Principles and Applications of Pavlovian Conditioning

A Lingering Fear

Juliette is an attorney for a prestigious law firm. Although her coworkers often ask her to socialize after work, Juliette always rejects their requests; instead, driving home, she proceeds hurriedly from her car to her apartment. Once inside, Juliette locks the door and refuses to leave until the next morning. On weekends, Juliette will shop with her sister, who lives with their parents several blocks away. However, once darkness approaches, Juliette compulsively returns to her apartment. Although her sister, her parents, or close friends sometimes visit during the evening, Juliette refuses any of their invitations to go out after dark. Several men—all seemingly pleasant, sociable, and handsome—have asked Juliette for dates during the past year. Juliette has desperately wanted to socialize with them, yet she has been unable to accept any of their invitations. Juliette's fear of going out at night and her inability to accept dates began thirteen months ago. She had dined with her parents at their home and had left about 9:30 p.m. Since it was a pleasant fall evening, she decided to walk the several blocks to her apartment. Within a block of her apartment, a man grabbed her, dragging her to a nearby alley. The man kicked her several times before running away upon hearing another person approach. Since Juliette did not see her assailant, the police doubted they could apprehend him. The few friends and relatives whom Juliette told about the attack tried to support her; yet, she found no solace. Juliette still has nightmares about the attack and often wakes up terrified. On the few occasions after the attack that Juliette did go out after dark, she felt very uncomfortable and had to return home. She has become fearful even thinking about having to go out at night and arranges her schedule so she is home before dark. Juliette wants to overcome her fears, but she does not know how to do it.

Juliette's fear of darkness is a classically conditioned emotional response that she acquired as a result of the attack. This fear motivates Juliette to avoid going out at night. In this chapter, we will describe the classical conditioning process responsible for Juliette's intense fear reaction. The learning mechanism that causes Juliette to avoid darkness will be discussed in Chapters 5 and 6.

Juliette does not have to remain afraid of going out into the darkness. There are two effective behavior therapies, systematic desensitization and flooding, that employ the classical conditioning process to eliminate intense, conditioned fear reactions like Juliette's. We will discuss systematic desensitization later in this chapter, and flooding in Chapter 5.

THE ACQUISITION OF THE CONDITIONED RESPONSE

The Conditioning Paradigm

Basic Components

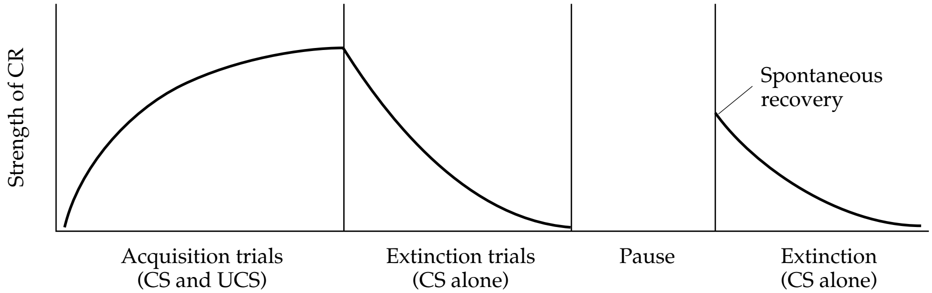
Four basic components make up the conditioning paradigm: (1) the **unconditioned stimulus (UCS),** (2) the **unconditioned response (UCR),** (3) the **conditioned stimulus (CS),** and (4) the **conditioned response (CR).** Prior to conditioning, the UCS elicits the UCR, but the CS cannot elicit the CR. During conditioning, the CS is paired with the UCS. Following conditioning, the CS is able to elicit the CR. The strength (or intensity) of the CR increases steadily during acquisition until a maximum or **asymptotic level** is reached (see **Figure 3.1**). The UCS-UCR complex is referred to as the **unconditioned reflex;** the CS-CR complex is called the **conditioned reflex.**

Although the pairing of the CS and UCS is essential to the development of the CR, other factors determine whether conditioning occurs as well as the final asymptotic level of the CR. We will detail the conditions that influence the ability of the CS to elicit the CR later in the chapter. Let's use two examples to illustrate the basic elements of conditioning.

The Conditioning of Hunger

Suppose you become hungry when arriving home after class; the home environment at this time of day is the CS eliciting the hunger reaction (the CR). This conditioned hunger reflects the association of arriving home (CS) with

FIGURE 3.1. Acquisition and extinction of a conditioned response. The strength of the conditioned response increases during acquisition, when the CS and UCS are paired, while presentation of the CS without the UCS during extinction lowers the strength of the conditioned response. The strength of the conditioned response will spontaneously recover when a short interval follows extinction, but it will decline again with additional presentations of the CS alone.



deprivation-induced hunger cues. A period of time without food is the UCS and the internal physiological changes produced by deprivation are the UCR. One probable cause of this conditioning is that you often arrive at home late in the day and have not eaten for awhile.

Your hunger undoubtedly intensifies when you go into the kitchen and see the refrigerator. Opening the refrigerator, you notice the milk and pie. Why does the sight of the refrigerator and the food increase your hunger and your motivation to obtain food? The answer lies in the association of the kitchen, the refrigerator, and the sight of food (CSs) with the taste and the smell of the food (UCSs).

When animals or people are exposed to food, they exhibit a set of unconditioned responses which prepare them to digest, metabolize, and store ingested food. These unconditioned feeding responses include the secretion of saliva, gastric juices, pancreatic enzymes, and insulin. One important action of insulin is to lower blood glucose, which in turn stimulates hunger and motivates eating (Mayer, 1953). Thus, we become hungry when we taste or smell food. The intensity of these unconditioned feeding responses is directly related to the palatability of food. The more attractive the food, the greater the unconditioned feeding responses and the more we eat.

These unconditioned feeding responses to food can be conditioned (Powley, 1977). The conditioning of these feeding responses to environmental cues plays an important role in your motivation to eat when you arrive home. Since cues such as the kitchen and the refrigerator have been associated with food, they are capable of eliciting these feeding responses. As a result of this conditioning experience, when you go to the kitchen and see the refrigerator, your body reflexively releases insulin, which lowers your blood glucose level and makes you hungry. As we will discover shortly, the strength of the conditioned response (CR) is dependent upon the intensity of the unconditioned stimulus (UCS). If you have associated the environment of the kitchen with highly palatable foods capable of eliciting an intense unconditioned feeding reaction, the stimuli in the kitchen will elicit an intense conditioned feeding response, and your hunger will be acute.

The Conditioning of Fear

For most people, experiencing turbulence in an airplane is an unpleasant event. When the plane drops suddenly and sharply (the UCS), an unconditioned pain reaction is elicited (the UCR). The psychological distress you experience when the airplane drops is one aspect of your pain reaction; the increased physiological arousal is another aspect. Although the unpleasantness may lessen as the plane continues to shake, you will most likely not experience relief until the turbulence ends.

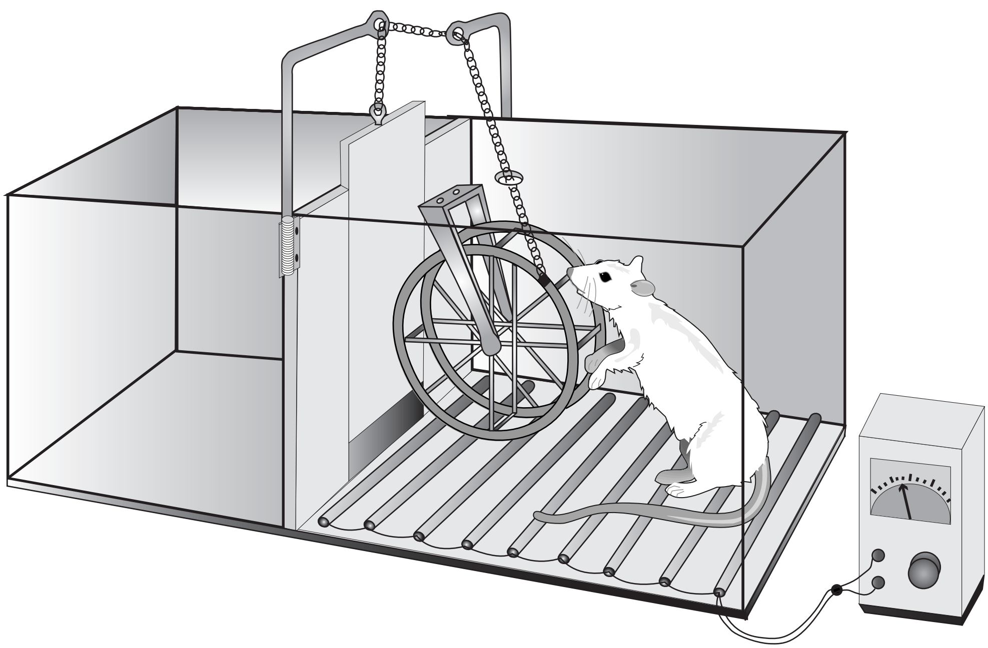
Experiences with turbulence differ considerably in their degree of aversiveness. You respond intensely to some experiences; others elicit only a mild pain reaction. Many factors determine the level of aversiveness. The severity of the turbulence is one factor influencing how intensely you respond; a lot of air movement will elicit a stronger pain reaction than a little air movement. This is one example of the influence of the strength of the UCS on the intensity of the UCR. Another factor that often affects the aversiveness of experiencing turbulence is the number of times you have experienced it before. You may experience less distress if you have never before encountered turbulence than if you have often experienced the unsettling motion of a plane (sensitization).

Through past experiences, the cues that predict turbulence become able to elicit an anticipatory pain reaction (the CR). We typically call this anticipatory pain reaction "fear." One stimulus associated with turbulence is slight movements of the airplane. Thus, you may become frightened (CR) when the plane dips or shakes slightly (CS). Another cue may be storm clouds or a darkening sky. Each of these CSs may have been associated with sudden and sharp movement of the airplane; if so, each can become able to elicit fear. Even a forecast of bad weather might become a conditioned stimulus that elicits fear.

Psychologists have consistently observed that fear is conditioned when a novel stimulus (the CS) is associated with an aversive event. The Russian physiologist Bechterev's (1913) observation that a conditioned response (for example, withdrawal of the leg) can be established by pairing a neutral stimulus with shock, was the first experimental demonstration of fear conditioning. In 1916, John Watson showed that emotional arousal can be conditioned during the pairing of a novel stimulus with shock. Other researchers have consistently reported the development of fear through classical conditioning in animals (Miller, 1948) and humans (Staats & Staats, 1957).

Fear also motivates an escape response to an aversive event. Neal Miller's classic 1948 study demonstrates the motivational properties of fear. Miller first conditioned fear in rats by administering electric shock in the white compartment of a shuttle box apparatus (see **Figure 3.2**). After administering the shock,

FIGURE 3.2. Apparatus similar to the one Miller (1948) employed to investigate acquisition of a fear response. The rat's emotional response to the white chamber, previously paired with shock, motivates the rat to learn to turn the wheel, which raises the gate and allows escape.



Miller allowed the rats to escape into the black compartment. After the initial pairings of the white compartment with shock, he confined the animals in the white compartment without presenting any additional shock. However, each rat could escape the white chamber by turning a wheel to open the door to the black compartment. Miller found that about half of the rats learned to turn the wheel to escape the aversive white chamber; the other half "froze" and did not learn the required response. The results show that the association of an environment (the white chamber) with an unconditioned aversive event (shock) can cause the environment to acquire motivational properties.

We learned earlier that the degree of hunger various environmental cues induce depends upon the UCS intensity; the stronger the UCS, the more intense our conditioned hunger reaction. The strength of the aversive unconditioned event also influences our conditioned fear reaction. We are more fearful of flying when the weather is bad than when the sun is shining and there are no storm clouds in the sky.

Not all people are frightened by flying in turbulent conditions, and some do not learn that driving is one way to reduce fear and avoid an unpleasant airplane ride. This chapter describes the conditions which influence the development of a conditioned fear response. Chapter 5 will detail the factors that govern avoidance acquisition.

Other Examples of Conditioned Responses

Hunger and fear are not the only examples of responses that can be conditioned. Other examples include feeling nauseous when seeing a type of food that has previously made you ill, becoming thirsty at a ball game as a result of previously consuming drinks in that setting, experiencing sexual arousal during a candlelight dinner because of previous sexual activity, and lowering your head when going down the stairs to the basement due to previously hitting your head when going down the stairs. These examples not only demonstrate four additional conditioned responses—nausea, thirst, sexual arousal, and lowering the head—but also show that stimuli other than food or shock can be involved in the conditioning process. The four unconditioned stimuli in the above examples are poison, fluid, sexual activity, and hitting your head. Of course, people encounter many more conditioned responses and unconditioned stimuli in the real world. Other examples are presented throughout the chapter.

Most of the experiments on classical conditioning have investigated the conditioning of only a single conditioned response. In most cases, several responses are conditioned during CS-UCS pairings. The conditioning of several responses has an obvious adaptive value. For example, when a CS is experienced along with food, several different digestive responses occur: the conditioned salivary reflex aids in swallowing, the conditioned gastric secretion response facilitates digestion, and the conditioned insulin release enhances food storage.

Conditioning Situations

Psychologists now use several techniques to investigate the conditioning process. Pavlov's surgical technique to measure the visceral reactions (saliva, gastric juices, insulin) to stimuli associated with food is the most familiar measure of conditioning. Other techniques that reveal the strength of conditioning include sign tracking, eyeblink conditioning, fear conditioning, and flavor-aversion learning. These measures of conditioning will be briefly described to familiarize you with the techniques; their widespread use will be evident in our discussion of Pavlovian conditioning principles and applications in this chapter.

Sign Tracking

Animals need to locate rewards (for example, food and water) in their natural environments. How do they find these rewards? Environmental events, or stimuli signaling the availability of reward, are approached and contacted by animals seeking reward. By tracking these environmental stimuli, an animal is able to obtain reward. Consider a predator tracking its prey: certain sights, movements, odors, and noises are characteristic of the prey. The predator can catch the prey only by approaching and then contacting these stimuli.

Predatory aggressive behavior reflects an instinctive species-specific response that can be improved with experience—experience increases a predatory animal's ability, for example, to aim its biting response toward the desired part of the prey (Eibl-Eibesfeldt, 1970) and to attack motionless prey (Eibl-Eibesfeldt, 1961; Fox, 1969). Predators, according to Eibl-Eibesfeldt, learn to limit their attack to the anterior part of the prey in order to avoid being bitten.

The establishment of effective predatory behavior is not the result of instrumental conditioning, or when a specific behavior is required to receive a reward, because a young predator's attack response improves even when its predatory behavior is unsuccessful. Furthermore, although nonpredatory animals can learn to kill other animals for food, they do not exhibit the instinctive species-specific responses characteristic of predatory behavior. For example, Moyer reported in 1972 that while nonpredatory rats can be trained to kill and eat mice, they never acquire the neck-biting aggressive response that predatory rats show. Pavlovian conditioning undoubtedly contributes to the enhancement of the predatory attack by causing the animal to approach and contact the stimuli characteristic of the prey.

