. Here, too, the strength of the conditioned responding decreases as the CS-US interval increases, but the effects of delay are usually not as pronounced as in trace conditioning (which is understandable, since in long-delay conditioning, the subject does not have to rely on its memory of the CS). In both trace and delay conditioning, studies of the CS-US interval provide support for the Associationists' principle of contiguity. However, the results are also consistent with the predictiveness rule, because as the CS-US interval increases, it becomes increasingly difficult for the subject to predict the exact moment when the US will occur.

In long-delay conditioning, Pavlov noted that the timing of the CRs changed over trials. Early in training, a dog would salivate as soon as the CS was presented, although the CS-US interval might be 10 seconds. As conditioning trials continued, however, these early CRs would gradually disappear, and the dog would salivate shortly before the food was presented (8 or 9 seconds after CS onset). This pattern indicates, first of all, that the dog had learned to estimate the duration of the CS quite accurately. In addition, it is consistent with the rule that the stimulus that is the best predictor of the US will be the most strongly conditioned. In this example, what stimulus is a better predictor of the US than CS onset? It is the compound stimulus—CS onset plus the passage of about 10 seconds. Therefore, it is this latter stimulus that ultimately elicits the most vigorous CRs.

The bottom of Figure 4-9 shows an example of **backward conditioning** in which the CS is presented after the US. Even if the CS is presented immediately after the US, the level of conditioning is markedly lower than in simultaneous or short-delay conditioning. From the perspective of the contiguity principle, this does not make sense: If the CS and US are equally contiguous in short-delay conditioning and in backward conditioning, the contiguity principle predicts that equally strong CRs should develop. As with Ebbinghaus's backward-list experiment (Chapter 2), the weakness of backward conditioning points to a limitation of the contiguity principle; that is, besides their temporal proximity, the order of the stimuli is important. Although backward conditioning may result in a weak excitatory association (Ayres, Haddad, & Albert, 1987; Champion & Jones, 1961), there is evidence that after a sufficient number of trials, a backward CS becomes inhibitory (Siegel & Domjan, 1971). The reasons for this inhibitory conditioning are complex (see Tait & Saladin, 1986; A. R. Wagner & Larew, 1985), but once again the predictiveness rule can serve as a useful guide: In backward conditioning, the onset of the CS signals a period of time in which the US will be absent; that is, as long as the backward CS is present, the subject can be certain that no US will occur.

This entire discussion has treated the timing between CS and US as the critical variable, but some recent studies by Donahoe and Vegas (2004) suggest a different idea, namely, that the timing between CS and UR may actually be the critical factor. In most common examples of classical conditioning, this distinction is not important, because the UR occurs very soon after the US begins, so the timing between CS and US is about the same as the timing between CS and UR. However, Donahoe and Vegas used a conditioned response with pigeons (recording throat movements in response to water injected into the mouth) where the UR took a while to begin and lasted for a while once it did begin. They found that the timing between the CS and the throat movement UR was more important for conditioning than the CS-US relation. If this finding applies to other classical conditioning preparations, we may need to rethink how we analyze the timing of events in classical conditioning.

CS-US Correlations

In each of the conditioning arrangements discussed so far, the temporal pattern of stimulus presentations is exactly the same on every trial. For example, in long-delay conditioning the onset of the US always follows the onset of the CS by the same amount of time, and the US never occurs at any other time. We can describe this perfect correlation between CS and US with two probabilities: The probability that the US will occur in the presence of the CS is 1 (i.e., the US is certain to occur); the probability that the US will occur in the absence of the CS is 0. In the real world, however, the relationships between stimuli are seldom so regular. A rabbit in the forest must learn to recognize stimuli that could indicate that a predator is nearby. The rustling of leaves could be a predator, or it could be simply a breeze. On some occasions the sound of a snapped twig may mean a hunter is nearby; on other occasions it may not. There are also times when a predator's attack is not preceded by any perceptible stimulus.

These less-than-perfect correlations between signals and consequences can also be stated in probabilistic terms. Given a particular stimulus, the probability of an attack by a predator may be high (but not 1). In the absence of the stimulus, the probability of an attack may be lower (but not 0). Although the relationships among stimuli are variable and uncertain in the real world, the ability to detect those imperfect correlations that do exist between signals and consequences has obvious advantages. It is important for an animal to know which stimuli are the most dependable signals of possible danger. In the laboratory, classical conditioning procedures can be used to evaluate an animal's ability to detect imperfect correlations between stimuli.

A series of experiments by Rescorla (1966, 1968) showed how the probability of the US in the presence of the CS and in its absence combine to determine the size of the CR. In a conditioned suppression procedure with rats, the CS was a 2-minute tone that was presented at random intervals averaging 8 minutes. For one group of rats, there was a 40 percent chance that a shock would occur during a 2-minute CS presentation, and there was a 20 percent chance that a shock would occur in any 2-minute period when the CS was not present. The US might occur at any moment during the presence or absence of the CS. Notice that neither the presence nor the absence of a CS was a definite signal that a US would occur, and neither provided any information about the timing of a US (since a shock could occur at any time). The only information the CS provided was whether the probability of shock was high or low.

