3

PRINCIPLES AND APPLICATIONS OF PAVLOVIAN CONDITIONING

LEARNING OBJECTIVES

3.1 Explain how hunger and fear can be conditioned.

3.2 Describe the ways the conditioned and the unconditioned stimuli can be paired.

3.3 Explain the conditions that influence the strength and rate of conditioning.

3.4 Describe how a conditioned response (CR) can be extinguished.

3.5 Explain how the conditioning and extinction processes can be disrupted.

3.6 Recount how a conditioned response (CR) can be acquired without pairing of the conditioned stimulus (CS) and the unconditioned stimulus (UCS).

3.7 Describe the use of systematic desensitization to eliminate a phobia.

A LINGERING FEAR

Juliette is a teacher at the local high school. Although her coworkers often ask her to socialize after work, Juliette always rejects their requests; instead, after 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 shops 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 13 months ago. She had dined with her parents at their home and had left about 9:30 p.m. Because 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 started to take off her underwear and began to rape her 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 being raped 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 Pavlovian 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 describe the Pavlovian conditioning process responsible for Juliette's intense fear reaction. The learning mechanism that causes Juliette to avoid darkness is discussed in Chapter 6.

Juliette does not have to remain afraid of going out into the darkness. There are two effective behavior therapies—(1) systematic desensitization and (2) flooding—that use the Pavlovian conditioning process to eliminate intense, conditioned fear reactions like Juliette's. We discuss systematic desensitization later in this chapter and response prevention or flooding in Chapter 6.

We began our discussion of Pavlovian conditioning in Chapter 1. In this chapter, we discuss in greater detail the process by which environmental conditions become able to elicit emotional responses as well as how those associations can be eliminated if they are harmful.

PRINCIPLES OF PAVLOVIAN CONDITIONING

3.1 Explain how hunger and fear can be conditioned.

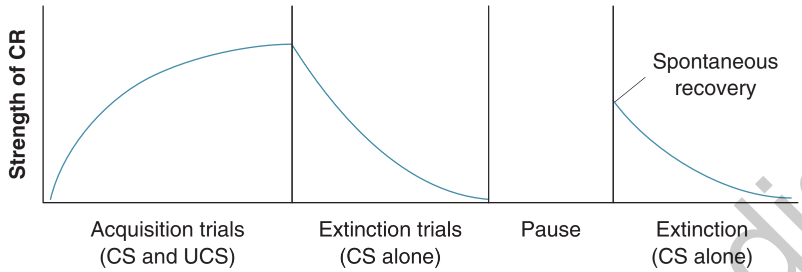
Pavlovian conditioning is the process through which emotions are learned. Some emotions are negative, such as Juliette's fear of darkness. Other examples of negative emotional reactions developed through Pavlovian conditioning include the emotion of anger toward a past romantic partner upon learning that person cheated on you or the emotion of frustration when thinking about a statistics problem that you have been unable to solve. Positive emotions also can be learned through Pavlovian conditioning and include the emotion of happiness elicited by a friend's impending visit or the emotion of joy when recalling your first kiss. Let's begin by reviewing the basic components of Pavlovian conditioning followed by a detailed description of conditioning of hunger and fear.

The Conditioning Process

Basic Components

As you learned in Chapter 1, there are four basic components of Pavlovian conditioning: (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 biologically significant event, or UCS, elicits the UCR, but the neutral environmental stimulus or CS cannot elicit the CR. During conditioning, the CS is experienced with the

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 spontaneously recovers when a short interval follows extinction, but it declines again with additional presentations of the CS alone.



Note: CR = conditioned response; CS = conditioned stimulus; UCS = unconditioned stimulus.

UCS. Following conditioning, the CS is able to elicit the CR, and the strength of the CR increases steadily during acquisition until a maximum or **asymptotic level** is reached (see **Figure 3.1**). The UCS–UCR complex is the unconditioned reflex; the CS–CR complex is the conditioned reflex.

Although the pairing of the CS and UCS is essential to the development of the CR, other factors determine both whether conditioning occurs as well as the final strength of the CR. We 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 components of conditioning.

The Conditioning of Hunger

Suppose you often arrive home late in the day, and you go into the kitchen and see the refrigerator. Opening the refrigerator, you notice the milk and pie. Why does being in the kitchen and seeing the refrigerator and the food make you hungry and motivate you to drink the milk and eat the pie? 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 UCRs that prepare them to digest, metabolize, and store ingested food. These unconditioned feeding responses include the secretion of saliva, gastric juices, and insulin. One important action of insulin is to lower blood glucose, which in turn stimulates hunger and motivates eating (Campfield & Smith, 2003). Thus, we become hungry when we taste or smell food. The intensity of these unconditioned feeding responses directly relates 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 (Weingarten & Martin, 1989). The conditioning of these feeding responses to environmental cues can lead to a desire to eat when encountering specific stimuli, such as your kitchen. Since cues such as the cupboard 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 cupboard or refrigerator, your body reflexively releases insulin, which lowers your blood glucose level and makes you hungry. As we discover shortly, the strength of the CR depends upon the intensity of the 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 Motivational Properties of Conditioned Hunger

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Michela Gallagher (1947–)

Gallagher received her doctorate from the University of Vermont under Bruce Kapp. She taught at the University of Vermont for 3 years and at the University of North Carolina at Chapel Hill for 17 years prior to joining the faculty at Johns Hopkins University, where she has taught for the past 19 years. Her work has contributed significantly to the understanding of the influence of experience in eating behavior and obesity. While at Johns Hopkins University, Gallagher served as chair of the Department of Psychological and Brain Sciences and as editor for the journal *Behavioral Neuroscience*. She received the International Behavioral Neuroscience Society Career Achievement Award in 2008 and the D. O. Hebb Distinguished Scientific Contributions Award from the American Psychological Association in 2009.

Michela Gallagher, Peter Holland, and their colleagues have shown that environmental events associated with food can develop sufficient motivational properties to override satiety and elicit eating even in nondeprived or satiated animals (Holland & Petrovich, 2005; Holland, Petrovich, & Gallagher, 2002; Petrovich & Gallagher, 2007; Petrovich, Ross, Gallagher, & Holland, 2007). Food consumption in satiated rats has been conditioned to a discrete stimulus, such as a tone (Holland & Petrovich, 2005) or to a distinctive contextual environment (Petrovich et al., 2007). In these studies, either the discrete or contextual stimulus was initially paired with food delivery in food-deprived (hungry) rats. The cues were then presented prior to food availability in satiated rats. The presence of these environmental events elicited eating even though the rats were no longer hungry. Not only can these environmental events motivate the consumption of the food experienced during conditioning but they can also motivate the consumption of either novel food (Petrovich et al., 2007) or other familiar foods (Petrovich, Ross, Holland, & Gallagher, 2007). Further, Reppucci and Petrovich (2012) found that exposure to food-related cues motivated excessive food consumption in satiated rats over a 4-hour period and excessive food intake continued for a second test day.