Brown and Jenkins (1968) conducted the first **sign-tracking,** or **autoshaping,** experiment. They placed pigeons in an operant chamber; this environmental chamber contained a small circular key, which could be illuminated, and a food dispenser. [In the typical operant conditioning situation, an animal (in this case a pigeon) must respond (peck at the key) in order to receive reinforcement. A more extensive discussion of operant conditioning will be found in Chapter 4.] Hungry pigeons were fed at 15-second intervals, and the key was illuminated for 8 seconds prior to each food presentation. The pigeons did not have to do anything to obtain food. Brown and Jenkins reported that the pigeons, instead of approaching the food dish when the food was presented, started to peck at the key. The pigeons did not have to peck at the key to obtain food, but the presentation of the illuminated key prior to food was sufficient to elicit a key-pecking response. The measure of conditioning was the frequency with which the pigeons responded to the key. The acquisition of the key-pecking response was slow, and the pigeons only gradually learned to peck at the illuminated key.

Perhaps you think that the pigeons' key pecking in the Brown and Jenkins study is an instrumental response reinforced by food rather than a conditioned response elicited by the illuminated key (see the discussion of the law of effect in Chapter 1). If the key pecking is indeed an operant response, then its characteristics would not differ with the use of various reinforcers. However, if the illuminated key is producing an instinctive response, then the pigeons' response will differ with various rewards. The research on autoshaping with reinforcers other than food indicates that the key-pecking response is a conditioned response rather than an operant behavior in the autoshaping paradigm.

Jenkins and Moore (1973) used either food or water as the reinforcer in their autoshaping study. Observations of the pigeons' key-pecking responses demonstrated distinct differences between pigeons receiving the reinforcer of food and those receiving water. Pigeons autoshaped with food pecked the key sharply and vigorously; their behavior resembled their response toward food. Pigeons autoshaped with water exhibited a slower, more sustained contact with the key. Furthermore, these pigeons frequently made swallowing movements; their behavior toward the key resembled their response to water. Jenkins and Moore also autoshaped pigeons using two keys: one with food reinforcement, the other with water reinforcement. The pigeons responded with intense, short pecks to the key associated with food and with slow, sustained contact to the key paired with water.

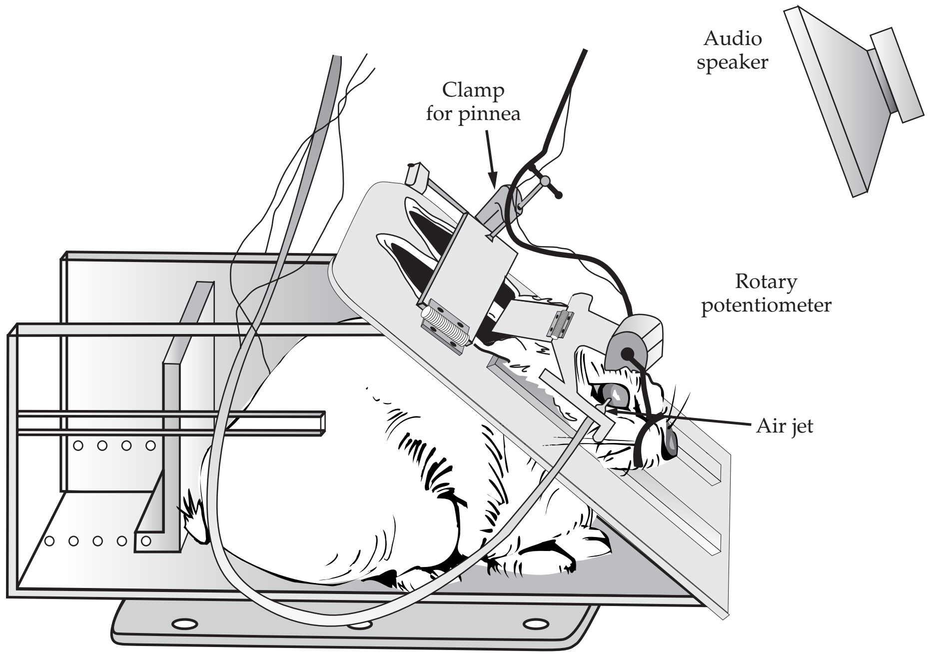
In an interesting study of autoshaping, Rackham (1971) reported conditioned fetish behavior in pigeons. Rackham used four mated pairs of birds, housing the male and female of each pair in adjacent compartments of a large chamber with a sliding door separating the two birds. A stimulus, a light, was turned on daily just prior to the removal of the sliding door, which allowed the male to initiate courtship with the female. Rackham initially observed that when the light came on, the male pigeons began to approach the light, nodding and bowing. They then began cooing, strutting, and pirouetting. Finally, midway through the study, Rackham observed the male pigeons emitting nest calls. The male pigeons' response to the light stimulus was similar to behavior they exhibited to the female. This conditioned courtship response, like the autoshaped eating and drinking responses observed by Jenkins and Moore (1973), was directed toward the conditioned stimulus.

Eyeblink Conditioning

A puff of air is presented to a rabbit's eye. The rabbit reflexively blinks its eye. If a tone is paired with the puff of air, the rabbit will come to blink in response to the tone as well as to the puff of air. The pairing of a tone (CS) with the puff of air (UCS) leads to the establishment of an eyeblink response (CR). The process that leads to the rabbit's response is called **eyeblink conditioning** (see **Figure 3.3**).

Eyeblink conditioning is possible because the rabbit not only has an outer eyelid similar to that of humans, but also an inner eyelid called a nictitating membrane. The nictitating membrane reacts by closing whenever it detects any air movement near the eye. The closure of the nictitating membrane then causes the rabbit's eye to blink. Researchers have widely used eyeblink conditioning to investigate the nature of Pavlovian conditioning (Gormezano, Kehoe, &

FIGURE 3.3. Illustration of an apparatus used to condition an eyeblink response. The potentiometer records the closure of the eye following its exposure to a puff of air (UCS) or a tone (CS).



Marshall, 1983). They have also used it to study the brain mechanisms that underlie conditioning (Thompson, Hicks, & Shvyrok, 1980). While most eyeblink conditioning studies have used rabbits as subjects, eyeblink conditioning also occurs in humans.

We need to make several important points about eyeblink conditioning. A puff of air (the UCS) will elicit a rapid eyeblink response. A mild irritation of the skin below the eye with a brief electrical shock will also produce a rapid, unconditioned eyeblink response. By contrast, the CS (tone, light, or tactile stimulus) will produce a slow, gradual closure of the eye. The measure of conditioning is the percentage of trials in which the rabbit responds to the CS. Eyeblink conditioning is quite slow, taking as many as 100 CS-UCS pairings before the rabbit responds to the CS on 50% of the trials.

Fear Conditioning

We discussed several examples of **fear conditioning** earlier in the chapter. Fear can be measured in several ways. One measure is escape or avoidance behavior in response to a stimulus associated with a painful UCS. However, while avoidance behavior is highly correlated with fear, avoidance performance does not automatically provide a measure of fear. As we will discover in Chapter 6, animals show no overt evidence of fear with a well-learned avoidance behavior (Kamin, Brimer, & Black, 1963). Further, animals can fail to avoid despite being afraid (Monti & Smith, 1976).

Another measure of fear is the **conditioned emotional response (CER).** Animals may freeze in an open environment when exposed to a feared stimulus. They will suppress operant behavior reinforced by food or water when a feared stimulus is present. Estes and Skinner (1941) developed a CER procedure for detecting the level of fear, and their methodology has been used often to provide a measure of conditioned fear (Davis, 1968; Hoffman, 1969). Fear conditioning develops much more rapidly than eyeblink conditioning, and significant suppression can be found within 10 trials.

To obtain a measure of conditioned fear, researchers first have animals learn to bar press or key peck to obtain food or water reinforcement. Following operant training, a neutral stimulus (usually a light or tone) is paired with an aversive event (usually electric shock or a loud noise). The animals are then returned to the operant chamber, and the tone or light CS is presented during the training session. The presentation of the CS follows an equal period of time when the CS is not present. Fear conditioned to the tone or light will lead to suppression of operant behavior. If fear is conditioned only to the CS, the animal will exhibit the operant behavior when the CS is not present.

To determine the level of fear conditioned to the CS, a suppression ratio is calculated. This **suppression ratio** compares the level of response during the interval when the CS is absent to the level of response when the CS is present. To obtain the ratio, the number of responses during the CS is divided by the total number of responses (responses during and before the CS).

$$\text{Suppression ratio} = \frac{\text{Responses during CS}}{\text{Responses during CS} + \text{Responses without CS}}$$

How can we interpret a particular suppression ratio? A suppression ratio of 0.5 indicates that fear has not been conditioned to the CS, because the animal responds equally when the CS is on and off. For example, if the animal responds 15 times when the CS is on and 15 times when it is off, the suppression ratio will be 0.5. A suppression ratio of 0 indicates that the animal responds only when the CS is off; for example, an animal might respond 0 times when the CS is on and 15 times when the CS is off. Only on rare occasions will the suppression ratio be as low as 0 or as high as 0.5. In most instances, the suppression ratio will fall between 0 and 0.5.

Flavor Aversion Learning

I have a friend who refuses to walk down a supermarket aisle where tomato sauce is displayed; he says that even the sight of cans of tomatoes makes him ill. My oldest son once got sick after eating string beans, and now he refuses to touch them. I once became nauseous several hours after eating at a local restaurant, and I have not returned there since. Almost all of us have some food we will not eat or a restaurant we avoid. Often, the reason for this behavior is that at some time we experienced illness after eating a particular food or dining at a particular place, and we associated the food or the place with the illness through classical conditioning. Such an experience creates a conditioned **flavor aversion** to the taste (or smell or sight) of the food or the place itself. Subsequently, we avoid it.

The classic research of John Garcia and his associates (Garcia, Kimeldorf, & Hunt, 1957; Garcia, Kimeldorf, & Koelling, 1955) demonstrated that animals learn to avoid a flavor associated with illness. Although rats have a strong preference for saccharin and will consume large quantities even when nondeprived, Garcia and colleagues discovered that the animals will not drink saccharin if illness follows its consumption. In their studies, rats were made ill after consuming saccharin by agents such as X-ray irradiation or lithium chloride; the rats subsequently avoided the taste of saccharin. The measure of conditioning is the amount of the fluid or food consumed. Flavor aversion learning is quite rapid, with significant avoidance observed after a single trial.

Does a person's dislike for a particular food reflect the establishment of a flavor aversion? It seems reasonable that people's aversion to a specific food often develops after they eat it and become ill. Informally questioning the students in my learning class last year, I found that many of them indeed had had an experience in which illness followed eating a certain food and that these students no longer could eat that food. If you have had a similar experience, perhaps you too can identify the cause of your aversion to some food. In a more formal investigation, Garb and Stunkard (1974) questioned 696 subjects about their food aversions, reporting that 38% of the subjects had at least one strong food aversion. The researchers found that 89% of the people reporting a strong food aversion could identify a specific instance associated with illness after eating the food. Even though most often the illness did not begin until several hours after consumption of the food, the subjects still avoided the food subsequently. Also, Garb and Stunkard's survey indicated that the subjects were more likely to develop aversions between the ages of 6 and 12 than at any other age.

More recent surveys suggest that the number of persons with flavor aversions is even higher than Garb and Stunkard reported. For example, Logue, Ophir, and Strauss (1981) found that over half of the college students they surveyed reported at least one food aversion. Further, many people have an aversion to a flavor even when they know that the flavor did not cause the illness. This observation suggests that aversions are controlled by mechanistic rather than cognitive processes; we will have more to say about the nature of flavor-aversion learning in Chapter 10.

Conditioning Paradigms

Five different paradigms have been used in conditioning studies (see **Figure 3.4**). These procedures represent the varied ways to pair a CS with a UCS. As we will discover, they are not equally effective.

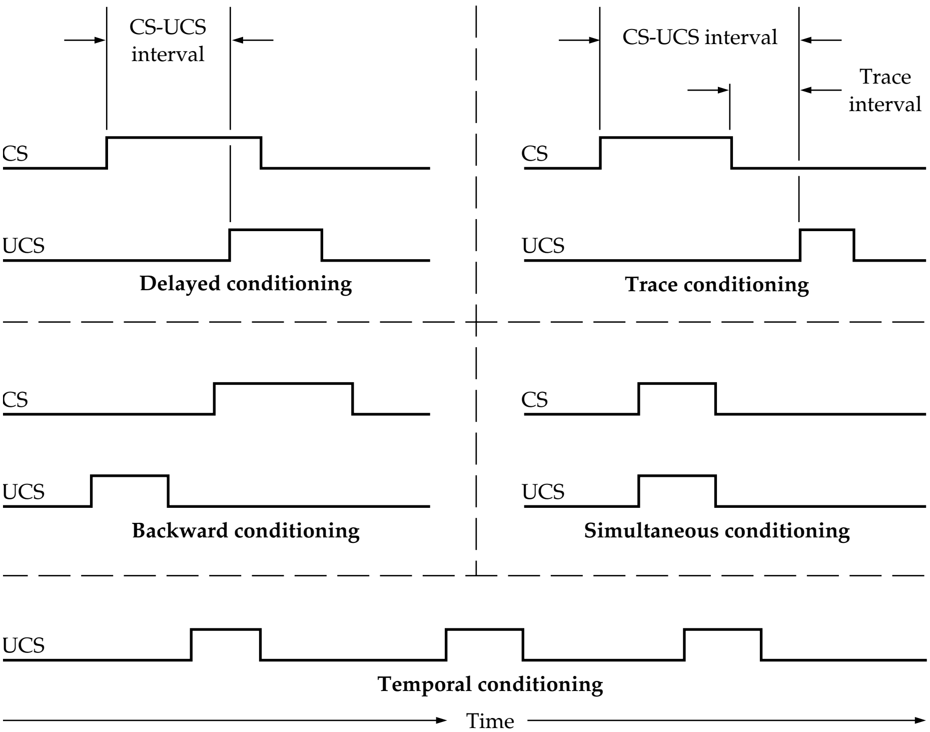
Delayed Conditioning

In **delayed conditioning,** the CS onset precedes UCS onset. The termination of the CS occurs either with UCS onset or during UCS presentation. If, for instance, a darkening sky precedes a severe storm, delayed conditioning may occur. The darkening sky is the CS; its occurrence precedes the storm, and it remains present until the storm occurs. A person who has experienced this type of conditioning may be frightened whenever he or she sees a darkened sky.