The results can be summarized as follows. Whenever the probability of shock was greater in the presence of the tone than in its absence, the tone became an excitatory CS (i.e., response suppression occurred when the tone was presented). When the probability of shock was the same in the presence and absence of the tone (e.g., a 40 percent chance of shock in both the presence and absence of the tone), there was no suppression at all to the tone. In another experiment, Rescorla included a group in which the chance of shock was actually lower when the CS was present than when it was absent (so the CS signaled a relative level of safety from shock), and in this case the CS became inhibitory.

Based on these results, Rescorla concluded that the traditional view of classical conditioning, which states that the *contiguity* of CS and US is what causes an association to develop, is incorrect. Notice that in the groups with equal probabilities of shock in the presence and absence of the CS, there were many pairings of the CS and US, yet there was no conditioning to the CS. Rescorla therefore proposed that the important variable in classical conditioning is not the contiguity of CS and US but rather the *correlation* between CS and US. If the correlation is positive (i.e., if the CS predicts a higher-than-normal probability of the US), the CS will become excitatory. If there is no correlation between CS and US (if the probability of the US is the same whether or not the CS is present), the CS will remain neutral. If the correlation between CS and US is negative (if the CS signals a lower-than-normal probability of the US), the CS will become inhibitory.

These studies clearly demonstrate a flaw in common belief about classical conditioning—that conditioning depends on a close pairing (contiguity) of CS and US. Instead of reciting the contiguity principle, students of classical conditioning would be much better off remembering the predictiveness rule: If a CS predicts that the US is likely to occur, the CS will become excitatory; if the CS predicts that the US is not likely to occur, the CS will become inhibitory. This rule is not perfect, but it works well in most cases.

HIGHER ORDER CONDITIONING

So far we have examined only procedures in which a CS is paired with (or correlated with) a US. However, this is not the only way a CS can acquire the ability to elicit a CR. In **second-order conditioning**, a CR is transferred from one CS to another. Pavlov described the following experiment to illustrate this process. First, the ticking of a metronome was firmly established as a CS in salivary conditioning by pairing the metronome with food. Because it was paired with the US, the metronome is called a **first-order CS.** Then another stimulus, a black square, was presented and immediately followed by the metronome on a number of occasions, but no food was presented on these trials. After a few trials of this type, the black square began to elicit salivation on its own, despite the fact that this stimulus was *never paired directly with the food* (but only with the metronome, a CS that was frequently paired with the food). In this example, the black square is called a second-order CS because it acquired its ability to elicit a CR by being paired with a first-order CS, the metronome.

Pavlov also reported that although it was quite difficult to obtain, he sometimes found evidence of third-order conditioning (the transfer of a CR from a second-order CS to yet another stimulus). He believed that these examples of second- and higher order conditioning were important because they broadened the scope of classical conditioning. If there were no such thing as higher order conditioning, then the only time an animal could learn through the process of classical conditioning would be when it encountered some US (food, water, a predator). But since higher order conditioning is possible, new CRs may be acquired any time the animal encounters an already conditioned CS along with some new, neutral stimulus. As more and more stimuli become CSs as a result of an animal's everyday experiences, the opportunities for further learning through higher order conditioning will expand at an increasing rate.

The following example illustrates how higher order conditioning can play an important role in an animal's ability to avoid dangerous situations in its environment. Although wolves are among the major predators of deer, the sight of a wolf does not elicit an unconditioned fear reaction in a young whitetail deer. Instead, the sight of a wolf must become a CS for fear as a result of a young deer's experience. This conditioning might occur in at least two ways. The sight of a wolf might be followed by an attack and injury to the young deer. More likely, however, the sight of wolves is simply paired with visible signs of fear in other deer. (Presumably, seeing the fear reactions of other deer elicits a fear reaction in the young deer.) Eventually, the sight of wolves becomes a first-order CS for a fear response in the young deer. Once this happens, higher order conditioning can occur whenever some initially neutral stimulus is paired with the sight of wolves. Perhaps certain sounds or odors frequently precede the appearance of wolves, and through second-order conditioning, these may come to elicit fear. Or perhaps wolves are usually encountered in certain parts of the forest, and so the deer becomes fearful and cautious when traveling through these places. Although these examples are hypothetical, they show how an initially neutral stimulus (the sight of wolves) can first develop the capacity to elicit a fear response and can then transfer this response to other stimuli.

Second-order conditioning has also been demonstrated with humans. For example, in a procedure called **evaluative conditioning**, subjects are asked to evaluate different stimuli—to rate how much they like them using a scale that ranges from "very disliked" to "very liked." The first-order CSs are typically words that people consistently rate as being positive (e.g., *honest* or *friendly*) or negative (e.g., *cruel* or *arrogant*). These words are first-order CSs, not unconditioned stimuli, because they would certainly have no value to someone who did not know the English language. For English speakers, these words presumably attained their positive or negative values because they have been associated with good or bad experiences in the past. In some studies, the second-order CSs are nonsense syllables, and if a nonsense syllable is repeatedly paired with a positive (or negative) word, subjects later give the nonsense syllable itself a positive (or negative) rating (Cicero & Tryon, 1989).

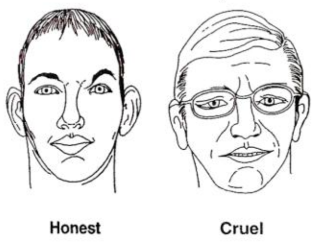


FIGURE 4-10 In evaluative conditioning, initially neutral stimuli such as pictures of faces are paired with positive or negative adjectives. After conditioning, people will have positive or negative reactions to the faces as well.