The elicitation of eating behavior by environmental events also has been reported in humans (Petrovich & Gallagher, 2007). For example, Birch, McPhee, Sullivan, and Johnson (1989) presented visual and auditory stimuli with snacks to hungry children on some days and other visual and auditory stimuli without snacks on other days. On test days, the children were satiated and the cues associated with food or those stimuli not previously paired with food were presented. The researchers reported that the stimuli associated with food led to greater snack consumption in satiated children than did the stimuli that had not been previously associated with food. Chocolate is a particularly attractive food, and Ridley-Siegert, Crombag, and Yeomans (2015) found visual stimuli associated with chocolate increased food consumption in adult human subjects significantly more than food consumption to visual stimuli associated with chips and even more than to non–food related visual stimuli.

Petrovich and Gallagher (2007) suggested that the elicitation of eating by conditioned stimuli helps us understand the causes of overeating and obesity in humans. The settings of fast-food and other chain restaurants—with a relatively uniform, recognizable appearance and relatively limited menu items—are ideal for specific food contexts to become conditioned stimuli, capable of overriding satiety cues, and thereby leading to overeating and obesity. In support of this view, Giuliano and Alsio (2012) observed that exposure to food-related cues increased the motivation for food, but even more so in obese humans.

The Neuroscience of Conditioned Hunger

The basolateral region of the amygdala appears to be responsible for the elicitation of feeding behavior by conditioned stimuli (Petrovich & Gallagher, 2007). Keefer and Petrovich (2017) reported that initial tone–food pairings activated the **basolateral amygdala** in sated rats, but continued tone–food pairings activated a neural circuit that started in the basolateral amygdala and ended in the medial prefrontal cortex, which is the brain area controlling executive or decision-making functions. Further, Keefer, Cole, and Petrovich (2016) observed that the neuropeptide orexin was active during tone–food pairings, while Cole, Hobin, and Petrovich (2015) found that tone–food pairing selectively aroused the neuropeptide orexin in the neural circuit from the amygdala to the prefrontal cortex. The basolateral amygdala also has projections to the nucleus accumbens (Klein & Thorne, 2007). As we will discover in Chapter 8, dopamine activity in the nucleus accumbens motivates reward-seeking behavior (Fraser, Haight, Gardner, & Flagel, 2016).

Damage to the basolateral region of the amygdala also has been found to prevent the conditioning of feeding in rats when the damage occurs prior to conditioning and to abolish it when it occurs following training (Galarce, McDannald, & Holland, 2010; Holland & Petrovich, 2005; Petrovich & Gallagher, 2007).

Research with human subjects shows that the amygdala becomes active in satiated subjects while viewing the names of preferred foods but not neutral foods (Arana et al., 2003). Further, thinking about liked or craved foods also activates the amygdala in human subjects (Pelchat, Johnson, Chan, Valdez, & Ragland, 2004).

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 aversive reaction is elicited (the UCR). The psychological distress you experience when the airplane drops is one aspect of your aversive reaction; the increased physiological arousal is another aspect. Although the unpleasantness may lessen as the airplane 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 aversive 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 elicits a stronger aversive 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 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 produced by turbulence of a plane (sensitization).

As a result of past experiences, the cues that predict turbulence can elicit an anticipatory pain reaction (the CR). We typically call this anticipatory pain reaction fear. One stimulus associated with turbulence is the fasten seatbelt light. Thus, you may become frightened (CR) when the pilot puts on the fasten seat belt light (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 CS that elicits fear.

Recall Juliette's fear of darkness described in the chapter opening vignette. Pavlovian conditioning provides an explanation of Juliette's fear. Being attacked was an UCS that elicited pain as the UCR. As the result of pairing nighttime with the attack, the darkness of nighttime has become a CS that elicits fear as the CR.

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 CR (e.g., withdrawal of the leg) can occur 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 Pavlovian conditioning in animals (Miller, 1948) and humans (Staats & Staats, 1957).

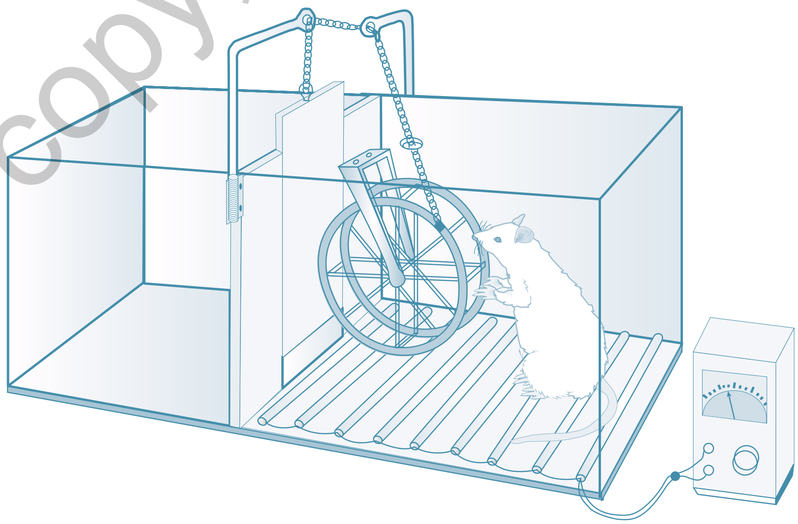
The Motivational Properties of Conditioned Fear

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, 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 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.

Many children become fearful when their parents become angry. In all likelihood, the angry face preceded punishment. Pischek-Simpson, Boschen, Neumann, and Waters (2009) found that presentation of an angry face prior to an aversive shock in human subjects conditioned fear to the angry face as indicated by a physiological measure of fear. No fear to an angry face was conditioned in the nonshock condition. Being fearful when a parent becomes angry is one example of fear developed through Pavlovian conditioning. People also are afraid of losing a job or failing a test. These fears undoubtedly develop through Pavlovian conditioning.