Trace Conditioning

With this conditioning paradigm, the CS is presented and terminated prior to UCS onset. A parent who calls a child to dinner is using a trace conditioning

FIGURE 3.4. Schematic drawing of the five major classical conditioning paradigms. The CS occurs prior to the UCS, but remains on until the UCS is presented in delayed conditioning; the CS occurs and ends prior to the UCS in trace conditioning; the CS and the UCS occur together in simultaneous conditioning; and the CS occurs after UCS in backward conditioning. There is no explicit CS in temporal conditioning.



procedure. In this example, the announcement of dinner (CS) terminates prior to the presentation of food (UCS). As we will discover in the next section, the hunger that this **trace conditioning** paradigm elicits can be quite weak unless the interval between CS termination and UCS onset (the trace interval) is very short.

Simultaneous Conditioning

The CS and UCS are presented together when the **simultaneous conditioning** paradigm is used. An example of simultaneous conditioning would be walking into a fast food restaurant. In this setting, the restaurant (CS) and the smell of food (UCS) occur at the same time. The simultaneous conditioning procedure in this case would probably lead to weak hunger conditioned to the restaurant.

Backward Conditioning

In the **backward conditioning** paradigm, the UCS is presented and terminated prior to the CS. Suppose that a candlelight dinner (CS) follows sexual activity (UCS). With this example of backward conditioning, sexual arousal to the candlelight dinner may not develop. In fact, contemporary research (Tait & Saladin, 1986) indicates that the backward conditioning procedure often results in the development of another type of CR. The backward conditioning paradigm is also a conditioned inhibition procedure; that is, the CS is actually paired with the absence of the UCS. In some instances, a person would experience a conditioned inhibition rather than conditioned excitation when exposed to the CS. We will look at the factors that determine whether a backward conditioning paradigm conditions excitation or inhibition in Chapter 9.

Temporal Conditioning

There is no distinctive CS in **temporal conditioning.** Instead, the UCS is presented at regular intervals, and over time the CR will be exhibited just prior to the onset of the UCS. To show that conditioning has occurred, the UCS is omitted, and the strength of the CR assessed. What mechanism allows for temporal conditioning? In temporal conditioning, a specific biological state often provides the CS. When the same internal state precedes each UCS exposure, that state will be conditioned to elicit the CR.

Consider the following example to illustrate the temporal conditioning procedure. You set your alarm to awaken you at 7:00 A.M. for an 8:00 A.M. class. After several months, you awaken just prior to the alarm's sounding. The reason lies in the temporal conditioning process. The alarm (UCS) produces an arousal reaction (UCR), which awakens you. Your internal state every day just before the alarm rings (the CS) becomes conditioned to produce arousal; this arousal (CR) awakens you prior to the alarm's sounding.

The five different paradigms for presenting the CS and UCS are not equally effective (Keith-Lucas & Guttman, 1975). The delayed conditioning paradigm usually is the most effective; the backward conditioning, the least. The other three paradigms typically have an intermediate level of effectiveness.

BEFORE YOU GO ON

- **How might a clinical psychologist measure Juliette's fear of darkness?**
- **What conditioning paradigm was responsible for the conditioning of Juliette's fear?**

Conditions Affecting the Acquisition of a Conditioned Response

In the last section, we learned that a conditioned response develops when a novel stimulus is paired with an unconditioned stimulus. However, the pairing of a CS and a UCS does not automatically insure that the subject will acquire a conditioned response. A number of factors determine whether a CR will develop following CS-UCS pairings. Let us now look at the factors that play an important role in classical conditioning.

Contiguity

Consider the following example to illustrate the importance of contiguity to the development of a conditioned response. An 8-year-old girl hits her 6-year-old brother. The mother informs her aggressive daughter that her father will punish her when he gets home from work. Even though this father frequently punishes his daughter for aggression toward her younger brother, the mother's threat instills no fear. The failure of her threat to elicit fear renders the mother unable to curb her daughter's inappropriate behavior.

Why doesn't the girl fear her mother's threat, since it has been consistently paired with her father's punishment? The answer to this question relates to the close temporal pairing, or **contiguity,** of the CS and UCS in classical conditioning. A threat (the CS) provides information concerning future punishment and elicits the emotional state that motivates avoidance behavior. Although the mother's threat does predict future punishment, the child's fright at the time of the threat is not adaptive, since the punishment will not occur for several hours. Instead of being frightened from the time that the threat is made until the father's arrival, the girl becomes afraid only when her father arrives. This girl's fear now motivates her to avoid punishment, perhaps by crying and promising not to hit her little brother again.

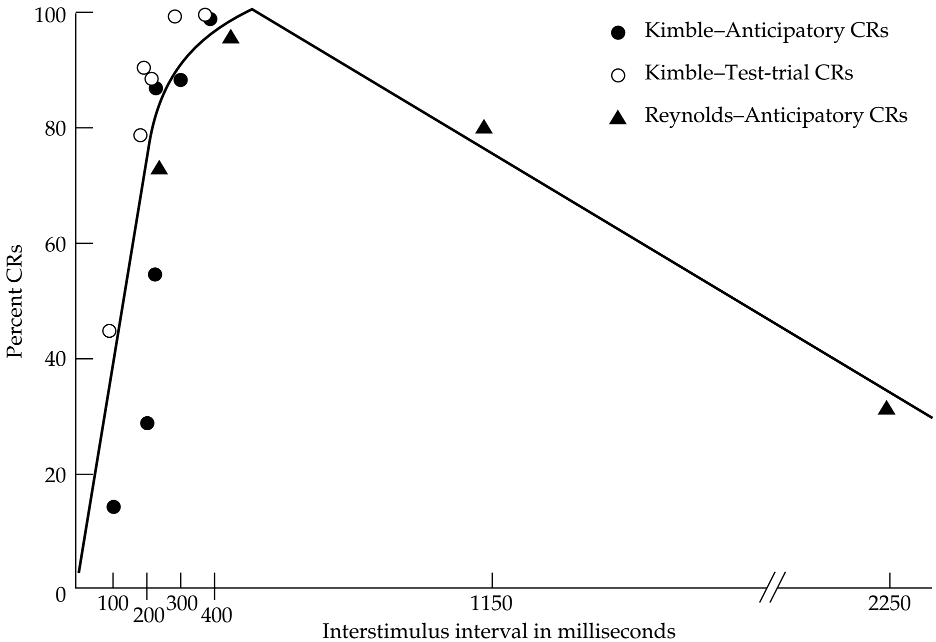
THE OPTIMAL CS-UCS INTERVAL. Many studies document the importance of contiguity to the acquisition of a conditioned response. Experiments designed to evaluate the influence of contiguity on classical conditioning have varied the interval between the CS and UCS, and then evaluated the strength of the CR. The results of these studies show that the optimal **CS-UCS interval,** or interstimulus interval (ISI), is very short. Intervals even shorter than the optimal ISI produce weaker conditioning, with the strength of the CR increasing as the ISI becomes longer until the optimal CS-UCS interval is reached. An ISI longer than the optimal CS-UCS interval also leads to weaker conditioning, with the intensity of the CR decreasing as the ISI increases beyond the optimal.

The optimal CS-UCS interval is different for different responses. For example, the optimal conditioning interval is 450 milliseconds for eyeblink conditioning. This 450-millisecond ISI for the conditioning of the eyelid closure reflex has been observed in both animals (Smith, Coleman, & Gormezano, 1969) and humans (Kimble & Reynolds, 1967). **Figure 3.5** presents the CS-UCS interval gradient for eyeblink conditioning in humans. Some other optimal ISIs include 2.0 seconds for skeletal movements (Noble & Harding, 1963), 4.0 seconds for salivary reflexes (Gormezano, 1972), and 20 seconds for heart rate responses (Church & Black, 1958).

Why does the optimal CS-UCS interval vary among responses? The optimal ISI is thought to reflect the latency to respond in a particular reflex system (Hilgard & Marquis, 1940). Hilgard and Marquis suggested that the different optimal CS-UCS intervals occur because the response latency of the autonomic nervous system is longer than that of the eyeblink closure reflex. Wagner and Brandon's theory (1989) addresses the question of how response latency affects the optimal ISI; we will look at their view in Chapter 9.

A BRIDGE BETWEEN THE CS AND THE UCS. We have learned that the acquisition of the CR is impaired when the CS-UCS interval is longer than a few seconds. Several studies (Pearce, Nicholas, & Dickinson, 1981; Rescorla, 1982) have

FIGURE 3.5. An idealized interstimulus interval (ISI) gradient obtained from eyeblink conditioning data in humans. The graph shows that the level of conditioning increases with CS-UCS delays up to the optimal interval, then declines with longer intervals.



reported that the attenuation of conditioning produced by a temporal gap between the CS and UCS can be reduced if a second stimulus is presented between the CS and UCS.

Consider the Rescorla (1982) study to illustrate this phenomenon. Rescorla's subjects, pigeons, were shown a colored light, followed by food 10 seconds later. On the trials when one color—for example, red—was presented, a second stimulus, either a white light or a tone, was presented during the 10 seconds between the red light and the food. The white light or tone was not presented on trials in which a different colored light, say green, was used. Rescorla found that the level of conditioning was significantly greater to the color (in this case, the red light) followed by the white light or tone than to the color (in this case, the green light) not followed by the intermediate stimulus.

Why does the intermediate stimulus produce conditioning despite the delay between the CS and UCS? According to Rescorla (1982), the intermediate stimulus acts as a catalyst, enhancing the association of the CS and the UCS. This observation suggests that with appropriate procedures, a high level of conditioning can develop even when there is a significant delay between the CS and the UCS.

LONG-DELAY LEARNING. There is one noteworthy exception to the contiguity principle. Animals and humans are capable of associating a flavor stimulus (CS) with an illness experience (UCS) that occurs several hours later. The association of taste with illness, called **flavor-aversion learning,** contrasts sharply with the other forms of classical conditioning, in which no conditioning occurs if the CS-UCS interval is longer than several minutes. While flavor-aversion learning can occur even with long delays, a CS-UCS interval gradient does exist for it, with the strongest conditioning occurring when the flavor and illness are separated only by 30 minutes (Garcia, Clark, & Hankins, 1973). We will take a more detailed look at flavor-aversion learning in Chapter 10.

The Influence of Intensity

CS INTENSITY. Suppose that you were bitten by a dog. Would you be more afraid of the dog if it were large or small? If we assume that the pain induced by bites (the UCS) from each are equivalent, research on the intensity of the CS and the strength of conditioning indicates your fear would be equivalent only if one dog bites you. However, if you were bitten by both sizes of dogs (not necessarily at the same time), you would be more afraid of the more intense CS, the large dog, even if its bite was no more painful. Let's now look at research examining the influence of CS intensity on CR strength.

Initial research indicated that the intensity of the CS does not affect CR strength. For example, Grant and Schneider (1948, 1949) reported that CS intensity did not influence the classical conditioning of the eyeblink response in humans. Carter (1941) and Wilcott (1953) showed similar results. However, more recent research clearly demonstrates that CS intensity can affect the strength of the conditioned response. A greater CR strength, produced by a more intense CS, has been shown in dogs (Barnes, 1956), rabbits (Frey, 1969), rats (Kamin & Schaub, 1963), and humans (Grice & Hunter, 1964).

Why does a more intense CS only sometimes elicit a stronger CR? When an animal or person experiences only a single stimulus (either weak or intense), an intense CS does not produce an appreciably greater CR than a weak CS. However, if the subject experiences both the intense and the weak CS, the intense CS will produce a greater CR.

A study by Grice and Hunter (1964) shows the important influence of the type of training procedure on the magnitude of CS intensity effect. In Grice and Hunter's study, one group of human subjects received 100 eyelid conditioning trials of a loud (100-db) tone CS paired with an air puff UCS. A second group of subjects had a soft (50-db) tone CS paired with the air puff for 100 trials, and a third group was given 50 trials with the loud tone and 50 with the soft tone. Grice and Hunter's results, presented in **Figure 3.6,** show that CS intensity (loudness of tone) had a much greater effect on conditioning when a subject experienced both stimuli than when a subject was exposed to only the soft or the loud tone.

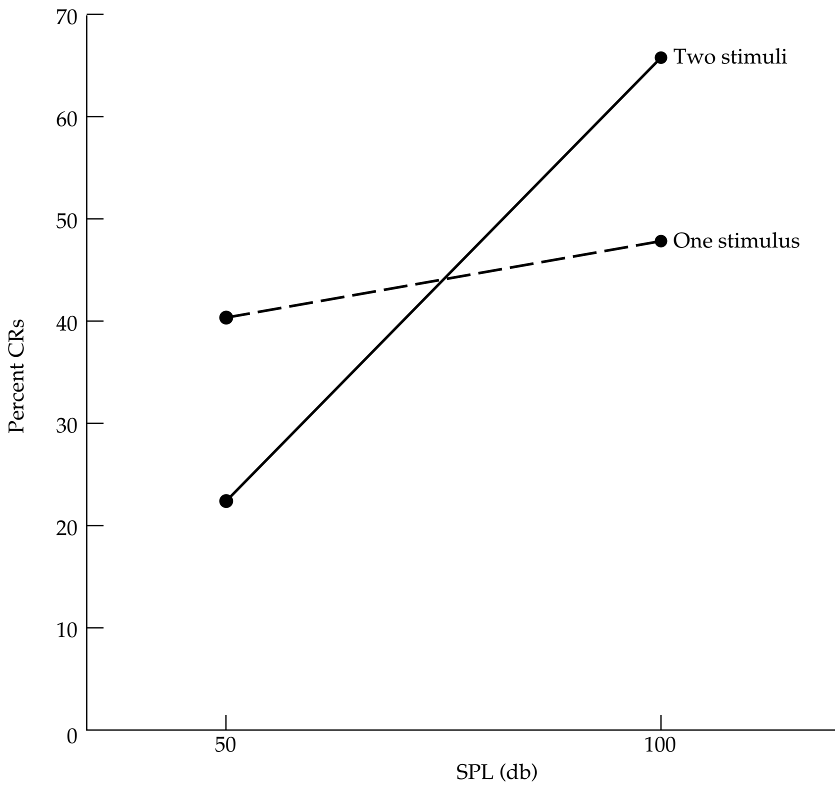
UCS INTENSITY. Recall Juliette's intense fear of darkness and men described in the chapter-opening vignette. The intensity of the attack was a critical factor in causing Juliette's extreme fear of darkness and men. Yet, not all experiences are as aversive as Juliette's attack. Suppose that you have the misfortune of being in an automobile accident. How much fear will arise the next time you get into a car? Research on UCS intensity and CR strength indicates that your level of fear will depend upon the intensity of the accident; the more severe the accident, the greater your fear of automobiles. Thus, if the accident was a minor one causing only slight discomfort, your subsequent fear will be minimal. A more severe accident will cause an intense fear.

The literature provides conclusive documentation that the strength of the CR increases with higher UCS intensity. To show the influence of UCS on eyelid response conditioning, Prokasy, Grant, and Myers (1958) gave their human subjects either a 50-, 120-, 190-, or 260-mm intensity air puff UCS paired with a light CS. They found that the strength of the CR was directly related to the UCS intensity; that is, the more intense the air puff, the stronger the eyeblink CR (see **Figure 3.7**).