In one interesting study, pictures of people's faces were the second-order stimuli, and while looking at some of these faces, subjects heard either positive or negative adjectives (Figure 4-10). The subjects later rated the faces as being "liked" if they had been paired with positive adjectives and "disliked" if they had been paired with negative adjectives. These positive or negative ratings of the faces occurred even if the subjects could not remember the adjectives that had been paired with individual faces. In other words, subjects knew they liked some faces and disliked others, but they could not say exactly why (Baeyens, Eelen, Van den Bergh, & Crombez, 1992).

This type of evaluative conditioning has long been used in advertising. A commercial may present a certain brand of cola along with stimuli that most viewers will evaluate positively, such as young, attractive people having a good time. Advertisers hope that viewers will be attracted to the people and that this positive reaction will become conditioned to the product being sold. So if the conditioning is successful, you may later have a positive reaction when you see the product in a store, regardless of whether you remember the commercial.

CLASSICAL CONDITIONING OUTSIDE THE LABORATORY

Although experiments on salivation, eyeblinks, and the skin conductance response may seem far removed from the world outside the laboratory, we should not underestimate the importance of classical conditioning in everyday life. Classical conditioning is important outside the laboratory in at least two ways. First, it gives us a way of understanding "involuntary" behaviors, those that are automatically elicited by certain stimuli whether we want them to occur or not. As discussed in the next section, many emotional reactions seem to fall into this category. Second, research on classical conditioning has led to several major treatment procedures for behavior disorders. These procedures can be used to strengthen desired "involuntary" responses or to weaken undesired responses. The remainder of this chapter examines the role of classical conditioning in these nonlaboratory settings.

Classical Conditioning and Emotional Responses

For the most part, emotional responses such as feelings of pleasure, happiness, anxiety, or excitement are difficult to measure in another person, and this makes them difficult to analyze scientifically. However, if we temporarily dispense with scientific rigor and examine our introspections, it should become clear that these sorts of emotional reactions are frequently triggered by specific stimuli. Furthermore, it is often obvious that the response-eliciting properties of the stimulus were acquired through experience. Suppose you open your mailbox and find a letter with the return address of a close friend. This stimulus may immediately evoke a pleasant and complex emotional reaction that you might loosely call affection, warmth, or fondness. Whatever you call the emotional reaction, there is no doubt that this particular stimulus—a person's handwritten address on an envelope—would not elicit the response from you shortly after your birth, nor would it elicit the response now if you did not know the person who sent you the letter. The envelope is a CS that elicits a pleasant emotional response only because the address has been associated with your friend. Other stimuli can elicit less pleasant emotional reactions. For many college students, examination periods can be a time of high anxiety. This anxiety can be conditioned to stimuli associated with the examination process—the textbooks on one's desk, a calendar with the date of the exam circled, or the sight of the building where the exam will be held.

Classical conditioning can also affect our emotional reactions to other people. In one study using evaluative conditioning, subjects were asked to look at photographs of people's faces, and each photograph was paired with either a pleasant, neutral, or unpleasant odor. When subjects later had to evaluate their preferences for the people in the photographs (with no odors present), they gave the highest ratings to faces previously paired with pleasant odors and the lowest ratings to those paired with unpleasant odors (Todrank, Byrnes, Wrzesniewski, & Rozin, 1995). This research surely encourages companies that sell mouthwash, deodorant, and perfume.

It is instructive to look for examples of classical conditioning in your daily life. In the following example, many readers will probably understand the emotional reaction of my friend Phil. Like the video games that have largely replaced them, pinball games can evoke a high level of enjoyment and excitement in some people. I once watched as Phil took his turn on a pinball machine that awarded a free game for a high score. During the course of play, the winning of a free game was signaled by a loud clunk. As Phil reached the critical score and heard the loud clunk, he smiled with satisfaction and exclaimed, "That's the most beautiful sound in the world!" Of course, objectively speaking, the clunk was not a beautiful sound at all. What Phil probably meant was that for him, the sound evoked a pleasant emotional response. By being repeatedly paired with the winning of a free game, this ordinary sound gained the capacity to elicit the emotional response of excitement.

A personal example shows that conditioned emotional responses are not under voluntary control, and that they are not necessarily guided by logic or by a knowledge of one's environment. Before my wife, Laurie, and I were married, our jobs required us to live more than 200 miles apart. We visited each other on weekends, about twice a month. Laurie owns a very distinctive winter coat—a white coat with broad horizontal stripes of red, yellow, and green. It is easy to find her in a crowd when she is wearing that coat. One day when Laurie was at her job and I was at mine, I was walking across the campus when I saw, ahead of me, someone wearing a coat just like Laurie's. My immediate reaction was a good example of a conditioned response: My heart started pounding rapidly, as when a person is startled by a loud noise. This response persisted for 10 or 20 seconds. What is noteworthy about the response is that it did not make sense, because I knew Laurie was several hundred miles away and the person wearing the coat could not possibly be her. In addition, whereas Laurie has a full-length coat, the coat I saw was short, and the person wearing it was a man with a beard. Yet none of these discrepancies was enough to prevent my conditioned heart-rate response, and my skin conductance response undoubtedly exhibited a large increase as well.