We discovered earlier that the degree of hunger that various environmental cues induce depends upon the UCS intensity: The stronger the UCS, the more intense our conditioned

FIGURE 3.2 ■ Apparatus similar to the one Neal 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.



Source: Adapted from Swenson, L. C. (1980). *Theories of learning.* Belmont-Calif.: Wadsworth. Copyright © Leland Swenson.

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. Similarly, the more severe the punishment, the more fearful the child becomes when his or her parent becomes angry.

Juliette's fear of the darkness of nighttime (CS) developed motivational properties as a result of pairing with the attack (UCS). As the attacker had begun to rape Juliette, this is an especially aversive event for her. It is not surprising that Juliette developed a strong fear of the darkness of nighttime. The darkness of nighttime now motivates Juliette to stay at home at night. Similarly, the child learns to stay away from an angry parent as a result of pairing an angry face with punishment.

Not all people are frightened by flying in turbulent conditions, and some do not learn that driving is a way to avoid an unpleasant airplane ride. Similarly, not all children are fearful of an angry parent, and some do not learn to stay away. This chapter describes the conditions that influence the development of a conditioned fear response. Chapter 6 details the factors that govern avoidance acquisition.

The Neuroscience of Conditioned Fear

We learned that the basolateral amygdala plays an important role in Pavlovian conditioned hunger. By contrast, the lateral and central amygdala appears to play an important role in Pavlovian fear conditioning. Duvarci, Popa, and Pare (2011) reported increased activity in the **central amygdala** during fear conditioning in rats, while Watabe and colleagues (2013) observed changes in the central amygdala activity following fear conditioning in mice. In addition, Dalzell and colleagues (2011) observed neural changes in the **lateral amygdala** following Pavlovian fear conditioning. Finally, mice selectively bred for high or low fear behavior show distinct differences in the number of neurons in the lateral amygdala (Coyner et al., 2014).

Damage to the lateral and central amygdala has been found to impair fear conditioning. For example, Nader, Majidishad, Amorapanth, and LeDoux (2001) found that damage to the lateral and central amygdala prevented the acquisition of fear response to an auditory stimulus presented with an electric shock. Similarly, Wallace and Rosen (2001) found that lesions of the lateral amygdala decreased the conditioned fear response to the context associated with a predator odor.

Other Examples of Conditioned Responses

Hunger and fear are not the only examples of CRs. 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, and experiencing sexual arousal during a candlelight dinner because of previous sexual activity. These examples not only demonstrate three additional CRs—(1) nausea, (2) thirst, and (3) sexual arousal—but also show that stimuli other than food or shock can be involved in the conditioning process. The three unconditioned stimuli in the previous examples are poison, fluid, and sexual activity. Of course, people encounter many more CRs and unconditioned stimuli in the real world. Other examples are presented throughout the chapter.

Most of the experiments on Pavlovian conditioning have investigated the conditioning of only a single CR. 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 Techniques

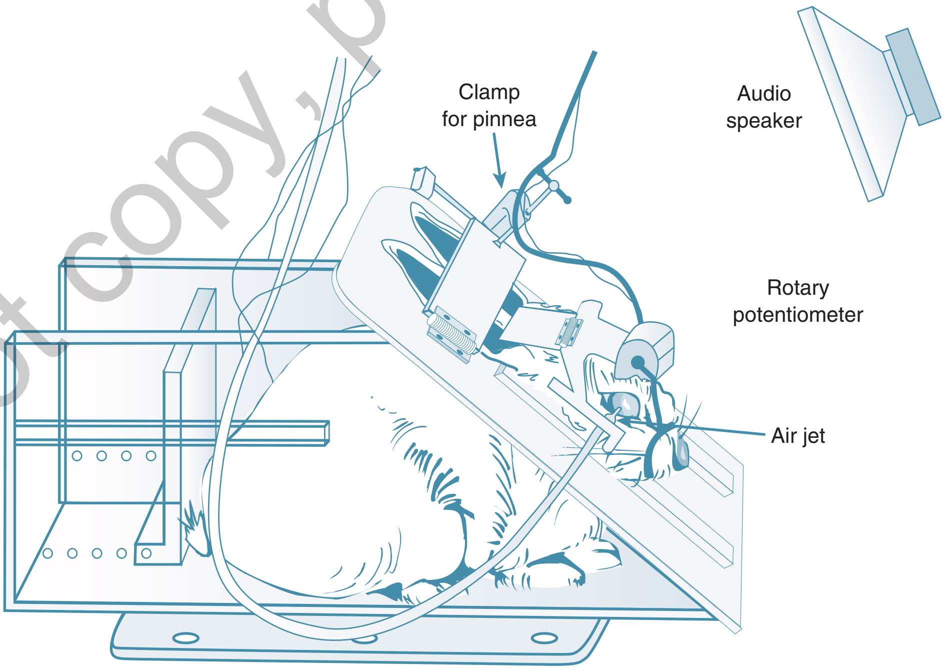
Psychologists now use several techniques to investigate the conditioning process. Pavlov's surgical technique to measure the visceral reactions (i.e., saliva, gastric juices, insulin) to stimuli associated with food is the most familiar measure of conditioning. Other techniques that reveal the strength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

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 found in 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

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).



Source: Gormezano, I. (1967). Classical conditioning. In J. B. Sidowski (Ed.), *Experimental methods of instrumentation in psychology.* New York: McGraw-Hill.

eyeblink conditioning to investigate the nature of Pavlovian conditioning (Domjan, 2005). They have also used it to study the brain mechanisms that underlie conditioning (Robleto, Poulos, & Thompson, 2004). 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 or a mild irritation of the skin below the eye with a brief electrical shock (UCSs) will elicit a rapid, unconditioned eyeblink response. By contrast, a tone, light, or tactile stimulus (CSs) will produce a slow, gradual closure of the eye. Further, 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 discover in Chapter 7, 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**. 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 conditioned emotional response procedure for detecting the level of fear, and their methodology has been used often to provide a measure of conditioned fear (Davis, 1968). Fear conditioning develops rapidly, 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.

Calculating a **suppression ratio** determines the level of fear conditioned to the CS. This suppression ratio compares the response level during the interval when the CS is absent to the response level 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 without the CS and with the CS).