The Salience of the CS

Martin Seligman (1970) suggested that animals or humans have an evolutionary predisposition or **preparedness** to associate a particular stimulus with a specific unconditioned stimulus, but that other CS-UCS associations cannot be learned. The concept of **contrapreparedness** suggests that some stimuli, despite

FIGURE 3.6. The percentage of conditioned responses during the last 60 trials is greater to a loud (100-db) tone than to a soft (50-db) tone in the two-stimuli condition, but not in the one-stimulus condition.

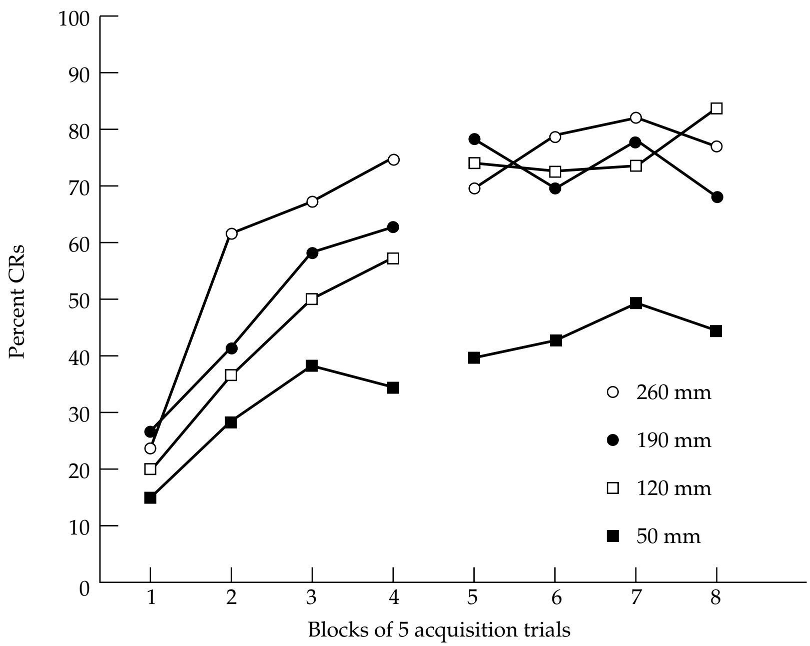


repeated CS-UCS pairings, cannot become associated with a particular UCS. The likelihood that a particular neutral stimulus will become able to elicit a conditioned response after pairing with an unconditioned stimulus reflects the **salience** of the neutral stimulus. Seligman proposed that preparedness makes a stimulus more salient. Thus, salient stimuli rapidly become associated with a particular unconditioned stimulus, while nonsalient stimuli do not, despite repeated CS-UCS pairings. Many, perhaps most, stimuli are not particularly salient or nonsalient; instead, most stimuli will gradually develop the ability to elicit a conditioned response as the result of conditioning experiences. In addition, salience is species-dependent; that is, a stimulus may be salient to one species but not to another. Chapter 10 discusses the biological significance of stimulus salience in Pavlovian conditioning; we will examine the influence of species-specific stimulus salience on the acquisition of a conditioned response in that chapter.

The Predictiveness of the CS

Robert Bolles (1972, 1979) proposed that contiguity alone is not sufficient for the development of a conditioned response. In Bolles's view, events must consistently occur together before we can acquire a conditioned response. A neutral stimulus may be simultaneously paired with a UCS, but unless the neutral stimulus reliably predicts the occurrence of the UCS, it will not elicit the CR. Additionally, when two or more stimuli are presented with the UCS, only the most reliable predictor of the UCS becomes able to elicit the CR.

FIGURE 3.7. The percentage of conditioned responses during acquisition increases with greater UCS intensity.



The following example illustrates the importance of **cue predictiveness** to the development of a conditioned response. Many parents threaten their children prior to punishment; yet their threats instill no fear, despite repeated threat (CS)-punishment (UCS) pairings. Why is parental threat ineffective? One likely reason is that these parents often threaten their children without punishing them. Under these circumstances, the threat is not a reliable predictor of punishment. Thus, its presentation will elicit little or no fear, even though the threat and punishment have frequently been experienced together. We will first examine evidence showing that CR acquisition is impaired if the UCS is often presented without the CS. Then we will review research which shows that presentations of the CS alone decrease the development of the CR.

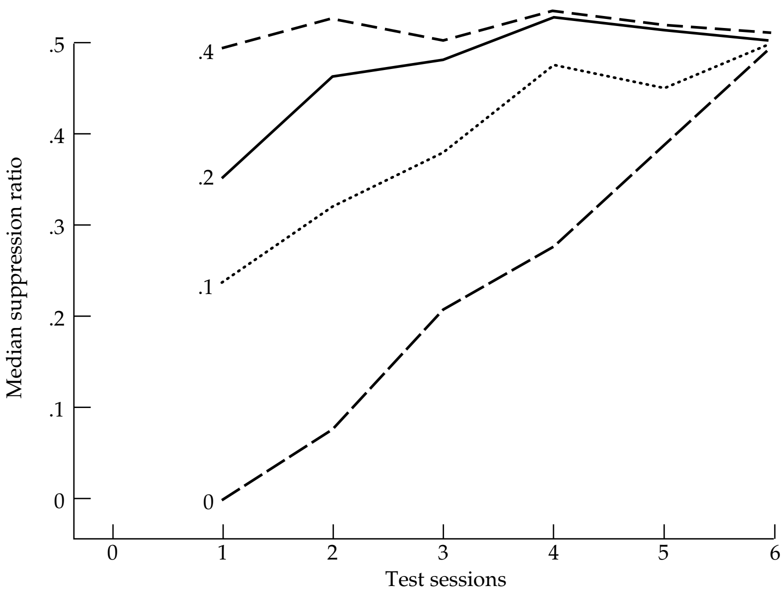
UCS-ALONE PRESENTATIONS. Robert Rescorla's (1968) research demonstrates the influence of cue predictiveness in classical conditioning. After his rats learned to bar press for food, Rescorla divided the 2-hour training sessions into 2-minute segments. One of three events occurred in each segment: (1) a distinctive cue (CS; tone) was paired with a shock (UCS); (2) a shock was presented without the distinctive cue; or (3) neither tone nor shock occurred. Rescorla varied the likelihood that the shock would occur with (or without) the tone in each 2-minute segment. He found that the tone suppressed the bar-press response for food when the tone reliably predicted shock, indicating that the rats had formed an association between the tone and shock. However, the influence of the tone on the rats' behavior diminished as the frequency of the shock occurring without the tone increased. The tone had no effect on behavior when the shock occurred as frequently when the tone was absent as it did when the tone was present. **Figure 3.8** presents the results for those subjects that received a 0.4 UCS-alone probability (or UCS alone on 40% of the 2-minute segments).

One important finding from Rescorla's data is that even with only a few pairings, the presentation of the tone produced intense fear and suppressed bar pressing if the shock was administered only with the tone. However, when the shock occurred without the tone as frequently as it did with it, no conditioning appears to occur, even with a large number of tone-shock pairings. These results indicate that the predictability of a stimulus, not the number of CS-UCS pairings, determines an environmental event's ability to elicit a CR.

CS-ALONE PRESENTATIONS. The acquisition of a CR is also impaired or prevented when the CS is presented alone during conditioning. Many studies (see Hall, 1976) have documented the attenuation of conditioning when the CS is presented without, as well as with, the UCS.

The level of conditioning depends upon the percentage of trials pairing the CS with the UCS; the greater the percentage, the greater the conditioning. Hartman and Grant's (1960) study provides one example of the influence of the percentage of paired CS-UCS presentations on CR strength. All of Hartman and Grant's human subjects received 40 light (CS) and air puff (UCS) pairings. For subjects in the 25% group, the UCS occurred following 40 of the 160 CS presentations; for subjects in the 50% group, the air puff followed the tone on 40 of 80 CS presentations; for subjects in the 75% group, the UCS followed the CS on 40 of 54 trials; and for subjects in the 100% group, the air puff was presented after

FIGURE 3.8. Suppression of bar-pressing behavior during six test sessions (a low value indicates that the CS elicits fear and thereby suppresses bar pressing for food). The probability of the UCS occurring with the CS is 0.4 for all groups, and the values shown in the graph represent the probability that the UCS will occur alone in a 2-minute segment. When the two probabilities are equal, the CS does not elicit fear and, therefore, does not suppress the response. Only when the UCS occurs more frequently with than without the CS will the CS elicit fear and suppress bar pressing.



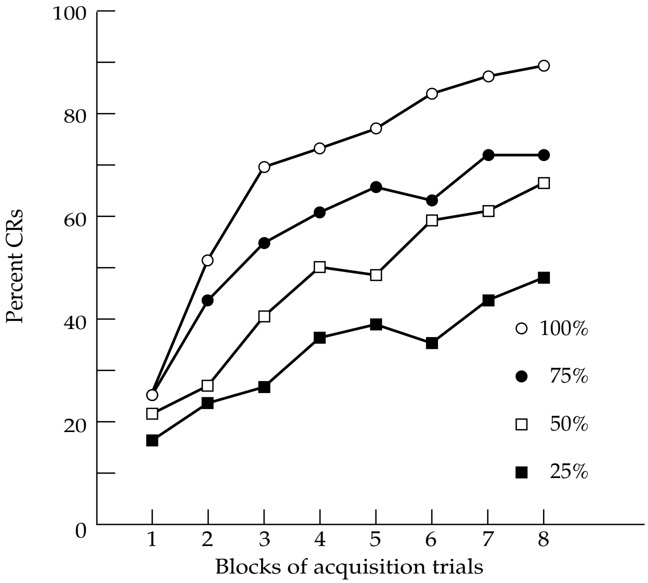
the light on 40 of 40 trials. Hartman and Grant's results showed that conditioning was strengthened as the percentage of trials that paired the CS with the UCS increased (see **Figure 3.9**).

The Redundancy of the CS

Recall from the last section the example of parental threats that fail to instill fear. In addition to a lack of predictiveness, another possible explanation for this lack of fear is that the child is already afraid when the threat is presented. Perhaps they are afraid of their parents; if so, parental presence (the CS) will interfere with the acquisition of fear to the threat, despite repeated threat-punishment pairings.

For a cue to elicit a CR, and thereby influence behavior, Bolles (1978) suggested that the cue must not only predict the occurrence of the UCS, but must also provide information not signaled by the other cues in the environment. The research of Leon Kamin (1968) suggests that the presence of a predictive cue (CS_1) will prevent, or **block,** the development of an association between a second cue (CS_2) also paired with the UCS. To demonstrate the importance of relative cue predictability, Kamin presented to all of his subjects a distinctive cue (CS_1, a

FIGURE 3.9. The percentage of conditioned responses during each block of acquisition trials decreases when the percentage of trials in which the UCS follows the CS also decreases.



light) paired with a shock (UCS) eight times during the first phase of the study (see **Figure 3.10**). In the second phase of the study, the experimental group subjects received eight pairings of the light (CS_1), a new cue (CS_2, a tone), and shock (UCS). Kamin observed that while presentation of the light (CS_1) suppressed bar pressing, the tone cue (CS_2) alone had no influence on it. The light had become associated with the shock, while tone had apparently not. Kamin's results do not indicate that a tone cannot be associated with shock. Control group animals that received only tone (CS_2)-shock pairings during the second phase of study showed strong suppression in response to the tone (CS_2).

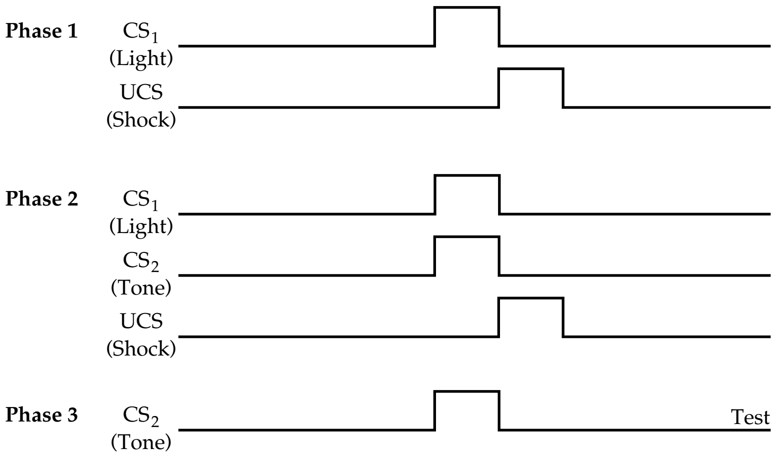
BEFORE YOU GO ON

- **How did the intensity of the attack contribute to the conditioning of Juliette's fear of darkness?**
- **Was salience a factor in the conditioning of Juliette's fear? Predictiveness? Redundancy?**

EXTINCTION OF THE CONDITIONED RESPONSE

Earlier in the chapter, you learned that environmental stimuli, through their association with deprivation, reward, or both, can acquire the ability to elicit hunger. Our conditioned responses typically have an adaptive function; the

FIGURE 3.10. The design of Kamin's blocking study. In phase 1, the CS, (light) is paired with the UCS (shock); in the second phase, both the CS_1 and CS_2 (tone) are paired with the UCS (shock). The ability of the CS_2 (tone) to elicit fear is assessed during phase 3.



development of a conditioned hunger enables us to eat at regularly scheduled times. However, the conditioning of hunger can also be harmful. For example, people can eat too much and become obese.

Clinical research (Masters, Burish, Hollon, & Rimm, 1987) has revealed that overweight people eat in many situations (for example, while watching television, driving, or at the movies). In order to lose weight, overweight people must restrict their food intake to the dining room (or the room where they usually eat), a process called **stimulus narrowing.** Yet, how can those who are overweight control their intake in varied environmental circumstances? One answer is through **extinction,** a method of eliminating a conditioned response. As the person's hunger response to varied environmental circumstances has developed through the classical conditioning process, so the conditioned hunger reaction can be extinguished through it.

Extinction can also be effective for people who are extremely fearful of flying. Because fear of flying may be acquired through the classical conditioning process, extinction again represents a potentially effective method for eliminating the conditioned reaction.

In the next section, we will describe the extinction process and explain how extinction might eliminate a person's hunger reaction to an environmental event like watching television or reduce someone's fear reaction to flying in an airplane. We will also explore the reason that extinction is not always an effective method of eliminating a conditioned response. Let's begin by looking at the extinction paradigm.

Extinction Paradigm

The extinction of a conditioned response will occur when the conditioned stimulus is presented without the unconditioned stimulus. The strength of the CR decreases as the number of CS-alone experiences increases, until eventually the CS elicits no CR (refer to **Figure 3.1**).

Pavlov reported in his classic 1927 book that a classically conditioned salivation response in dogs could rapidly be extinguished by presenting the CS (tone) without the UCS (meat powder). Since Pavlov's initial observations, many psychologists have documented the extinction of a CR by using CS-alone presentations; the extinction process is definitely one of the most reliable conditioning phenomenon.