Classical Conditioning and the Immune System

As you probably know, the body's immune system is designed to fight off infections. Whenever bacteria, viruses, or foreign cells enter a person's body, the immune system produces antibodies that attack and kill these invaders. For a long time, scientists tended to think of the immune system as a fairly independent system that had little communication with other bodily functions. This viewpoint has changed, however, and there is now abundant evidence for complex interactions between the immune system and the nervous system. To put it another way, there is abundant evidence that psychological factors can affect the workings of the immune system (Ader, 2001). For example, it is known that intense or prolonged psychological stress can weaken the immune system, making the individual more susceptible to illnesses ranging from the common cold to cancer.

There are also quite a few experiments showing that the immune system can be influenced by classical conditioning. Ader and Cohen (1975) conducted a landmark study in this area. They gave rats a single conditioning trial in which the CS was saccharin-flavored water and the US was an injection of cyclophosphamide, a drug that suppresses the activity of the immune system. A few days later, the rats were injected with a small quantity of foreign cells (red blood cells from sheep) that their immune systems would normally attack vigorously. One group of rats was then given saccharin-flavored water once again, whereas a control group received plain water. Ader and Cohen found that for rats in the saccharin-water group, the response of the immune system was weaker than for rats in the plain-water group; that is, fewer antibodies were produced by rats in the saccharin-water group. In other words, it appeared that the saccharin, which normally has no effect on the immune system, now produced a conditioned response, a weakening of the immune system. Later studies replicated this effect and, by ruling out other possible explanations, demonstrated that it is indeed due to classical conditioning (Ader, Felten, & Cohen, 1990).

On the other side of the coin, there is evidence that immune system activity can also be increased through classical conditioning. Solvason, Ghanata, and Hiramoto (1988) reported a particularly clear example of a conditioned increase in immune activity. Mice exposed to the odor of camphor as a CS were then injected with the drug interferon as the US. Interferon normally causes an increase in the activity of natural killer cells in the bloodstream—cells that are involved in combating viruses and the growth of tumors. After a few pairings of the camphor odor and interferon, presenting the camphor odor by itself was enough to produce an increase in activity of the natural killer cells. A similar study with healthy human adults also obtained increases in natural killer cells through classical conditioning (Buske-Kirschbaum, Kirschbaum, Stierle, Jabaij, & Hellhammer, 1994).

Although much about the nature of classically conditioned immune responses remains a mystery, researchers have recognized the potential importance of this phenomenon. For people whose immune systems have been temporarily weakened through illness or fatigue, the development of psychological techniques to strengthen immune activity could be beneficial (Olness, 1999). In contrast, some medical treatments require a decrease in immune activity. For example, in operations where an organ is transplanted from one person to another, it is essential to suppress the activity of the immune system so that the body does not reject the transplanted organ. One study with mice demonstrated that using conditioned stimuli may help in such situations. First, saccharin was paired with cyclophosphamide to establish it as a CS for immune suppression. The mice then received small grafts of transplanted skin. After receiving the skin grafts, some of the mice were again exposed to saccharin, and these mice were slower to reject the transplanted skin than were mice not given any more saccharin (Gorczynski, 1990). Human research on classical conditioning and the immune system is still fairly limited, but this type of research may eventually produce ways to better control immune system activity for the benefit of the patient.

Applications in Behavior Therapy

Systematic Desensitization for Phobias. One of the most widely used procedures of behavior therapy is **systematic desensitization**, a treatment for phobias that arose directly out of laboratory research on classical conditioning. A phobia is an excessive and irrational fear of an object, place, or situation. Phobias come in numerous forms, for example, fear of closed spaces, of open spaces, of heights, of water, of crowds, of speaking before a group, of taking an examination, of insects, of snakes, of dogs, and of birds. Some of these phobias may sound almost amusing, but they are no joke to those who suffer from them, and they are frequently quite debilitating. A fear of insects or snakes may preclude going to a picnic or taking a walk in the woods. A fear of crowds may make it impossible for a person to go to the supermarket, to a movie, or to ride on a bus or train. A fear of birds or of open spaces may literally make an individual a prisoner in his or her home.

How do phobias arise? After Pavlov's discovery, classical conditioning was seen as one possible source of irrational fears. This hypothesis was bolstered by a famous (or, more accurately, infamous) experiment by John B. Watson and Rosalie Rayner (1921). Watson and Rayner used classical conditioning to develop a phobia in a normal 11-month-old infant named Albert. Before the experiment, few things frightened Albert, but one that did was the loud noise of a hammer hitting a steel bar. Upon hearing the noise, Albert would start to cry. Since this stimulus elicited a reliable response from Albert, it was used as the US in a series of conditioning trials. The CS was a live white rat, which initially produced no signs of fear in Albert. On the first conditioning trial, the noise was presented just as Albert was reaching out to touch the rat, and as a result Albert began to cry. Albert subsequently received seven more conditioning trials of this type. After this experience, Albert's behavior indicated that he had been classically conditioned: He cried when he was presented with the white rat by itself. This experimentally induced fear also generalized to a white rabbit and to other white furry objects, including a ball of cotton and a Santa Claus mask. After a month had passed, these stimuli still elicited some fear in Albert, although his reactions to them were somewhat diminished.

If this experiment sounds cruel and unethical, rest assured that modern legal safeguards for the protection of human subjects would make it difficult or impossible for a psychologist to conduct such a study today. In any case, Watson and Rayner concluded that a long-lasting fear of an initially neutral stimulus can result from the pairing of that stimulus with some fearful event. Today, psychologists recognize that phobias are complex phenomena that can arise through means other than classical conditioning, such as through observational learning and verbal communication (Mineka, 1985; Rachman, 1991). Nevertheless, classical conditioning still seems to be an important component in the development of many phobias.