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

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 Pavlovian 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, after consuming saccharin, rats were made ill by agents such as X-ray irradiation or lithium chloride (LiCl); the rats subsequently avoided the saccharin. The measure of conditioning is the amount of the fluid or food consumed. Flavor aversion learning is quite rapid; significant avoidance is 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.

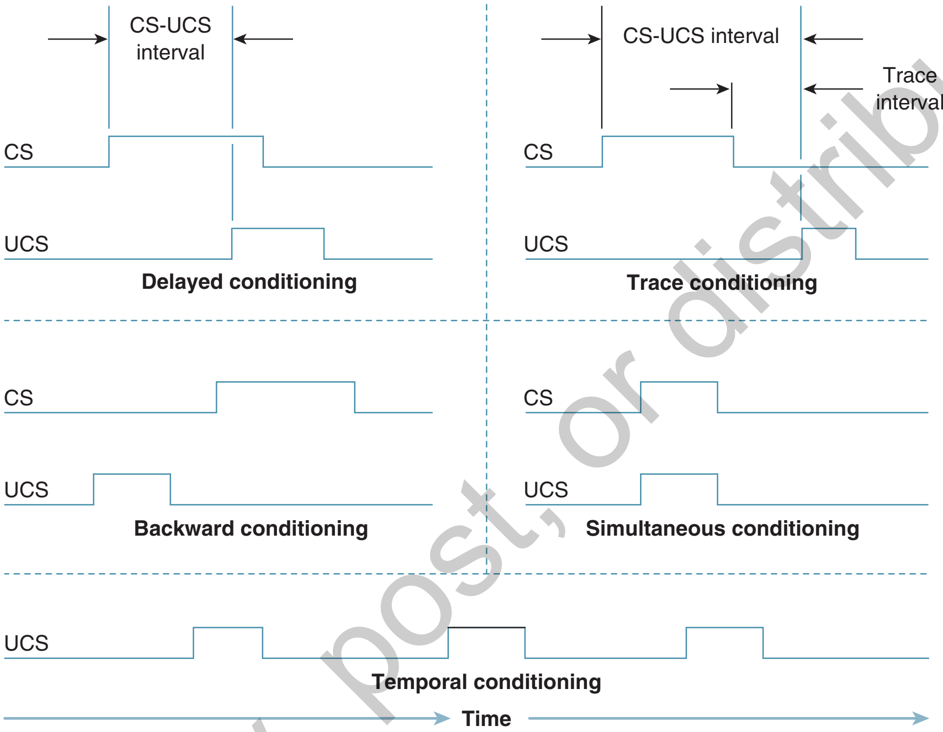
More recent surveys suggest that the number of persons with flavor aversions is even higher than Garb and Stunkard (1974) reported. For example, Logue, Ophir, and Strauss (1981) found that over half the college students they surveyed reported at least one food aversion. Further, many people have an aversion to a flavor even when they know that the flavor did not cause the illness. This observation suggests that mechanistic rather than cognitive processes control aversions; we have more to say about the nature of flavor aversion learning in Chapter 8.

TEMPORAL RELATIONSHIPS BETWEEN THE CONDITIONED STIMULUS AND THE UNCONDITIONED STIMULUS

3.2 Describe the ways the conditioned and the unconditioned stimuli can be paired.

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

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



Note: CS = conditioned stimulus; UCS = unconditioned stimulus.

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. In other words, there is no time delay between the CS and onset of the UCS. 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 seeing a darkened sky.

Juliette's fear of nighttime darkness was conditioned using the delayed conditioned procedure. Nighttime darkness (CS) preceded the attack (UCS) and continued during the course of the attack.

Trace Conditioning

With this conditioning procedure, the CS is presented and terminated prior to UCS onset. In other words, there are delays of varying lengths between the termination of the CS and the onset of the UCS. A parent who calls a child to dinner is using a **trace conditioning** procedure. In this example, the announcement of dinner (CS) terminates prior to the presentation of food (UCS). As we discover in the next section, the hunger that the trace conditioning procedure 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** procedure is used. An example of simultaneous conditioning is walking into a gourmet 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 may lead to weak hunger conditioned to the gourmet restaurant.

Backward Conditioning

In the **backward conditioning** procedure, 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) demonstrates that the backward conditioning procedure is also a conditioned inhibition procedure; that is, the CS is actually paired with the absence of the UCS. In some instances, a person experiences a conditioned inhibition rather than conditioned excitation when exposed to the CS. In Chapter 4, we look at the factors that determine whether a backward conditioning paradigm conditions excitation or **inhibition**.

Temporal Conditioning

There is no distinctive CS in **temporal conditioning**. Instead, the UCS is presented at regular intervals, and over time the CR occurs 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 procedures 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 is usually the least. The other three procedures typically have an intermediate level of effectiveness. These differences most likely reflect differences in the neural systems that mediate each Pavlovian conditioning procedure. According to Carey, Carrera, and Damianopoulos (2014), delayed conditioning is under the control of the **cerebellum**, which is the brain area responsible for reflexive reactions to environmental events, while trace conditioning is mediated by the **hippocampus**, which is the area of the brain responsible for the storage and retrieval of events. In support of the view, Flesher, Butt, and Kinney-Hurd (2011) observed that increased acetylcholine activity in the hippocampus during trace conditioning but not during delayed conditioning.

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?

Review

- The ability of environmental events to produce emotional reactions that in turn motivate operant behavior develops through the Pavlovian 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 a UCS, can elicit an innate response.
- As the result of conditioning, the neutral environmental stimulus, now a CS, can also elicit a response, called the CR.
- An environmental event paired with food activates the basolateral amygdala and elicits conditioned hunger, while a stimulus paired with a painful event arouses the central and lateral amygdala and elicits a conditioned fear.
- With delayed conditioning, the CS remains present until the UCS begins and is under the control of the cerebellum.
- With trace conditioning, the CS ends prior to the onset of the UCS and is under the control of the hippocampus.
- With simultaneous conditioning, the CS and UCS occur at the same time, while backward conditioning presents the CS following the presentation of the UCS.
- Temporal conditioning takes place when the UCS is presented at regular intervals of time.
- Delayed conditioning is the most efficient and backward conditioning the least.

CONDITIONS AFFECTING THE ACQUISITION OF A CONDITIONED RESPONSE

3.3 Explain the conditions that influence the strength and rate of conditioning.

In the previous section, we learned that a CR develops when a novel stimulus is paired with a UCS. However, the pairing of a CS and a UCS does not automatically insure that the subject will acquire a CR. 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 Pavlovian conditioning.