Extinction is one way to eliminate a person's hunger reaction to environmental stimuli such as watching television. In this case, the person can eliminate the hunger response by repeatedly watching television without eating food (the UCS). However, people experiencing hunger-inducing circumstances are not always able to refrain from eating. Other behavioral techniques (for example, aversive counterconditioning or reinforcement therapy) are often necessary to inhibit eating and, thereby, to extinguish the conditioned hunger response. The use of reinforcement is examined in Chapter 4; the use of punishment is discussed in Chapter 5.

Fear of flying can also be eliminated by extinction. If a person flies and does not experience extreme plane movements, the fear will be diminished. However, fear is not only an aversive emotion, it can also be an intense motivator of avoidance behavior. Thus, people who are afraid of flying may not be able to withstand the fear and inhibit their avoidance of flying. Other techniques (for example, desensitization, response prevention, and modeling) also are available to eliminate fears. Desensitization is discussed in this chapter; response prevention in Chapter 5, and modeling in Chapter 8.

How Rapidly Does a Conditioned Response Extinguish?

We have learned that many factors can facilitate or hinder the acquisition of the CR; we will next discuss the variables that determine its rate of extinction.

The Strength of the CR

Hull (1943) envisioned the extinction process as a mirror image of acquisition; that is, the stronger the CS-CR bond, the more difficult it is to extinguish the CR. Thus, Hull assumed that the stronger the CR, the slower the extinction of that response. Although many studies have found that acquisition level does influence resistance to extinction, other research shows the relationship between the strength of the CR during acquisition and the rate of the extinction of that response is not a perfect correspondence. As Hall (1976) stated, one reason for this discrepancy is that the omission of the UCS during extinction changes the subject's motivational level from that which existed during acquisition. This altered motivation level makes extinction differ from acquisition, and thereby decreases the correlation between the CR acquisition level and the resistance to extinction.

The Influence of Predictiveness

In 1939, Humphreys examined how the percentage of trials in which the UCS followed the CS during acquisition influenced resistance to extinction. To study this effect, he conditioned an eyelid response in humans. During acquisition, subjects in group 1 received 96 CS-UCS pairings and no CS-alone presentations; subjects in group 2 received 48 CS-UCS pairings and 48 CS-alone presentations; and subjects in group 3 were given 48 CS-UCS pairings and no CS-alone presentations. Humphreys discovered that in the subjects who received CS-UCS pairings on 50% of the trials (group 2), the conditioned eyeblink response extinguished significantly more slowly than in those subjects given CS-UCS pairings on 100% of the trials (groups 1 and 3). Humphrey's results, presented in **Figure 3.11,** show that the number of CS-UCS pairings during acquisition does not determine resistance to extinction; the rates of extinction were equal in animals given only 48 or 96 CS-UCS pairings. Instead, extinction was more rapid when the CS was more predictive of the UCS during acquisition.

Duration of CS Exposure

We have discovered that the strength of the conditioned response declines as the CS-alone experience increases. You might think that the number of CS-alone presentations would determine the level of extinction; that is, as the number of extinction trials increases, the strength of the CR declines. However, research

FIGURE 3.11. The extinction of the conditioned response as a function of the percentage of trials where the UCS followed the CS during acquisition. Subjects in groups 1 and 3 received CS-UCS pairings on 100% of the acquisition trials; those in group 2, on 50%. Resistance to extinction is greater with only partial pairings of CS and UCS during acquisition.

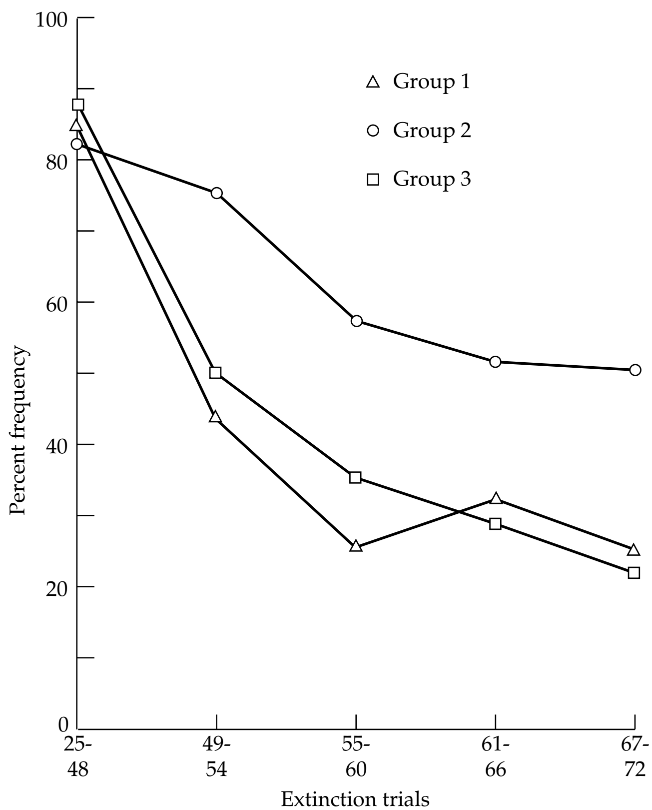
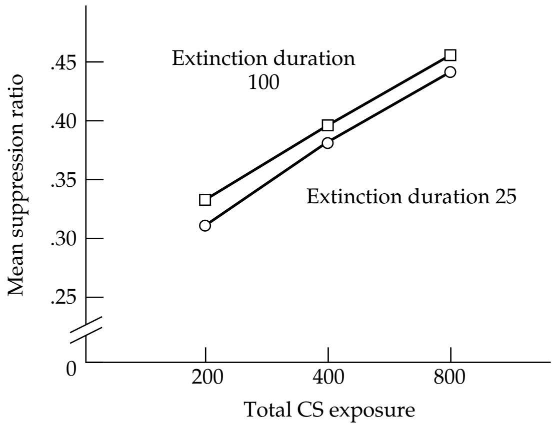


FIGURE 3.12. The suppression of the licking-for-water response to the conditioned stimulus decreases (or the suppression ratio increases) with greater duration of CS exposure during extinction.



(Monti & Smith, 1976; Shipley, 1974) clearly shows that the total duration of CS-alone exposure, not the number of extinction trials, determines the rate of extinction. These studies demonstrate that as the duration of CS-alone exposure increases, the strength of the CR weakens. Let's briefly look at Shipley's study to see the influence of CS-alone duration on the extinction of a CR.

Shipley (1974) initially trained water-deprived rats to lick a water tube to obtain liquid reinforcement. Following lick training, the animals received 20 exposures to a tone paired with electric shock. Extinction occurred following fear conditioning. Half of the animals were given 25-sec. CS-alone exposures during extinction; the other half received 100-sec. CS-alone experiences during extinction. One-third of the animals in both the 25-sec. and the 100-sec. CS duration groups were given sufficient extinction experience that they received a total of 200 sec. of CS exposure; another third received 400 sec., and the last third 800 sec. of exposure. For example, to have 200 total sec. of CS exposure, the animals given 25 sec. on each trial received 8 trials, compared to 2 trials for subjects receiving 100 sec. on each. Shipley reported that the suppression of licking the CS produced was not affected by either the number of CS-alone exposures or the duration of each exposure. Only the total duration of CS exposure during extinction determined the rate of extinction for the CR; the greater the length of the total CS exposure during extinction, the less suppression the tone produced (see **Figure 3.12**).

We have examined the variables which affect extinction rate; let's next look at the spontaneous recovery of responding following the extinction of a CR.

Spontaneous Recovery

Pavlov (1927) proposed that the extinction of a CR is caused by the **inhibition** of the CR. This inhibition develops because of the activation of a central inhibitory state that occurs when the CS is presented without the UCS. The continued presentation of the CS without the UCS strengthens this inhibitory state and acts to prevent the occurrence of the CR.

The initial inhibition of the CR during extinction is only temporary. According to Pavlov, the arousal of the inhibitory state declines following the initial extinction. As the strength of the inhibitory state diminishes, the ability of the CS to elicit the CR returns (see **Figure 3.1**). The return of the CR following extinction is called **spontaneous recovery.** The continued presentation of the CS without the UCS eventually leads to the long-term suppression of the CR. The inhibition of a CR can become permanent as the result of conditioned inhibition; we will discuss the conditioned inhibition process shortly.

Other Inhibitory Processes

We have learned that a temporary inhibition is involved in the extinction of a conditioned response. The inhibition of the CR can also become permanent, a process Pavlov called conditioned inhibition. There are also several other types of inhibition: external inhibition, latent inhibition, and inhibition of delay. Inhibition can be disrupted through a process called disinhibition.

Conditioned Inhibition

The initial inhibition of a CR can become permanent. If a new stimulus (CS−) similar to the conditioned stimulus (CS+) is presented in the absence of the unconditioned stimulus, the CS− will act to inhibit a CR to the CS+. The process of developing a permanent inhibitor is called **conditioned inhibition.** Conditioned inhibition is believed to reflect the ability of the CS− to activate the inhibitory state, which can suppress the CR.

Consider the following example to illustrate the conditioned inhibition phenomenon. Recall our discussion of conditioned hunger; because of past experiences, you became hungry when arriving home after your classes. Suppose that when you open the refrigerator, you find no food. In all likelihood, the empty refrigerator would act to inhibit your hunger. This inhibitory property of the empty refrigerator developed as a result of past pairings of the empty refrigerator with an absence of food. Many studies have shown that associating new stimuli with the absence of the UCS causes these stimuli to develop permanent inhibitory properties. Let's examine one of these studies.

Rescorla and LoLordo (1965) initially trained dogs to avoid electric shock using a Sidman avoidance schedule. With this procedure, the dogs received a shock every 10 seconds unless they jumped over a hurdle dividing the two compartments of a shuttlebox (see Chapter 5). If a dog avoided a shock, the next shock was postponed for 30 seconds. The advantage of this technique is twofold: it employs no external CS, and it allows the researcher to assess the influence of fear-inducing cues (CS+) and fear-inhibiting cues (CS−). After three days of avoidance conditioning, the dogs were locked in one compartment of the shuttlebox and exposed on some trials to a 1,200-hertz tone (CS+) and shock (UCS) and on other trials to a 400-hertz tone (CS−) without shock. Following conditioned inhibition training, the CS+ aroused fear and increased avoidance responses. In contrast, the CS− inhibited fear, causing the dogs to stop responding. These results indicate that the CS+ elicited fear and the

CS− inhibited fear, and that conditioned stimuli have an important motivational influence on instrumental behavior. We will examine that influence in Chapter 7.

External Inhibition

Pavlov (1927) suggested that inhibition could occur in situations other than extinction. In support of his theory, he observed that the presentation of a novel stimulus during conditioning reduces the strength of the conditioned response. Pavlov labeled this temporary activation of the inhibitory state **external inhibition.** The inhibition of the CR will not occur on a subsequent trial unless the novel stimulus is presented again; if the novel stimulus is not presented during the next trial, the strength of the conditioned response will return to its previous level.

Latent Inhibition

Preexposure to the CS impairs conditioning of the CR when the CS and UCS are later presented together. Lubow and Moore (1959) attributed the effect of CS preexposure to **latent inhibition;** that is, they argued that exposure to the CS prior to conditioning caused the CS to acquire inhibitory properties that subsequently interfered with excitatory conditioning when the CS and the UCS were paired.

Mackintosh (1983) believes that CS preexposure leads to learned irrelevance—the subject learns that a stimulus does not predict any significant event. The subject therefore has difficulty recognizing the correlation between the stimulus and the UCS.

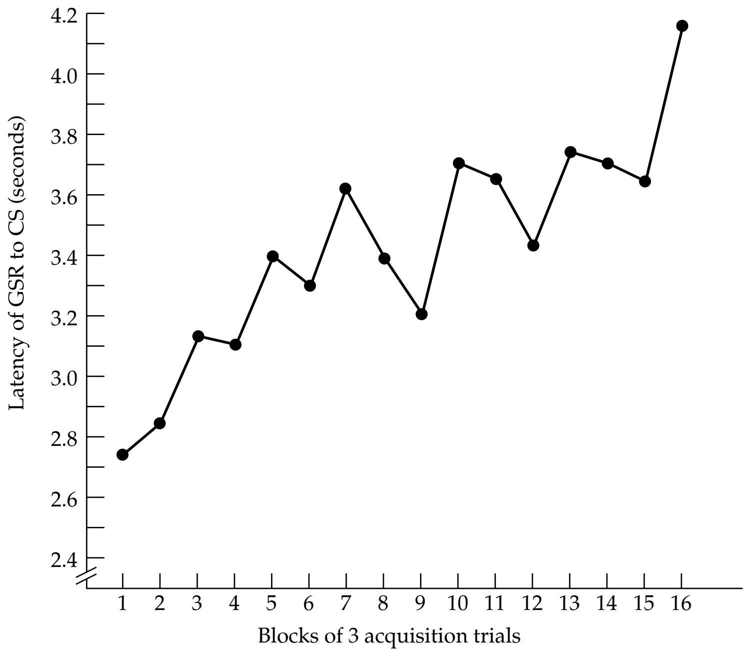
A number of studies (Baker & Mackintosh, 1977; Rescorla, 1971) have examined the effect of CS preexposure on the acquisition of conditioned inhibition. If the impact of CS preexposure resulted from inhibition, then CS preexposure should enhance conditioned inhibition training. However, these studies show that preexposure to a stimulus not only retards excitatory conditioning but also interferes with inhibitory conditioning. Thus, it appears that CS preexposure does not lead to the development of latent inhibition. We will look more closely at the influence of CS preexposure on classical conditioning in Chapter 9.

Inhibition of Delay

There are many occasions when a short delay separates the CS and the UCS. For example, several minutes elapse from the time we enter a restaurant until we receive our food. Under these conditions, we inhibit our responses until just prior to receiving the food. (If we did begin to salivate as soon as we entered the restaurant, our mouths would be dry when we were served our food, and our digestive processes would be impaired.) Further, the ability to inhibit the response until the end of the CS-UCS interval improves with experience. At first, we respond immediately when a CS is presented; our ability to withhold the CR improves with increased exposure to CS-UCS pairings.

Pavlov's classic research (1927) demonstrated that the dogs developed the ability to suppress the CR until the end of the CS-UCS interval, a phenomenon he labeled **inhibition of delay.** Other experimenters (Kimmel, 1965; Sheffield, 1965) have also shown that animals and humans can inhibit the CR until just

FIGURE 3.13. The average latency of GSR response to a conditioned stimulus, which preceded the unconditioned stimulus by 7.5 seconds, increases as the number of CS-UCS pairings increases.



before the UCS presentation. For example, Kimmel (1965) gave human subjects 50 trials of a red light (CS) paired with shock (UCS). The red light was presented 7.5 seconds prior to shock, and both terminated simultaneously. Kimmel reported that the latency of the galvanic skin response (GSR) increased with increased training trials (see **Figure 3.13**).