If this analysis is correct, then the principles of classical conditioning should also describe how a phobia can be cured. To be specific, if the CS (the phobic object or event) is repeatedly presented without the US, the phobia should extinguish. Yet numerous case histories indicate that phobias can be extremely persistent. Why is it that phobias do not gradually disappear on their own? For example, if a teenager's fear of crowds stems from a childhood experience in which he was lost in a crowd, why doesn't the phobia extinguish as a result of repeated exposures to crowds with no aversive consequences? One obvious explanation is simply that the individual carefully avoids the phobic object or event, and without exposure to the CS, extinction cannot occur. Another possible explanation is the self-sustaining nature of some phobias. Thus if a person is fearful of crowds, any attempt to attend a movie, a football game, or the like will result in fear, discomfort, and possibly embarrassment if the person becomes so anxious that he or she must leave abruptly. If this happens, the phobic stimulus has once again been paired with aversive consequences, and the phobia may be strengthened.

Systematic desensitization is a procedure in which the patient is exposed to the phobic object in a gradual way, so that fear and discomfort are kept to a minimum and extinction is allowed to occur. The treatment has three parts: the construction of a fear hierarchy, training in relaxation, and the gradual presentation of items in the fear hierarchy to the patient. The *fear hierarchy* is a list of fearful situations of progressively increasing intensity. At the bottom of the list is an item that evokes only a very mild fear response in the patient, and at the top is the most highly feared situation.

After the fear hierarchy is constructed, the patient is given training in **progressive relaxation**, or deep muscle relaxation. This technique, developed by Wolpe (1958), is a means of inducing a state of bodily calm and relaxation by having the person alternately tense and relax specific groups of muscles. For instance, the patient is first instructed to make

a fist and to tense all the muscles of the hand as tightly as possible. After holding this tension for 5 to 10 seconds, the patient is instructed to release the tension and to concentrate on making the muscles of the hand as relaxed and as limp as possible for 15 to 20 seconds. This same procedure is used for muscles in the arms, neck, head, trunk, and legs. The idea behind this procedure is that many people have a high level of muscle tension without being aware of it, and if simply told to "completely relax" a set of muscles, they will be unable to do so. However, by contrasting a high degree of muscle tension with subsequent relaxation, a person can learn to relax the muscles on cue. The progressive relaxation procedure takes about 20 minutes, and when it is completed patients usually report that they feel very relaxed. At this point the extinction of the phobia can begin.

The therapist begins with the weakest item in the hierarchy, describes the scene to the patient, and asks the patient to imagine this scene as vividly as possible. For example, in the treatment of a teenager who developed a fear of driving after an automobile accident, the first instruction was to imagine "looking at his car as it was before the accident" (Kushner, 1965). Because the patient is in a relaxed state, and because the lowest item did not evoke much fear to begin with, it usually can be imagined with little or no fear. The patient is instructed to continue to imagine the scene for about 20 seconds. After a short pause in which the patient is told to relax, the first item is again presented. If the patient reports that the item produces no fear, the therapist moves on to the second item on the list, and the procedure is repeated. The therapist slowly progresses up the list, being certain that the fear of one item is completely gone before going on to the next item. A typical fear hierarchy contains 10 or 15 items, but there have been cases in which lists of over 100 items were constructed. The hierarchy for the patient with a fear of driving included the following nine items:

1. Imagine looking at your car as it was before the accident.
2. Imagine leaning against your car.
3. Imagine sitting in your car with the ignition turned off.
4. Imagine sitting in your car and turning on the ignition, with the car stationary but the motor idling.
5. Imagine backing out of your driveway and turning the car so you are in a position to drive off.
6. Imagine driving the car around the block on which you live.
7. Imagine driving along a straight road with no intersections.
8. Imagine you are approaching an intersection with no traffic appearing.
9. Imagine approaching the same intersection with another car nearing the intersection to your right, where there is a stop sign. This was the situation leading to the patient's accident. (paraphrased from Kushner, 1965, pp. 194–195)

In this case, the patient made rapid progress, and after only six sessions, the young man could again drive his car without fear. A 3-month follow-up found no return of the phobic symptoms. This case history is a bit unusual in the brevity of therapy (10 to 20 sessions are more typical) but not in its final outcome. G. L. Paul (1969) reviewed about 75 published reports on the use of systematic desensitization that together involved thousands of patients. In most of these reports, about 80 to 90 percent of the patients were cured of their phobias—a very high success rate for any type of therapy in the realm of mental health. There were only a few reports of relapses and no evidence of symptom substitution (the appearance of a new psychological disorder after the original problem disappears). This mass of evidence suggests that systematic desensitization is an effective and efficient treatment for phobias.

The basic systematic desensitization procedure has been adapted and modified in many ways for use in different circumstances. In some cases, real stimuli are used instead of relying on the patient's imagination. Sturges and Sturges (1998) treated an 11-year-old girl with a fear of elevators by systematically exposing her to an elevator (beginning by having her just stand near an elevator, and ending with her riding alone on the elevator). In another variation of systematic desensitization, humor was used in place of relaxation training, based on the reasoning that humor would also counteract anxiety. Individuals with an extreme fear of spiders were asked to create jokes about spiders, and they were presented with humorous scenes involving spiders. This treatment proved to be just about as effective as the more traditional relaxation training in reducing spider phobias (Ventis, Higbee, & Murdock, 2001).