Contiguity

Consider the following example to illustrate the importance of contiguity to the development of a CR. 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, even though it has been consistently paired with her father's punishment? The answer to this question relates to the importance of the close temporal pairing, or contiguity, of the CS and UCS in Pavlovian conditioning. A threat (the CS) provides information concerning future punishment and elicits the emotional fear response 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 because 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. Similarly, the contiguity between nighttime darkness and the attack contributed to Juliette's intense fear and her avoidance of going out at night.

The Optimal Conditioned Stimulus–Unconditioned Stimulus Interval

Many studies document the importance of contiguity to the acquisition of a CR. Experiments designed to evaluate the influence of contiguity on Pavlovian 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 **conditioned stimulus (CS)–unconditioned stimulus (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 interval.

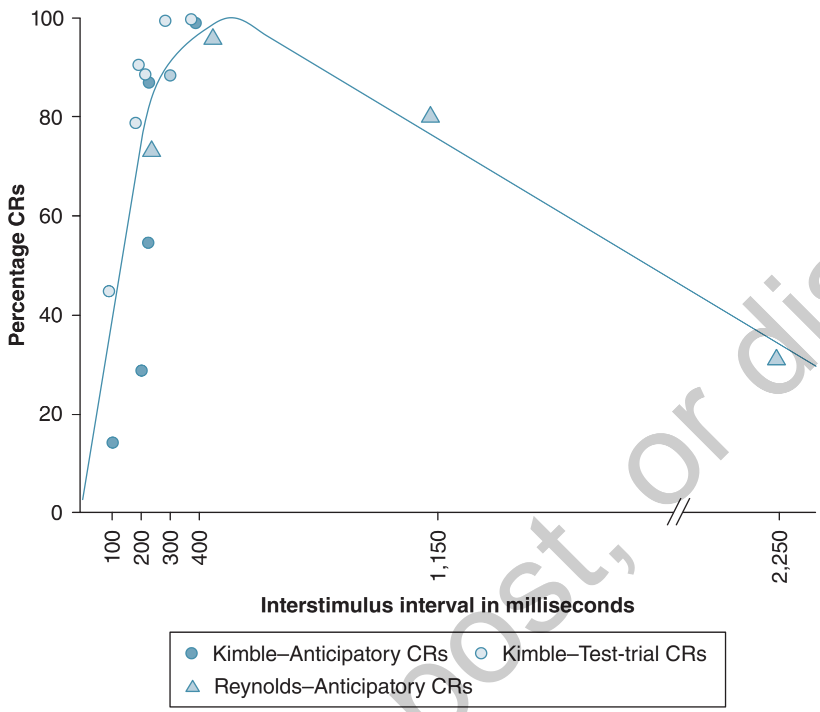
The optimal CS–UCS interval is different for different responses. For example, the optimal conditioning interval is 450 milliseconds for eyeblink conditioning. This 450-millisecond ISI for the conditioning of the eyelid closure reflex has been observed in both animals (Smith, Coleman, & Gormezano, 1969) 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 heart rate response is longer than that of the eyeblink closure reflex. Wagner and Brandon's 1989 article addresses the question of how response latency affects the optimal ISI; we look at their view in Chapter 4.

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 Pavlovian 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; the strongest conditioning occurs when the flavor and illness are separated by only 30 minutes (Garcia, Clark, & Hankins, 1973). We take a more detailed look at flavor aversion learning in Chapter 8.

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 and then declines with longer intervals.



Source: Data from Kimble, G. A., & Reynolds, B. (1967). Eyelid conditioning as a function of the interval between conditioned and unconditioned stimuli. In G. A. Kimble (Ed.), *Foundations of conditioning and learning.* New York: Appleton-Century-Crofts.

Note: CR = conditioned response.

The Influence of Intensity

Conditional Stimulus Intensity

Suppose that you were bitten by a dog. Would you be more afraid if it were a large dog or if it were a small dog? 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 intensity conditioning indicates your fear would be equivalent only if one dog bites you. By contrast, you would be more afraid of the more intense CS, the large dog, even if its bite were no more painful if you had been bitten by both dogs. Let's now look at research examining the influence of CS intensity on CR strength if you were bitten by one or by both sizes of dogs (not necessarily at the same time).

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 Pavlovian 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 CR. 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? An intense CS does not produce an appreciably greater CR than does a weak CS when an animal or person experiences only a single stimulus (either weak or intense). However, if the animal 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 trials with the soft tone.

Grice and Hunter's (1964) results 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.

Unconditional Stimulus 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.

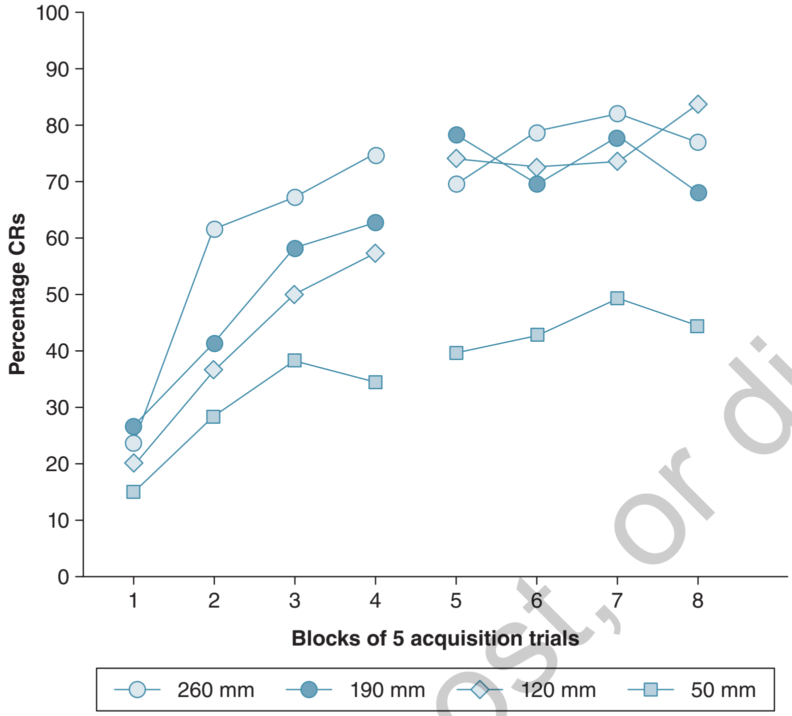
The literature provides conclusive documentation that the strength of the CR increases with higher UCS intensity. To show the influence of UCS intensity on eyelid response conditioning, Prokasy, Grant, and Myers (1958) gave their human subjects a 50-, 120-, 190-, or 260-mm intensity air puff UCS paired 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 3.6**).