Disinhibition

We have learned that the presentation of a novel stimulus during conditioning causes the CS to inhibit the elicitation of the CR. Presenting a novel stimulus during extinction also causes disruption; however, in this case, the novel stimulus causes an increase in the strength of the conditioned response. The extinction process will proceed normally on the next trial if the novel stimulus is not presented. Pavlov labeled the process of increasing the strength of the CR **disinhibition.**

Kimmel's (1965) study shows the disinhibition phenomenon in an inhibition-of-delay paradigm. Kimmel observed that a novel tone presented with the CS disrupted the ability of the subjects to withhold the CR during the 7.5-second CS-UCS interval. Whereas the subjects exhibited the CR approximately 4.0 seconds after the CS was presented following 50 acquisition trials, the latency dropped to 2.3 seconds when the novel stimulus was presented along with the CS. These results indicate that a novel stimulus can disrupt the inhibition of a CR. They also show that inhibition is responsible for the suppression of the CR observed in the inhibition-of-delay phenomenon.

BEFORE YOU GO ON

- **How might Juliette's fear of darkness be extinguished?**
- **What problems might a clinical psychologist encounter trying to extinguish Juliette's fear?**

A CR WITHOUT A CS-UCS PAIRING?

Although many conditioned responses are acquired through direct experience, many stimuli develop the ability to elicit a conditioned response indirectly; that is, a stimulus which is never directly paired with the UCS nevertheless elicits a CR. For example, although many people with test anxiety have developed their fear because of the direct pairing of a test and failure, many others who have never failed an examination also fear tests. We will next discuss three ways—higher-order conditioning, sensory preconditioning, and vicarious conditioning—that a CR can develop without a CS-UCS pairing. A fourth way—stimulus generalization (see Chapter 1)—will be explored further in Chapter 7.

Higher-Order Conditioning

You did poorly last semester in Professor Jones's class. Not only do you dislike Professor Jones, but you also dislike Professor Rice, who is Professor Jones's friend. Why do you dislike Professor Rice, with whom you have never had a class? Higher-order conditioning provides one likely reason for your dislike.

The Higher-Order Conditioning Paradigm

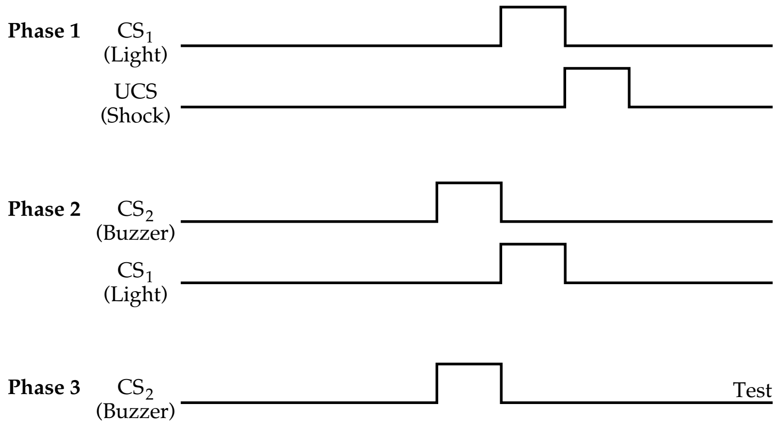
Pavlov (1927) observed that following several CS-UCS pairings, presenting the CS with another neutral stimulus (CS_2) enabled the CS_2 to elicit the CR. In one of Pavlov's studies using dogs, a tone (the beat of a metronome) was paired with meat powder. After this first-order conditioning, the tone was presented with a black square, but the meat powder was omitted. Following the black square-tone pairings, the black square (CS_2) alone was able to elicit salivation. Pavlov called this conditioning process higher-order conditioning. (In this particular study, the higher-order conditioning was of the second-order.) **Figure 3.14** presents a diagram of the **higher-order conditioning** process.

Research on Higher-Order Conditioning

The strength of a CR acquired through higher-order conditioning is weaker than that developed through first-order conditioning. Pavlov discovered that a second-order CR is approximately 50% as strong as a first-order CR, and a third-order CR is very weak. He found it impossible to develop a fourth-order CR.

Psychologists since the time of Pavlov's original studies have not always been successful in producing a CR through higher-order conditioning. Rescorla's (Holland & Rescorla, 1975; Rescorla, 1973, 1978; Rizley & Rescorla, 1972) elegant analysis of the higher-order conditioning process demonstrates the reason for these failures. According to Rescorla, the problem with higher-order conditioning

FIGURE 3.14. The higher-order conditioning process. In phase 1, the CS_1 (light) is paired with the UCS; in phase 2, the CS_1 (light) and the CS_2 (buzzer) are presented together. The ability of the CS_2 to elicit the CR is evaluated in phase 3.



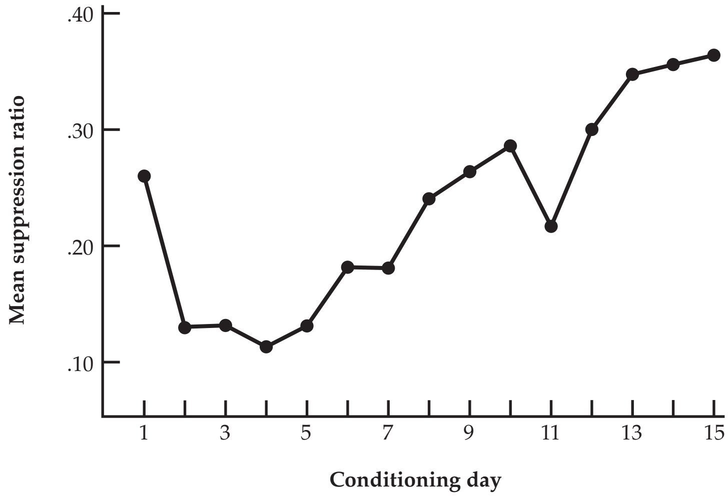
is that the pairing of CS_2-CS_1 without the UCS during the second phase of conditioning also represents a conditioned inhibition paradigm. Thus, not only are the CS_2-CS_1 pairings conditioning the excitation of the CR to the CS_2, but they are also conditioning the inhibition of the CR by pairing the compound stimulus (CS_2 & CS_1) in the absence of the UCS.

When will higher-order conditioning occur? Rescorla and his associates have discovered that conditioned excitation develops more rapidly than conditioned inhibition. Thus, with only a few pairings, a CS_2 will elicit the CR. However, as conditioned inhibition develops, CR strength declines until the CS_2 can no longer elicit the CR. At this time, the conditioned inhibition equals the conditioned excitation produced by the CS_2, and the presentation of the CS_2 will not elicit the CR.

Rizley and Rescorla's (1972) study illustrates the influence of the number of CS_2-CS_1 pairings on the strength of a higher-order conditioned fear. Rizley and Rescorla presented eight pairings of a 10-second flashing light (CS_1) paired with a 1 ma. 0.5-second electric shock (UCS). Following first-order conditioning, the light (CS_1) was paired with a 1,800-Hz tone (CS_2). Rizley and Rescorla discovered that the strength of the fear conditioned to the CS_2 increased with initial CS_2-CS_1 pairings, reaching a maximum strength after four pairings (see **Figure 3.15**). However, the intensity of fear elicited by the CS_2 declined with each additional pairing until the CS_2 produced no fear after 15 CS_2-CS_1 presentations. Holland and Rescorla (1975) obtained similar results in measuring the effects of higher-order conditioning on the development of a conditioned appetitive response.

The observation that the strength of a second-order CR diminishes after the presentation of more than a few CS_2-CS_1 pairings does not indicate that higher-order conditioning has no role in real-world settings. For example, once a CR, such as fear, is conditioned to a CS_2, such as high places, the fear the CS_2 produces will motivate avoidance behavior, resulting in only a brief exposure to the

FIGURE 3.15. The fear response to CS_2 increases with a few CS_1 and CS_2 pairings, but decreases with greater pairings of CS_1 and CS_2.



CS_2. This rapid avoidance response will result in slow development of conditioned inhibition. The slow acquisition of conditioned inhibition permits the CS_2 to elicit fear for a very long, possibly indefinite, period of time.

Sensory Preconditioning

Consider the following example to illustrate the sensory preconditioning process. Your neighbor owns a large German shepherd; you associate the neighbor with his dog. As you are walking down the street, the dog bites you, causing you to become afraid of the dog. You may also develop a dislike for your neighbor as the result of your previous association of the neighbor with the dog.

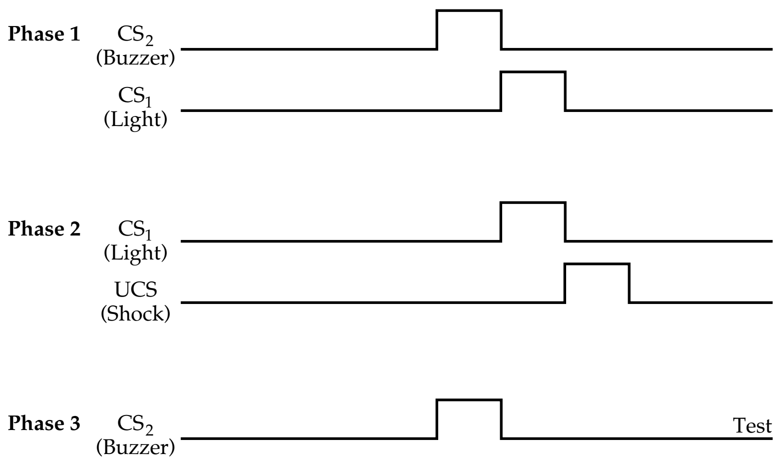
The Sensory Preconditioning Paradigm

In **sensory preconditioning,** two neutral stimuli, CS_1 and CS_2, are paired (see **Figure 3.16**). Following the association of CS_1 and CS_2 (dog and neighbor), CS_1 is presented with an unconditioned stimulus (bite). The CS_1-UCS pairing results in the ability of the CS_2, as well as the CS_1, to elicit the CR (fear). Thus, as a result of the initial CS_2-CS_1 association, the CS_2 is able to produce the CR even though it was never directly paired with the UCS.

Research on Sensory Preconditioning

Brogden's (1939) classic research represents an early successful sensory preconditioning study. In the first phase of Brogden's experiment, dogs in the experimental condition received 200 simultaneous pairings of a light and a buzzer. Control animals did not receive light-buzzer pairings. Following this initial conditioning, one of the cues (either the light or the buzzer) was presented with an electric shock to the dog's foot. Brogden reported that presentation of the cue not paired with shock elicited the CR (leg flexion) in experimental animals but not in

FIGURE 3.16. The sensory preconditioning process. In phase 1, the CS_1 (light) and CS_2 (buzzer) are paired; in phase 2, the CS_1 (light) is presented with the UCS. The ability of the CS_2 (buzzer) to elicit the CR is evaluated in phase 3.



control animals. Although Brogden's results showed that a cue can develop the ability to elicit a CR through the sensory preconditioning process, the leg flexion CR to the CS_2 was weaker than the CR to the CS_1. Other researchers (see Kimble, 1961) during the 1940s and 1950s also observed that the magnitude of the sensory preconditioning effect was small.

More recent studies (Rizley & Rescorla, 1972; Tait, Marquis, Williams, Weinstein, & Suboski, 1969) indicate that the early studies did not employ the best procedures to produce a strong, reliable sensory preconditioning effect. These later studies found that the CS_2 will elicit a strong CR if, during the initial conditioning, (1) the CS_2 precedes the CS_1 by several seconds and (2) only a few CS_2-CS_1 pairings are used in order to prevent the development of learned irrelevance. Recall that when the CS is presented without the UCS prior to conditioning, it diminishes the conditioning of a CR when the CS and UCS are later paired during training.

Vicarious Conditioning

A person can develop an emotional response to a specific stimulus through direct experience; a person can also learn to respond to a particular stimulus after observing the experiences of others. For example, a person can become afraid of dogs after being bitten, or after seeing another person being bitten. The development of a CS's ability to elicit a CR following such an observation is called **vicarious conditioning.** Although many emotional responses are clearly developed through direct conditioning experience, the research (see Bandura, 1977) also demonstrates that CS-CR associations can be acquired through vicarious conditioning experiences. Let's examine several studies which show the vicarious conditioning of a CR.

Research on Vicarious Conditioning

Berger's study (1962) demonstrates the vicarious conditioning of a conditioned fear reaction to a neutral stimulus. Berger's subjects listened to a neutral tone and then saw another person receiving an electric shock and exhibiting pain reactions (this other person, a confederate, pretended to be shocked and hurt). Berger found that subjects who repeatedly heard the tone and then witnessed the scene developed an emotional response to the tone. Bandura and Rosenthal (1966) also observed that vicarious conditioning of fear occurred when a subject observed another person being shocked.

One can also develop an emotional reaction by observing people fail at a task (Bandura, Blanchard, & Ritter, 1969; Craig & Weinstein, 1965). In the Craig and Weinstein study, subjects watched another person either succeed or fail at a motor task. The subjects who witnessed the other person failing showed a stronger conditioned stress reaction to the task than subjects who saw the other person succeed. This indicates we can learn to fear a task merely by watching others fail at it.

Vicarious conditioning is not unique to humans. Crooks (1967) reported that monkeys can develop a fear of certain objects after viewing the experience of another monkey with these objects. In Crooks's study, the subjects heard a tape-recorded distress sound when a model monkey touched some particular objects; they did not hear the emotional reaction when the model touched other objects. Crooks discovered that subjects subsequently played with the objects not associated with distress but would not touch the objects that appeared to have hurt the other monkey. In a more recent study, Mineka, Davidson, Cook, and Keir (1984) found that monkeys learned to fear snakes after seeing another monkey react fearfully to a snake. In the absence of this experience, the monkeys showed no evidence of a fear of snakes.

The Importance of Arousal

We do not always develop a CR after watching the experiences of others. For vicarious conditioning to occur, we must respond emotionally to the scene we witness. Bandura and Rosenthal (1966) evaluated the level of vicarious CR conditioning as a function of the subject's arousal level during conditioning. They found that observers moderately aroused by seeing another person being shocked subsequently showed a strong autonomic reaction to the tone that was paired with the scene; subjects either minimally distressed or intensely upset by viewing the shock displayed only weak vicarious conditioning. The highly aroused subjects stopped attending to the person receiving the shock; Bandura and Rosenthal suggested that their altered attention reduced the association of the tone with shock. These results indicate that we must be aroused—but not too aroused—if we are to develop conditioned responses from observing the experiences of others.

We have learned that the strength of higher-order conditioning, sensory preconditioning, and vicarious conditioning is weaker than conditioning developed through the direct pairing of the CS and the UCS. Does this weaker conditioning mean that an intense CR cannot develop indirectly? The answer to this question is no. Several sources may contribute to the intensity of the conditioned response. For example, the combined influence of vicarious conditioning and sensory preconditioning may cause an intense conditioned reaction to the CS.