In the aftermath of the terrorist attacks of September 11, 2001, many employees of the Pentagon building in Washington DC were not emotionally prepared to reenter the building where so many of their friends and coworkers were killed or injured. To help them recover, health specialists used mass desensitization in which groups of about 50 employees were gradually reexposed to their workplace environment. They began with a bus ride to a hill overlooking the Pentagon, then proceeded to some of the damaged offices, and finally to the Pentagon's "ground zero," the site where the plane hit the building. Each step of the way the workers were encouraged to discuss their memories and their emotions, and they were assisted by stress management counselors. Although we must be careful in drawing conclusions because this was not a controlled experiment, all but one worker (who had physical injuries) were later able to return to work (Waldrep & Waits, 2002).

A technique that relies on modern computer technology is **virtual reality therapy**, in which the patient wears a headset that displays realistic visual images that change with every head movement, simulating a three-dimensional environment. For instance, a man with a fear of flying was exposed to more and more challenging simulations of riding in a helicopter, and eventually his fear of flying diminished. Virtual reality therapy has been successfully used for fears of animals, heights, public speaking, and so on (North, North, & Coble, 2002). This technique has several advantages over traditional systematic desensitization; namely, the stimuli are very realistic, they can be controlled precisely, and they can be tailored to the needs of each individual patient. The procedure does not rely on the patient's ability to imagine the objects or situations. Because of these advantages, it seems likely that the use of computer-generated stimuli will become more widespread in the future.

WWW

Full-text versions of some of the classic writings of Pavlov, Watson, and other psychologists are available at *http://psychclassics.yorku.ca/author.htm.*

Aversive Counterconditioning. Although it may sound paradoxical, people are frequently very poor at controlling their own behaviors. Consider several classes of behavior that are all too common in our society: overeating, excessive drinking, smoking, drug abuse. Whereas many people who engage in these behaviors know they are potentially harmful and claim they would like to stop, they also claim that they are unable to do so. The problem is that although the behaviors are detrimental to one's health, there are strong sources of motivation for continuing the behaviors. The motives may be of different types: Performing the behavior may be highly enjoyable, or refraining from the behavior may be unpleasant, or both. To put it simply, these behaviors have short-term advantages and long-term disadvantages. We will examine such conflicting motives in more detail in Chapter 14, but for now let us consider one behavioral technique designed to combat these unwanted behaviors.

The goal of **aversive counterconditioning** is to develop an aversive CR to stimuli associated with the undesirable behavior. For instance, if the patient is an alcoholic, the procedure may involve conditioning the responses of nausea and queasiness of the stomach to the sight, smell, and taste of alcohol. The term *counterconditioning* is used because the technique is designed to replace a positive emotional response to certain stimuli (such as alcohol) with a negative one. In the 1940s, Voegtlin and his associates conducted extensive research on the use of aversive counterconditioning as a treatment for

alcoholism (Voegtlin, 1940; Lemere, Voegtlin, Broz, O'Hallaren, & Tupper, 1942). Over the years, more than 4,000 alcoholics volunteered to participate in Voegtlin's distinctly unpleasant therapy. Over a 10-day period, a patient received about a half dozen treatment sessions in which alcoholic beverages were paired with an emetic (a drug that produces nausea). Conditioning sessions took place in a quiet, darkened room in which a collection of liquor bottles was illuminated to enhance their salience. First, the patient received an emetic, and soon the first signs of nausea would begin. The patient was then given a large glass of whiskey and was instructed to look at, smell, taste, and swallow the whiskey until vomiting occurred (which was usually no more than a few minutes). In later conditioning sessions, the whiskey was replaced with a variety of other liquors to ensure that the aversion was not limited to one type of liquor. It is hard to imagine a more unpleasant therapy, and the patients' willingness to participate gives an indication both of their commitment to overcome their alcoholism and of their inability to do so on their own.

Because a number of different treatments for alcoholism are known to promote short-term abstinence, the real test of a treatment's effectiveness is its long-term success rate. Figure 4-11 shows the percentages of former patients who were totally abstinent for various lengths of time after the therapy. As can be seen, the percentage of individuals who were totally abstinent declined over time. The diminishing percentages may reflect the process of extinction: If over the years a person repeatedly encounters the sight or smell of alcohol (at weddings, at parties, on television) in the absence of the US (the emetic), the CR of nausea should eventually wear off. At least two types of evidence support the role of extinction. First, patients who received "booster sessions" (further conditioning sessions a few months after the original treatment) were, on the average, abstinent for longer periods of time. Such reconditioning sessions probably counteracted the effects of extinction. Second, those who continued to associate with old drinking friends (and were thereby exposed to alcohol) were the most likely to fail.