The Salience of the Conditioned Stimulus

Martin Seligman (1970) suggested that animals or humans have an evolutionary predisposition or **preparedness** to associate some particular stimulus with a specific UCS but that other CS–UCS associations cannot be learned. The concept of **contrapreparedness** suggests that some stimuli, despite repeated CS–UCS pairings, cannot become associated with a particular UCS. The likelihood that a particular neutral stimulus will become able to elicit a CR after pairing with a UCS 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 UCS, 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 CR 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 8 discusses the biological significance of stimulus salience in Pavlovian conditioning; we examine the influence of species-specific stimulus salience on the acquisition of a CR in that chapter.

FIGURE 3.6 ■ The percentage of conditioned responses during acquisition increases with greater UCS intensity.



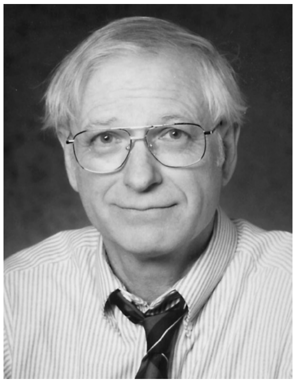
Source: Adapted from Prokasy, W. P., Jr., Grant, D. A., & Myers, N. A. (1958). Eyelid conditioning as a function of unconditioned stimulus intensity and intertrial interval. *Journal of Experimental Psychology,* 55, 242–246. Copyright 1958 by the American Psychological Association. Reprinted by permission.

Note: CR = conditioned response.

The Predictiveness of the Conditioned Stimulus

Robert Bolles (1972, 1979) proposed that contiguity alone is not sufficient for the development of a CR. In Bolles's view, events must consistently occur together before we can acquire a CR. A neutral stimulus may be 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.

The following example illustrates the importance of **cue predictiveness** to the development of a CR. 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 sometimes punish their children without threatening 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 next examine evidence showing that CR acquisition is impaired if the UCS is sometimes presented without the CS. Then we review research that shows how presentations of the CS alone decrease the development of the CR.



Courtesy of Robert Rescorla

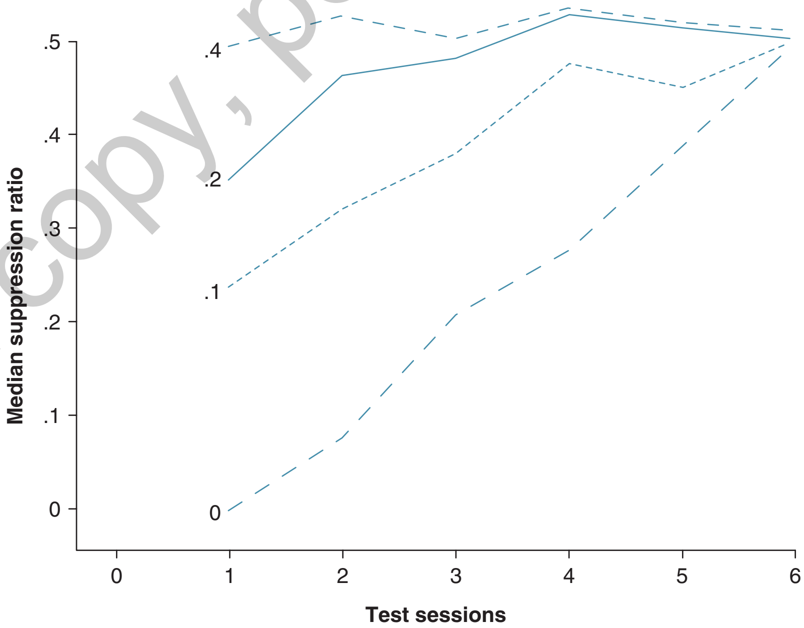
Robert A. Rescorla (1940–)

Rescorla received his doctorate from the University of Pennsylvania under the direction of Richard Solomon. He then taught at Yale University for 15 years before spending the past 37 years at the University of Pennsylvania. While at Penn, he served as chair of the Department of Psychology and dean of the College of Arts and Sciences. His research has contributed significantly to an understanding of the Pavlovian conditioning process. He was a recipient of the Award for Distinguished Scientific Contributions from the American Psychological Association in 1986.

Unconditioned Stimulus-Alone Presentations

Robert Rescorla's (1968) research demonstrates the influence of cue predictiveness in Pavlovian 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 with no tone as it did when the tone was present. **Figure 3.7** presents the results for the subjects that received a .4 CS–UCS probability (or CS paired with the UCS on 40% of the 2-minute segments).

FIGURE 3.7 ■ Suppression of bar-pressing behavior during six extinction 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.



Source: Adapted from Rescorla, R. A. (1968). Probability of shock in the presence and absence of CS in fear conditioning. *Journal of Comparative and Physiological Psychology,* 68, 1–5. Copyright 1968 by the American Psychological Association. Reprinted by permission.

Note: CS = conditioned stimulus.

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 appeared 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. It should be noted that the number of CS–UCS pairings is important when two stimuli are equally predictive of the occurrence of the UCS.

Conditioned Stimulus-Alone Presentations

The acquisition of a CR is also impaired or prevented when the CS is presented alone during conditioning. Many studies (see J. F. 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 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.

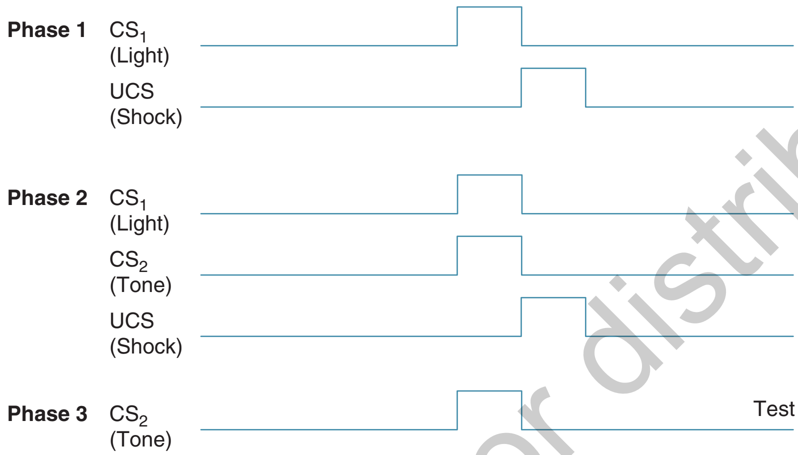
The Redundancy of the Conditioned Stimulus

Recall from the previous section the example of parental threats that fail to instill fear. In addition to a lack of cue predictiveness, another possible explanation for this lack of fear is that the child is already afraid when the threat is presented. Perhaps she is afraid of her 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 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 light) paired with a shock (UCS) eight times during the first phase of the study (see **Figure 3.8**). 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 the study showed strong suppression in response to the tone (CS_2). The prevention of conditioning to CS_2 by the CS_1 is called **blocking**.