BEFORE YOU GO ON

- **How might Juliette have developed a fear of darkness through higher-order conditioning? sensory preconditioning? vicarious conditioning?**

APPLICATIONS OF PAVLOVIAN CONDITIONING

We will discuss three applications of Pavlovian conditioning in this chapter. The first involves the use of Pavlovian conditioning principles to modify phobic behavior. This procedure, called systematic desensitization, has been used to eliminate the fears of people with phobias for over forty years. The second application, which involves extinction of a person's craving for a drug, has only recently been used to treat drug addiction. The last application has not been clinically tested, but it represents a possible use of Pavlovian conditioning to correct immune system dysfunction in patients with lupus and other diseases of the immune system.

Systematic Desensitization

Suppose a person is extremely frightened of taking examinations. This fear could cause the individual to do poorly in college. What can be done to allow this student to take examinations with minimal or no fear? **Systematic desensitization,** a therapy developed by Joseph Wolpe, acts to inhibit fear and suppress phobic behavior (a phobia is an unrealistic fear of an object or situation). Wolpe's therapy can help people with extreme test anxiety. His treatment is based on Pavlovian conditioning principles and represents an important application of classical conditioning. Let's examine this technique to discover how Pavlovian conditioning can alleviate extreme fear.

Original Animal Studies

Wolpe's therapy developed from his animal research. In an initial study (Wolpe, 1958), he shocked one group of cats in their home cages after they heard a buzzer. For the other cats, he paired the buzzer with food in the home cages and then shocked them. Both groups of cats later showed extreme fear of the buzzer; one indication of their fear was their refusal to eat when hearing the buzzer. Since fear inhibited eating, Wolpe reasoned that eating could—if sufficiently intense—suppress fear. As we learned in Chapter 1, counterconditioning is the process of establishing a response that competes with a previously acquired response. Wolpe suggested that counterconditioning is a potentially effective way of treating human phobic behavior. He based this idea on three lines of evidence: (1) Sherrington's statement (1906) that an animal can only experience one emotional state at a time—a phenomenon Wolpe termed **reciprocal inhibition;** (2) Jones's report (1924) that she had successfully eliminated a young boy's conditioned fear of rabbits by presenting the feared stimulus (a rabbit) while the boy was eating (see Chapter 1); and (3) Wolpe's own research using cats.

Wolpe initially placed the cats—which had developed a conditioned fear of the buzzer and the environment in which the buzzer was experienced—in a cage with food; this cage was quite dissimilar to their home cage. He used the dissimilar cage, which produced only a low fear level due to little generalization (see Chapter 1), because the home cage would produce too intense a fear and therefore inhibit eating. Wolpe observed that the cats ate in the dissimilar cage and did not appear afraid either during or after eating. Wolpe concluded that in the dissimilar environment, the eating response had replaced the fear response. Once the fear in the dissimilar cage was eliminated, the cats were less fearful in another cage more closely resembling the home cage. The reason for this reduced fear was that the inhibition of fear conditioned to the dissimilar cage generalized to the second cage. Using the counterconditioning process with this second cage, Wolpe found that presentation of food in this cage quickly reversed the cats' fear. Wolpe continued the gradual counterconditioning treatment by slowly changing the characteristics of the test cage until the cats were able to eat in their home cages without any evidence of fear. Wolpe also found that a gradual exposure of the buzzer paired with food modified the cats' fear response to the buzzer.

Clinical Treatment

Wolpe (1958) believed that human phobias could be eliminated in a manner similar to the one he used with his cats. He chose not to use eating to inhibit human fears, but instead used three classes of inhibitors: relaxation, assertion, and sexual responses. We will limit our discussion in this chapter to the use of relaxation.

Wolpe's therapy using relaxation to counter human phobic behavior is called systematic desensitization. Basically, desensitization involves relaxing while imagining anxiety-inducing scenes. To promote relaxation, Wolpe used a series of muscle exercises Jacobson developed in 1938. These exercises involve tensing a particular muscle and then releasing this tension. Presumably, tension is related to anxiety, and tension reduction is relaxing (or reinforcing). The patient tenses and relaxes each major muscle group in a specific sequence.

Masters, Burish, Hollon, and Rimm (1987) indicated that relaxation is most effective when the tension phase lasts approximately 10 seconds and is followed by 10 to 15 seconds of relaxation for each muscle group. The typical procedure requires about 30 to 40 minutes to complete; however, later in therapy, patients need less time as they become more readily able to experience relaxation. Once relaxed, patients are required to think of a specific word (for example, *calm*). This procedure, which Russell and Sipich labeled **cue-controlled relaxation** in 1973, promotes the development of a conditioned relaxation response that enables a specific stimulus to elicit relaxation promptly; the patient then uses the cue to inhibit any anxiety occurring during therapy.

The desensitization treatment consists of four separate phases: (1) the construction of the anxiety hierarchy, (2) relaxation training, (3) counterconditioning, or the pairing of relaxation with the feared stimulus, and (4) an assessment of whether the patient can successfully interact with the phobic object. In the first stage, patients are instructed to construct a graded series of anxiety-inducing scenes related to their phobia. A 10-to-15-item list of low-, moderate-, and high-anxiety scenes is typically employed. Using index cards, the patient writes descriptions of the scenes and then ranks them in a hierarchy from those that produce low to those that produce high anxiety.

Paul (1969) identified two major types of hierarchies: thematic and spatial-temporal. In **thematic hierarchies,** the scenes are related to a basic theme. **Table 3.1** presents a hierarchy detailing the anxiety an insurance salesman experienced when anticipating interactions with coworkers or clients. Each scene in the hierarchy is somewhat different, but all are related to his fear of possible failure in professional situations. In contrast, a **spatial-temporal hierarchy** is based on phobic behavior in which the intensity of fear is determined by distance (either physical or temporal) to the phobic object. The test anxiety hierarchy shown in **Table 3.2** indicates that the level of anxiety is related to the proximity to exam time.

We need to point out one important aspect of the hierarchy presented in **Table 3.2.** Perhaps contrary to your intuition, this student experienced more anxiety en route to the exam than when actually in the test area. Others may have a different hierarchy; when taking the exam, they experience the most fear. These observations indicate that each individual's phobic response is highly idiosyncratic and dependent on that person's unique learning experience. Therefore, a hierarchy must be specially constructed for each student. Some phobias require a combination of thematic and spatial-temporal hierarchies. For example, a person with a height phobia can experience varying levels of anxiety at different places and at different distances form the edges of these places.

TABLE 3.1. Thematic Hierarchy

Level	Scene
1	In your office with an agent, R. C., discussing a prospective interview. The client in question is stalling on his payment, and you must tell R. C. what to do.
2	Monday morning working in your office. In a few minutes you will attend the regularly scheduled sales meeting. You are prepared for the meeting.
3	Conducting an exploratory interview with a prospective client.
4	Sitting at home. The telephone rings.
5	Anticipating returning a call from the district director.
6	Anticipating returning a call from a stranger.
7	Entering the Monday sales meeting unprepared.
8	Anticipating a visit from the regional director.
9	Listening as a fellow agent requests a joint visit with a client.
10	On a joint visit with a fellow agent.
11	Attempting to close a sale.
12	Thinking about attending an agents' and managers' meeting.
13	Thinking of contacting a client who should have been contacted earlier.
14	Thinking about calling a prospective client.
15	Thinking about the regional director's request for names of prospective agents.
16	Alone, driving to prospective client's home.
17	Calling a prospective client.

Note: In the fear hierarchy, a higher level represents greater fear.
Source: Masters, J. C., Burish, T. G., Hollon, S. D., and Rimm, D. C. (1987). *Behavior therapy: Techniques and empirical findings* (3rd ed.). San Diego, Calif.: Harcourt Brace Jovanovich. Reprinted by permission of the publisher.

TABLE 3.2. Spatial-Temporal Hierarchy

Level	Scene
1	Four days before an examination.
2	Three days before an examination.
3	Two days before an examination.
4	One day before an examination.
5	The night before an examination.
6	The examination paper lies face down before the student.
7	Awaiting the distribution of examination papers.
8	Before the unopened doors of the examination room.
9	In the process of answering an examination paper.
10	On the way to the university on the day of the examination.

Note: In the fear hierarchy, a higher level represents greater fear.
Source: Wolpe, J. (1982). *The practice of behavior therapy* (3rd ed.). Oxford: Pergamon.

After the hierarchy is constructed, the patient learns to relax. Relaxation training follows the establishment of the hierarchy to prevent the generalization of relaxation to the hierarchical stimuli and thereby preclude an accurate assessment of the level of fear to each stimulus. The counterconditioning phase of treatment begins following relaxation training. The patient is instructed to relax and imagine as clearly as possible the lowest scene on the hierarchy. Since even this scene elicits some anxiety, Masters, Burish, Hollon, and Rimm (1987) suggested that the first exposure be quite brief (5 seconds). The duration of the imagined scene can then be slowly increased as counterconditioning progresses.

It is important that the patient not become anxious while picturing the scene; otherwise, additional anxiety, rather than relaxation, will be conditioned. The therapist instructs the patient to signal when experiencing anxiety, and the therapist terminates the scene. After a scene has ended, the patient is instructed to relax. The scene can again be visualized when relaxation has been reinstated. If the individual can imagine the first scene without any discomfort, the next scene in the hierarchy is imagined. The process of slowly counterconditioning each level of the hierarchy continues until the patient can imagine the most aversive scene without becoming anxious.

Clinical Effectiveness

The last phase of desensitization evaluates the therapy's success. To test the effectiveness of desensitization, the individual is required to encounter the feared object. The success of desensitization as a treatment for phobic behavior is quite impressive. Wolpe (1958) reported that 90% of 210 patients showed significant improvement with desensitization, compared to a 60% success rate when psychoanalysis was used. The comparison is more striking when one considers that desensitization produced a rapid extinction of phobic behavior—according to Wolpe (1976), a range of 12 to 29 sessions was effective—compared to the longer length of treatment (3 to 5 years) necessary for psychoanalysis to cure phobic behavior. Although Lazarus (1971) reported that some patients showed a relapse 1 to 3 years after therapy, the renewed anxiety could be readily reversed with additional desensitization. The range of phobias successfully treated or extinguished by desensitization is impressive: fears of heights, driving, snakes, dogs, insects, tests, water, flying, rejection by others, crowds, enclosed places, and injections are a few in a long list. In addition, desensitization apparently can be used with any behavior disorder initiated by anxiety. For instance, desensitization should help treat an alcoholic whose drinking occurs in response to anxiety. In general, research has demonstrated that systematic desensitization is a very effective way of successfully treating phobic behavior (Emmelkamp & Scholing, 1990; Nietzel, Bernstein, & Milich, 1994).

However, systematic desensitization therapy requires that patients be able to vividly imagine the fearful scene. Approximately 10% of patients cannot imagine the phobic object sufficiently to experience anxiety (Masters, Burish, Hollon, & Rimm, 1987); for these patients another form of therapy is needed. Further, Rachman (1990) observed that therapy is more effective when a patient confronts a real rather than imagined phobic object. Imagined scenes are used in the initial phase of systematic desensitization in order to control the duration of exposure and prevent the association of the phobic objects with anxiety. You might be wondering if a patient can confront a phobic object, but be able to control the duration of exposure to that object. Fortunately, modern technology appears to have made this possible. What is that technology? Perhaps you guessed: the use of a virtual reality environment.

Rothbaum, Hodges, Kooper, and Opdyke (1995) evaluated whether graded exposure to height-related stimuli in a virtual reality environment could effectively treat acrophobia. The researchers constructed a number of height-related stimuli, such as standing on a bridge, standing on a balcony, or riding in a glass elevator. The height of the stimuli varied: the bridge could be up to 80 meters above water, while the balcony or elevator could be as high as 49 floors. Rothbaum, Hodges, Kooper, and Opdyke reported that a graded virtual reality exposure to height-related stimuli was an effective treatment for acrophobia. Following treatment, patients were able to stand on a real bridge or balcony or ride in a glass elevator. Similarly, Carlin, Hoffman, and Weghorst (1997) found that a virtual reality environment can be used to treat a spider phobia. Virtual reality is a relatively new technology. As the technology improves, it seems highly likely that its use in systematic desensitization treatment will become more widespread.

Explorations for the Future

Desensitization is a well-established application of Pavlovian conditioning. Researchers are developing new applications based on current research; we will look at two of these new applications in this section.

An Intense Craving

In Chapter 2, we discovered that animals and people experience withdrawal following a drug exposure. The withdrawal from the drug can be intense, and can act to motivate continued use of the drug. An opponent withdrawal state can be conditioned to the environmental cues surrounding drug administration, and exposure to these cues can produce withdrawal as a conditioned response. The conditioned withdrawal response produces a drug craving which then motivates use of the drug. Further, the greater the intensity of the withdrawal response, the greater the craving and the higher the likelihood of continued drug use.

Can an environmental stimulus produce withdrawal symptoms? Wikler and Prescor (1967) demonstrated that the **conditioned withdrawal reaction** can be elicited even after months of abstinence. They repeatedly injected dogs with morphine when the animals were in a distinctive cage. The addicted dogs were then allowed to overcome their unconditioned withdrawal reaction in their home cages and were not injected for several months. When placed in the distinctive cages again, these dogs showed a strong withdrawal reaction, including excessive shaking, hypothermia, loss of appetite, and increased emotionality.

Why is it so difficult for an addict to quit using drugs? Whenever an addict encounters the cues associated with a drug (for example, the end of a meal for a smoker), a conditioned withdrawal will be elicited. The experience of this withdrawal may motivate the person to resume taking the drug. According to Solomon (1980), conditioned withdrawal reactions are what make eliminating addictions so difficult.

Any substance abuse treatment needs to pay attention to conditioned withdrawal reactions. To ensure a permanent cure, an addict must not only stop "cold turkey" and withstand the pain of withdrawal, he or she must also extinguish the conditioned withdrawal reactions all of the cues associated with the addictive behavior produce. Ignoring these conditioned withdrawal reactions increases the likelihood that addicts will eventually return to their addictive behavior. Consider the alcoholic who goes to a bar just to socialize. Even though this alcoholic may have abstained for weeks, the environment of the bar can produce a conditioned withdrawal reaction and motivate this person to resume drinking.

Can exposure to drug-related stimuli enhance an addict's ability to avoid relapse? Charles O'Brien and his colleagues (Childress, Ehrman, McLellan, & O'Brien, 1986; Ehrman, Robbins, Childress, & O'Brien, 1992) have addressed this issue. Childress, Ehrman, McLellan, and O'Brien (1986) repeatedly exposed cocaine addicts to the stimuli they associated with drug taking. Extinction experiences for these cocaine abusers involved watching videotapes of their "cook-up" procedure, listening to audiotapes of cocaine talk, and handling their drug paraphernalia. Childress, Ehrman, McLellan, and O'Brien reported that their patients' withdrawal responses and craving for drugs decreased as a result of exposure to drug-related cues. Further, the extinction treatment significantly reduced the resumption of drug use.