If the declining percentages in Figure 4-11 seem discouraging, several points should be made. First, a similar pattern of increasing relapses over time occurs with every known treatment for alcoholism; in fact, Voegtlin's success rates are quite high compared to those of other treatments. Furthermore, these percentages are extremely conservative estimates of the success of Voegtlin's procedures, because he used a very strict criterion for success—total abstinence. Individuals who drank with moderation after the treatment were counted as failures, as were those who suffered a relapse, received reconditioning sessions, and were

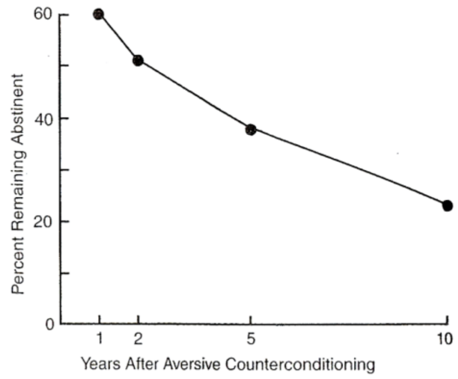


FIGURE 4-11 The percentages of Voegtlin's clients who remained completely abstinent for various amounts of time following aversive counterconditioning for alcoholism. (After Lemere & Voegtlin, 1950)

once again abstinent. Figure 4-11 therefore presents the most pessimistic view possible regarding the effectiveness of this treatment. In the United States, the use of aversive counterconditioning as a treatment for alcoholism has increased substantially since the 1970s, with success rates remaining about the same as those in Figure 4-11.

Aversive counterconditioning has also been used with reasonable success for other problems besides alcoholism, including drug use, cigarette smoking, overeating, and sexual deviations. Different aversive stimuli have been used including electric shock, unpleasant odors, or disgusting mental images. Counterconditioning is often included as one component of multifaceted treatment programs that also involve family counseling, self-control training, and other techniques (D. L. Johnson & Brinker, 2001; J. W. Smith & Frawley, 1990).

In a case study involving a sexual deviation, Marks and Gelder (1967) used electric shock as a US to eliminate a male client's fetish for female clothing. Before therapy, the client was sexually aroused by a photograph of a nude female (which is considered normal), but also by the sight of female panties, a slip, a skirt, and pajamas. The client then received 20 trials in which the panties were paired with shock, after which they no longer elicited arousal. Next, the other pieces of clothing were paired with shock, one at a time, until only the nude photograph (never paired with shock) elicited arousal. In this way, the man's abnormal sexual attraction to clothing was eliminated while leaving his sexual attraction to females intact.

In summary, aversive counterconditioning is a procedure that attempts to decrease unwanted behaviors by conditioning aversive reactions to stimuli associated with the behaviors. Its effectiveness is variable. It appears to be a useful procedure for eliminating certain sexual deviations. When used as a treatment for alcoholism or smoking, some clients have relapses, but others remain abstinent for years. The success rates are significantly higher than those found when individuals try to stop drinking or smoking without professional help. The effectiveness of aversive counterconditioning can be enhanced by offering periodic reconditioning sessions and by instructing clients to avoid stimuli associated with the problem behavior (bars, drinking companions, smoke-filled rooms, etc.).

Treatment of Nocturnal Enuresis. Children usually learn to use the toilet instead of wetting their pants by about age 3 or 4. For most children, the control of nighttime elimination occurs shortly afterward. However, a substantial portion of children continue to wet their beds at ages 5 and older, and this behavior becomes an increasing problem for both child and parents. Fortunately, most cases of nocturnal enuresis (bedwetting) can be cured by a straightforward procedure developed by Mowrer and Mowrer (1938), called the bell-and-pad method. The pad, a water-detecting device, is placed beneath the child's sheets; a single drop of urine will activate the device and ring the bell to wake up the child. The child is instructed in advance to turn off the alarm, go to the toilet and urinate, then go back to sleep. The bell and pad are used every night until the problem disappears.

In this procedure, the bell is a US that elicits two responses in the child: (1) awakening and (2) the tightening of those muscles necessary to prevent further urination (responses that occur because the child has no difficulty retaining urine when awake). The goal of the procedure is to transfer either or both of these responses to an internal CS—the sensations associated with having a full bladder. For simplicity, let us call the CS a full bladder. By repeatedly pairing a full bladder with the bell, the response of awakening and/or tightening the muscles so as to retain one's urine would eventually be elicited by the full bladder alone, before the bell sounds.

The classical conditioning explanation of the bell-and-pad method is not the only one; others have suggested that avoidance learning, as described in Chapter 8, is involved. Yet regardless of which is the most appropriate explanation, the procedure is largely successful. Various studies have found success rates of about 80 percent, and in some of the "unsuccessful" cases the symptoms, though not completely gone, were improved. Relapses are a frequent problem, however, with perhaps 25 percent of the children eventually experiencing a return of bedwetting. These relapses can be readily treated with a period of reconditioning, but Young and Morgan (1972) tried a modified procedure in an effort to minimize relapses. With the alarm system active, children were given a type of overlearning in which they drank two pints of liquid just before going to bed (thus making the task of remaining dry more difficult). Only 10 percent of the children trained with this procedure had relapses, compared to 20 percent without the overlearning procedure. The bell-and-pad method is more effective than the medications that are commonly prescribed to treat enuresis, and more doctors are now recommending this treatment method to parents (Houts, 2003; Vogel, Young, & Primack, 1996).

Summary of the Classical Conditioning Therapies. Behavior therapies based on principles of classical conditioning have been used to strengthen, eliminate, or replace behaviors. The Mowrers' treatment for nocturnal enuresis is an example of a procedure designed to strengthen a behavior (i.e., nighttime retention). Systematic desensitization is used to eliminate the emotional responses of fear and anxiety. Aversive counterconditioning is designed to replace pleasant emotional responses to such stimuli as alcohol and cigarette smoke with aversion. Each of these procedures has its share of failures and relapses, but each can also boast of long-term successes for a significant percentage of those who receive treatment.