Blocking also has been observed in humans. Prados and colleagues (2013) determined the ability of human subjects to associate a spatial cue with a goal environment. When the spatial cue (CS_2) was presented with another spatial cue (CS_1) that had already been presented with the goal environment, CS_2 did not become associated with the goal location. By contrast, CS_2 did become associated with the goal environment if it was presented alone with the goal location. These researchers also found that blocking occurred in rats in a flavor aversion paradigm

FIGURE 3.8 ■ The design of Kamin's blocking study. In Phase 1, the CS_1 (light) is paired with the UCS (shock); in the second phase, both the CS_1 (light) 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.



Note: CS = conditioned stimulus; UCS = unconditioned stimulus.

when a specific flavor was presented prior to illness along with flavors that had previously been paired with illness.

The Importance of Surprise

Why does blocking occur? Nicholas Mackintosh suggests that surprise is necessary for Pavlovian conditioning to occur; that is, the occurrence of the UCS must be surprising for the conditioned and unconditioned stimuli to be associated. In the blocking paradigm, the occurrence of UCS is not surprising when the CS_2 is presented due to the presence of CS_1. What if the UCS was surprising in the presence of CS_1 and CS_2? Would blocking to CS_2 in the presence of CS_1 not occur? Dickinson, Hall, and Mackintosh (1976) conducted such a study. In the first phase of their study, CS_1 was presented prior to two UCSs, and strong conditioning occurred to CS_1. In the second phase of their study, both CS_1 and CS_2 were presented prior to either one or two UCSs. Blocking was found when two UCSs were presented but not when one UCS was presented. When CS_1 was followed by two UCSs in the first phase of the study, two UCSs occurring in the second phase of the study was not surprising. By contrast, only one UCS occurring in the second phase was surprising, which resulted in CS_2 being associated with the UCS; therefore, blocking was not observed.

The Neuroscience of Predictiveness and Surprise

It is worth noting that the **corticomedial amygdala** is activated by a surprising event, while the presentation of a stimulus that is predictive of an event that is no longer surprising activates the basolateral amygdala (Boll, Gamer, Gluth, Finsterbusch, & Buchel, 2013). Evidently, different amygdala circuits are activated by predictive and surprising events. Comparable results were observed by Holland (2013) for predictive and surprising events in human fear conditioning. Using blood-oxygen level-dependent response as a measure of brain activity, Holland found that a surprising event activated the corticomedial amygdala, while the basolateral amygdala became active during a predictive event.

Why is the lack of a surprising event responsible for blocking? And why did a surprising event in the second phase of the Dickinson, Hall, and Mackintosh (1976) study lead to a failure to observe blocking? Answers to these two questions are explored in the next chapter.

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?

Review

- Temporal contiguity affects the strength of conditioning; the longer the interval between the CS and UCS, the weaker the conditioning.
- An aversion to a flavor cue paired with illness is an exception; it can develop despite a lack of contiguity.
- An intense stimulus typically leads to a stronger CR, while 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.
- The presence of CS (CS_1) can block the development of a CR to a new stimulus (CS_2) when both stimuli are paired with the UCS due to a lack of surprise.
- Surprising events activate the corticomedial amygdala, while events that are predictive are under the control of the basolateral amygdala.

EXTINCTION OF THE CONDITIONED RESPONSE

3.4 Describe how a conditioned response (CR) can be extinguished.

Earlier in the chapter, you learned that environmental stimuli, through their association with food, can acquire the ability to elicit hunger. CRs typically have an adaptive function by enabling us to eat at regularly scheduled times. However, the conditioning of hunger can also be harmful if it causes people to eat too much and become obese.

Clinical research has revealed that overweight people eat in many situations such as watching television, driving, or at the movies (Masters, Burish, Hollon, & Rimm, 1987). In order to lose weight, overweight people should restrict their food intake to 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 CR. The person's hunger response to varied environmental circumstances has developed through the Pavlovian conditioning process, so the conditioned hunger reaction can be extinguished through this process.

Extinction can also be effective for people who are extremely fearful of flying. Because fear of flying may be acquired through the Pavlovian conditioning process, extinction again represents a potentially effective method for eliminating the conditioned reaction. Extinction also represents a way that Juliette could eliminate her fear of nighttime darkness; that is, if she were to experience nighttime darkness (CS) in the absence of being attacked (UCR), her fear of nighttime darkness would be extinguished.

In the next section, we 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 also explore the reason that extinction is not always an effective method of eliminating a CR. Let's begin by looking at the extinction procedure.

Extinction Procedure

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

Pavlov reported in his classic 1927 book that a 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 phenomena (Westbrook & Bouton, 2010).

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 (e.g., 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 5; the use of punishment is discussed in Chapter 6.

Extinction can also eliminate fear of flying. Fear is diminished if a person flies and does not experience extreme plane movements. 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. Similarly, Juliette probably would not be able to experience the nighttime darkness sufficiently to extinguish her fear. Other techniques (e.g., systematic desensitization, response prevention, and modeling) also are available to eliminate fears. Systematic desensitization is discussed later in this chapter, response prevention in Chapter 7, and modeling in Chapter 11.

Extinction appears to be specific to the context in which extinction occurred with a change of context leading to a renewal of the conditioned fear response (Maren, Phan, & Liberzon, 2013) and a conditioned appetitive response (Anderson & Petrovich, 2017). Fujiwara and colleagues (2012) found that following extinction of a taste aversion in one context, animals will avoid the extinguished taste in a new context. The researchers also observed that the context renewal effect is dependent on a functioning hippocampus and that dorsal hippocampal lesions disrupted the context-dependent renewal effect. Ji and Maren (2005) reported a similar disruption of context-specific extinction of a conditioned fear response in rats with dorsal hippocampal lesions. It seems that animals will limit extinction of a CR to the conditioning context as long as they can remember the context in which extinction occurred.