Ehrman, Robbins, Childress, and O'Brien (1992) found that when cocaine users are exposed to cocaine-related stimuli (talking about drug experiences, watching a videotape of people buying and using cocaine, pretending to freebase and smoke cocaine), these stimuli elicit increased heart rates as well as feelings of cocaine craving. Cocaine users reported no craving nor exhibited any physiological response to either heroin-related stimuli or nondrug-related stimuli. In contrast, subjects who did not use cocaine showed no psychological or physiological response to cocaine-related stimuli. The results of these studies indicate the important role the environment plays in motivating addictive behavior. In the future, we can expect this extinction procedure to play a more prominent role in the treatment of addictive disorders.

Robert Ader and Nathan Cohen (Ader & Cohen, 1981, 1985, 1993) discovered that environmental events could suppress the functioning of our immune systems. Interestingly, they made this discovery by accident. Following the pairing of saccharin-flavored water (CS) with cyclophosphamide (UCS), a drug which produces nausea, Ader and Cohen extinguished the aversion to the saccharin-flavored water. They reported that some of their animals died as a result of the presentation of the CS without the UCS.

Why would presentation of saccharin-flavored water kill some of their animals? Ader and Cohen (1981) recognized that cyclophosphamide not only produces nausea but also suppresses the immune system. Perhaps the association of saccharin and cyclophosphamide resulted in the conditioning of immune system suppression as well as of nausea.

Ader and Cohen (1981) tested the idea that conditioned immune system suppression was responsible for the deaths of animals exposed to the saccharin-flavored water CS. These researchers injected animals with red blood cells from sheep. This alien substance normally activates the animals' immune systems and produces high levels of antibodies. Following injection of the red blood cells, some animals were presented saccharin paired with cyclophosphamide. Other animals did not experience the saccharin-cyclophosphamide pairing. All animals then were placed in several extinction trials in which saccharin was presented alone. Ader and Cohen reported that the presence of saccharin during extinction produced significantly fewer antibodies in those animals that received saccharin paired with cyclophosphamide than in animals that had not experienced saccharin and cyclophosphamide. These results indicate that exposure to an environmental event (saccharin) associated with a drug (cyclophosphamide) produced immune system suppression as a CR. Other researchers (Gorczynski, 1987; O'Reilly & Exon, 1986) have also reported that a flavor paired with cyclophosphamide becomes able to suppress immune system functioning.

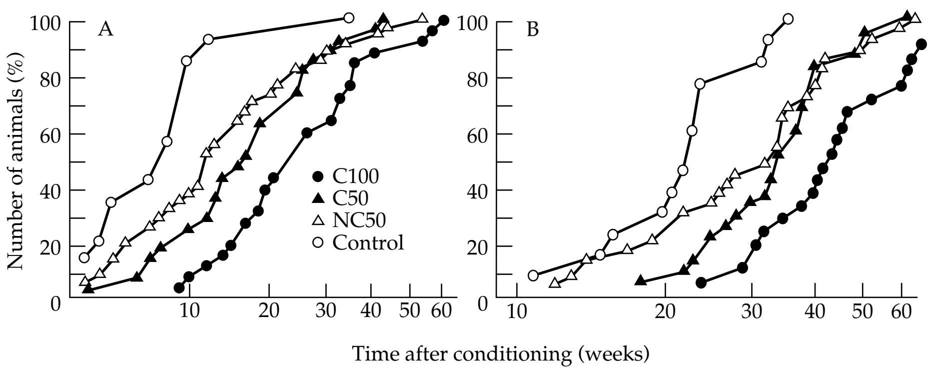
Cyclophosphamide is not the only immunopharmacologic agent that has been used to produce **conditioned immune system suppression.** Coussons, Dykstra, and Lysle (1992) paired a distinctive environmental stimulus with morphine, a drug that suppresses several nonspecific immune responses. Following conditioning, exposure to the environmental stimulus produced a conditioned immune system suppression. Other immunopharmacologic agents that can produce conditioned immunosuppression include corticosteroids (King, Husband, & Kusnecov, 1987) and antilymphocyte serum (Kusnecov, Sivyer, King, Husband, Cripps, & Clancy, 1983). Electric shock also can cause immune system suppression, and the stimuli associated with a shock stressor will become able to produce conditioned immune system suppression (Lysle & Maslonek, 1991; Zalcman, Irwin, & Anisman, 1991).

The conditioning of immune system functions could be used to treat diseases of the immune system. The drug cyclophosphamide is used to suppress the immune system as part of the treatment for lupus, a disorder in which the immune system causes the body to attack itself. Yet cyclophosphamide has some seriously debilitating side effects. Perhaps the dose of cyclophosphamide could be reduced and its use supplemented with a psychological treatment to suppress the immune system. Ader and Cohen (1982) provided support for this idea by showing that the conditioning of immune system suppression delayed the development of systemic lupus erythematosus in New Zealand mice. In this study, the experimental group female mice received one trial of saccharin-cyclophosphamide pairing each week. Ader and Cohen found that these experimental animals showed a slower rate of lupus progression and a lower mortality than animals that did not experience trials of saccharin paired with cyclophosphamide or than animals that experienced trials of saccharin without cyclophosphamide. Some retardation of illness was seen in animals that experienced an equal number of saccharin-cyclophosphamide and saccharin-saline pairings. **Figure 3.17** presents the results of this study.

Can Pavlovian conditioning be used in the treatment of lupus? Olness and Ader (1992) described their successful application of Pavlovian conditioning to the treatment of severe lupus in an 11-year-old girl. Their treatment consisted of six pairings of a taste (cod liver oil) and smell (rose perfume) with cyclophosphamide over a 12-month period. The pairings were given every other month. (The usual treatment would have consisted of 12 cyclophosphamide treatments.) The girl received a taste-only experience between each cyclophosphamide treatment. Olness and Ader found a significant reduction in the symptoms of lupus in the girl during the 12-month treatment period. Also, she continued to do well when evaluated 5 years after the conditioning treatment ended. While the results of a single case study must be viewed with caution, this successful application of Pavlovian conditioning suggests an important breakthrough in the treatment of this immune system disorder.

In several diseases in which the immune system is suppressed, such as acquired immune deficiency syndrome (AIDS), psychologists have attempted to condition increased immune system functioning. Several studies (Hiramoto, Hiramoto, Solvason, & Ghanta, 1987; Krank & MacQueen, 1988; Solvason, Ghanta,

FIGURE 3.17. A slowing of the progression of the immune disease lupus erythematosus in New Zealand mice is produced by conditioned immune system suppression. The development of disease and mortality rates were lower in animals in group C100, which were given one pairing of saccharin and cyclophosphamide, than in group NC50, which received unpaired saccharin and cyclophosphamide, or in control mice, which were given saccharin but no cyclophosphamide. The mice in the C50 group received two saccharin-cyclophosphamide and two saccharin-saline pairings each week. These animals showed some retardation in disease progression.



& Hiramoto, 1988) have reported **conditioned immune system enhancement.** In a study involving human subjects, Buske-Kirschbaum, Kirschbaum, Stierle, Jabaij, and Helhammer (1994) paired a sherbet flavor with injections of adrenaline. One unconditioned response to adrenaline is increased activity of natural killer (NK) cells of the immune system. Following several sherbet-adrenaline pairings, the sherbet elicited an enhanced immune system response. While it seems clear that immune system enhancement can be conditioned, additional research is needed to determine its applicability to the treatment of AIDS and other diseases involving immune system suppression.

BEFORE YOU GO ON

- **How might systematic desensitization be used to overcome Juliette's fear of darkness?**
- **What might be the effect of Juliette's fear on her immune system?**

CHAPTER SUMMARY

Many environmental stimuli can produce internal reactions; these emotional responses often make a particular response more likely. The hunger you experience while watching a food commercial on television, or the fear you experience when anticipating an airplane flight in bad weather, are two examples of our emotional reactions to environmental stimuli. Furthermore, the hunger response may be sufficiently intense to make it more likely you will get a sandwich from the refrigerator, or the fear response may be intense enough to make you more likely to cancel your flight plans.

The ability of environmental events to produce emotional reactions which, in turn, motivate instrumental behavior develops through the classical conditioning process. Conditioning involves the pairing of a neutral environmental cue with a biologically important event. Prior to conditioning, only the biologically important stimulus, called an unconditioned stimulus, can elicit a response. This response, called the unconditioned response, consists of both an overt behavioral reaction and an internal emotional response. As the result of conditioning, the neutral environmental stimulus, now a conditioned stimulus, can also elicit a response, called the conditioned response.

There are five conditioning paradigms. With delayed conditioning, the CS remains present until the UCS begins. The CS ends prior to the onset of the UCS with trace conditioning. With simultaneous conditioning, the CS and UCS occur at the same time. Backward conditioning presents the CS following the presentation of the UCS, and temporal conditioning takes place when the UCS is presented at regular intervals of time. Delayed conditioning is usually the most efficient and backward conditioning the least.

Five factors, in addition to its pairing with the unconditioned stimulus, influence whether a stimulus develops the ability to elicit a conditioned response. One factor affecting the strength of conditioning is temporal contiguity: contiguity must exist between the CS and UCS for conditioning to occur. An aversion to a flavor cue paired with illness is an exception; it can develop despite a lack of contiguity. An intermediate stimulus between the CS and UCS can facilitate the development of a conditioned response.

The intensity of the CS and UCS is a second factor affecting the intensity of the CR. An intense stimulus typically leads to a stronger CR. A third variable conditioning is salience. Some stimuli are more salient than others and therefore are more likely to elicit a CR following pairing with a UCS. The stimulus must also be a reliable predictor of the UCS. The more often the CS occurs without the UCS, or the UCS without the CS, the weaker the CR. Redundancy is the final factor affecting the strength of the conditioned response. The presence of a conditioned stimulus can prevent or block the development of a conditioned response to a new stimulus when both stimuli are paired with the UCS.

Stimuli sometimes produce undesired conditioned emotional reactions. Extinction represents an effective method of eliminating the ability of the conditioned stimulus to elicit the conditioned response; the presentation of the CS without the UCS will cause a reduction in CR strength. With continued CS-alone presentations, the conditioned stimulus will eventually fail to elicit the conditioned response.

Extinction of a conditioned response is thought to reflect an inhibitory process. The dissipation of inhibition is believed to cause spontaneous recovery, which is the return of a CR following an interval between extinction and testing without additional CS-UCS pairings.

Other inhibitory processes that suppress conditioned responses include conditioned inhibition, external inhibition, and inhibition of delay. Conditioned inhibition develops when the CS+ is paired with the UCS and the CS− with the absence of the UCS. External inhibition occurs when a novel stimulus is experienced prior to the CS during acquisition. Inhibition of delay reflects the suppression of the CR until presentation of the UCS. These inhibitory processes can be disrupted during extinction by the presentation of a novel stimulus, causing a disinhibition effect and resulting in an increased CR strength.

A conditioned stimulus can develop the ability to elicit the conditioned response indirectly; that is, without being directly paired with the UCS. Indirect conditioning methods include higher-order conditioning, sensory preconditioning, and vicarious conditioning. Higher-order conditioning occurs when, after CS_1 and UCS pairings, a new stimulus (CS_2) is presented with the CS_1 and UCS. In contrast, the CS_1 and CS_2 occur together prior to CS_1 and UCS pairings with sensory preconditioning. In both higher-order conditioning and sensory preconditioning, the CS_2 elicits the CR even though it has never been directly paired with the UCS.

A CR can be established through vicarious conditioning when one person observes another person experiencing the pairing of CS and UCS. For vicarious conditioning to occur, the observer must be sufficiently aroused while witnessing the other person's conditioning experience.

Pavlovian conditioning principles have been successfully used to modify undesired conditioned responses. Wolpe developed a technique called systematic desensitization, a graduated counterconditioning procedure, to eliminate phobias. The patient first constructs a hierarchy of feared stimuli; relaxation is then paired with the feared stimuli. The counterconditioning process begins with imagining the least feared stimulus for a brief time. The time the patient spends imagining this stimulus is increased until the patient can imagine it without any discomfort. The next stimulus on the hierarchy is then associated with relaxation. The process of slowly counterconditioning each level continues until the patient can imagine the most aversive stimulus without becoming anxious. The success of desensitization is considerable; the elimination of fear of heights, driving, tests, flying, and enclosed places are a few examples of its successful application.

The stimuli paired with the use of drugs can elicit a conditioned withdrawal state. This withdrawal state produces a craving for the drug and motivates resumption of drug use. As part of a treatment program for addiction, exposure to the stimuli associated with drug use can extinguish the conditioned craving and reduce the likelihood of continued use.

A flavor stimulus presented prior to the administration of cyclophosphamide, a drug that suppresses the immune system, can become able to elicit a conditioned suppression of the immune system. Conditioned immune system suppression can help explain the increased susceptibility to disease associated with exposure to stressful events. It also represents a potential application of Pavlovian conditioning in the treatment of lupus and other diseases of the immune system. Immune system enhancement can also be conditioned, and may represent an application of Pavlovian conditioning in the treatment of AIDS.

CRITICAL THINKING QUESTIONS

1. Pavlovian conditioning has a significant influence on human emotions. Identify your emotional response to several environmental events. Describe the experiences that led to the establishment of these emotional responses. Indicate the CS, CR, UCS, and UCR in these examples. How have these conditioned emotional responses affected your life?
2. Tamiko becomes extremely anxious prior to giving a speech. Mia feels only slightly tense when speaking in public. Using the principles presented in the text, suggest possible explanations for the differences in fear shown by Tamiko and Mia.
3. Greg has an intense desire to smoke cigarettes. His nicotine craving occurs after a meal, a class, or a movie, as well as at other times. Describe the process responsible for Greg's craving. How might Greg eliminate his craving? What problems might Greg encounter? How can he avoid these problems?

KEY TERMS

asymptotic level
autoshaping
backward conditioning
blocking
conditioned emotional response
conditioned immune system enhancement
conditioned immune system suppression
conditioned inhibition
conditioned reflex
conditioned response
conditioned stimulus
conditioned withdrawal reaction
contiguity
contrapredaredness

CS-UCS interval
cue-controlled relaxation
cue predictiveness
delayed conditioning
disinhibition
external inhibition
extinction of conditioned response
eyeblink conditioning
fear conditioning
flavor-aversion learning
higher-order conditioning
inhibition
inhibition of delay
latent inhibition
preparedness
reciprocal inhibition
salience
sensory preconditioning
sign tracking
simultaneous conditioning
spatial-temporal hierarchy
spontaneous recovery
stimulus narrowing
suppression ratio
systematic desensitization
temporal conditioning
thematic hierarchy
trace conditioning
unconditioned reflex
unconditioned response
unconditioned stimulus
vicarious conditioning