PRACTICE QUIZ

1. When the CS and US are separated by some time interval, this is called ________.
2. In an evaluative conditioning procedure in which pictures of people are paired with either positive or negative adjectives, the adjectives are ________ and the pictures of people are ________.
3. If a rat drinks sweetened water and then receives a drug that suppresses the immune system, giving sweetened water at a later time can ________.
4. When the effectiveness of aversive counterconditioning for alcoholism weakens over time, this could be an example of the conditioning principle of ________.
5. In the classical conditioning treatment for bedwetting, the unconditioned stimulus is ________.

Answers

1. trace conditioning 2. first-order CSs, second-order CSs
3. suppress the immune system 4. extinction
5. an alarm that wakes up the child

SUMMARY

In its simplest form, classical conditioning involves the repeated pairing of a conditioned stimulus (CS) with an unconditioned stimulus (US) that naturally elicits an unconditioned response (UR). After repeated pairings, the CS starts to elicit a conditioned response (CR). Pavlov used the salivation response of dogs to study classical conditioning, but in modern research some common conditioning preparations are eyeblink conditioning, conditioned suppression, the skin conductance response, and taste-aversion learning.

According to Pavlov's stimulus substitution theory, the CS should produce the same response that the US originally did. In reality, however, sometimes the CR is different in form, and sometimes it is actually the opposite of the UR. At the physiological level, stimulus substitution theory states that neural centers for the CS become connected to either the center for the US (an S-S connection) or directly to the center for the response (an S-R connection). Some experiments on US devaluation or revaluation favor the S-S view.

Throughout the animal kingdom, instances of classical conditioning exhibit the same basic principles, including acquisition, extinction, spontaneous recovery, disinhibition, conditioned inhibition, generalization, and discrimination. The most effective temporal arrangement for conditioning occurs in short-delay conditioning; weaker conditioning usually occurs in simultaneous, long-delay, or trace conditioning. In backward conditioning, the CS may become a conditioned inhibitor. In other conditioning arrangements, such as second-order conditioning a CR is transferred, not from US to CS, but from one CS to another.

In everyday life, classically conditioned responses can be seen in our emotional reactions to many different stimuli. In behavior therapy, systematic desensitization is used to extinguish phobias by gradually presenting more and more intense fear-provoking stimuli while the patient is in a relaxed state. Aversive counterconditioning is used to replace positive responses to certain stimuli (e.g., alcohol, cigarettes) with negative responses. Alarm systems are used to train children to avoid bedwetting.

REVIEW QUESTIONS

1. Define CS, US, UR, and CR. Use the examples of salivary conditioning and conditioning of the skin conductance response to illustrate these four concepts.
2. What is Pavlov's stimulus substitution theory? What are its strengths and weaknesses? How do experiments on US devaluation or revaluation help to decide whether S-S or S-R associations are formed during classical conditioning?
3. What three different types of evidence show that extinction does not simply erase the association that was formed during classical conditioning?
4. Describe one temporal arrangement between CS and US that produces strong excitatory conditioning, one that produces weak excitatory conditioning, and one that can produce inhibitory conditioning. Give a reasonable explanation of why each different procedure produces the results that it does.
5. Explain how television advertisers can use classical conditioning to give viewers a positive feeling about their product. How could they use classical conditioning to give viewers a negative reaction to other brands? Can you think of actual commercials that use these techniques?
6. Explain how systematic desensitization is used to treat phobias. Explain how extinction and generalization are important parts of the procedure. Why don't phobias extinguish by themselves, without the need for treatment?
7. Describe how aversive counterconditioning can be used to treat alcoholism. Does the fact that some patients have relapses, especially many years after treatment, indicate that there is something incorrect about the principles of classical conditioning? Why or why not?

CHAPTER 5

Theories and Research on Classical Conditioning

LEARNING OBJECTIVES

After reading this chapter, you should be able to

- explain the blocking effect and why it is important
- describe the basic concepts of the Rescorla-Wagner model and how it accounts for conditioning phenomena such as acquisition, extinction, blocking, and conditioned inhibition
- describe the different types of associations that can form during classical conditioning
- explain how heredity can influence what animals and people learn through classical conditioning
- discuss the role that classical conditioning plays in drug tolerance and addiction
- describe research on the physiological mechanisms of classical conditioning in primitive animals, mammals, and humans

Chapter 4 described some of the most basic terms and concepts of classical conditioning and some of the ways it can affect our daily lives. Most of the concepts presented in that chapter either were developed by Pavlov or can be traced back to some of his ideas. Pavlov saw classical conditioning as a simple, mechanical, rule-governed type of learning, yet one that might account for a good deal of our learned behaviors. The present chapter examines some of the ways in which psychologists' conceptions of classical conditioning have changed over the years. Perhaps the clearest theme emerging from modern research on classical conditioning is that although it is one of the simplest types of learning, it is more complicated than was once believed. This is not to say that modern conditioning experiments have obtained chaotic results that follow no rules; rather, it is simply that the modern rules (theories) of conditioning have become more complex and more sophisticated.

This chapter will survey some current themes and issues in the field of classical conditioning. The chapter is divided into five sections, each of which addresses different questions. The first