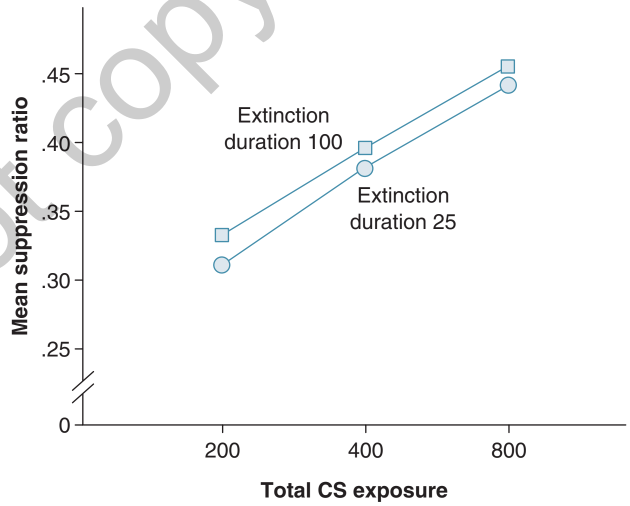
How Rapidly Does a Conditioned Response Extinguish?

We have discovered that the strength of the CR 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 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 (1974) study to see the influence of CS-alone duration on the extinction of a CR. Shipley 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 the animals were given 25-second CS-alone exposures during extinction; the other half received 100-second CS-alone experiences during extinction. One-third of the animals in both the 25-second and the 100-second CS duration groups were given sufficient extinction experience that they received a total of 200 seconds of CS exposure; another third received 400 seconds, and the last third 800 seconds of exposure. For example, to have 200 total seconds of CS exposure, the animals given 25 seconds on each trial received eight trials, compared to two trials for subjects receiving 100 seconds on each. Shipley reported that neither the number of CS-alone exposures nor the duration of each exposure affected the suppression of licking by the CS. 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 3.9**).

What happens when the CS is presented sometime after extinction? We answer that question next.

FIGURE 3.9 ■ 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.



Source: Adapted from Shipley, R. H. (1974). Extinction of conditioned fear in rats as a function of several parameters of CS exposure. *Journal of Comparative and Physiological Psychology,* 87, 669–707. Copyright 1974 by the American Psychological Association. Reprinted by permission.

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 (1927), 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** earlier in the chapter). The return of the CR following extinction is called **spontaneous recovery**. Spontaneous recovery is a very reliable phenomenon following extinction (Rescorla, 2004). The hippocampus plays a very important role in the recovery of the CR following extinction. Maren (2014) observed no spontaneous recovery of a conditioned fear if the hippocampus was inhibited following extinction. According to Maren, the hippocampus, the brain area responsible for the retrieval of past events, mediates the recovery of an extinguished conditioned emotional response.

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 discuss the conditioned inhibition process next.

OTHER INHIBITORY PROCESSES

3.5 Explain how the conditioning and extinction processes can be disrupted.

We have learned that a temporary inhibition is involved in the extinction of a CR. The inhibition of the CR can also become permanent, a process Pavlov (1927) called conditioned inhibition. There are also several other types of inhibition: external inhibition and inhibition of delay. Inhibition can be disrupted through a process called disinhibition.

Conditioned Inhibition

The temporary inhibition of a CR can become permanent. If a new stimulus (CS–) similar to the CS (CS+) is presented in the absence of the UCS, 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 food pantry, you find it to be empty. It is likely that the empty food pantry would act to inhibit your hunger. This inhibitory property of the empty food pantry developed as a result of past pairings of the empty food pantry 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 (1953) 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 shuttle box (see Chapter 7). 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 3 days of avoidance conditioning, the dogs were locked in one compartment of the shuttle box and exposed on some trials to a 1200-Hz tone (CS+) and shock (UCS) and on other trials to a 400-Hz 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 influence on avoidance behavior. We examine that influence in Chapter 6.

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 CR. 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 CR will return to its previous level.

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 before we receive 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 digestion 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.

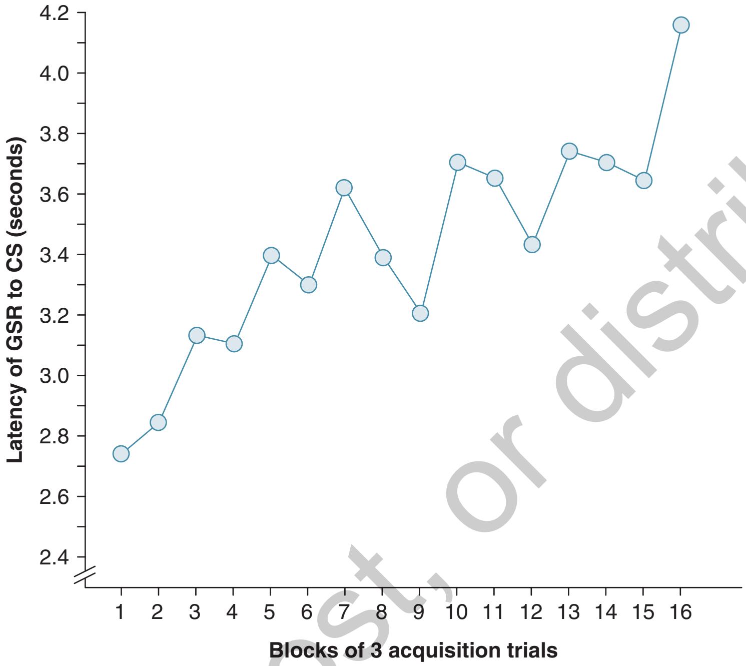
Pavlov's (1927) classic research demonstrated that the dogs developed the ability to suppress the CR until the end of the CS–UCS interval, a phenomenon he labeled **inhibition of delay**. Other experimenters (Kimmel, 1965; Sheffield, 1965) have also shown that animals and humans can inhibit the CR until just 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 3.10**).

Disinhibition

Pavlov (1927) reported that the presentation of a novel stimulus during extinction leads to an increased strength of the CR. 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 as a result of presenting a novel stimulus during extinction **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.

FIGURE 3.10 ■ 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.



Source: Kimmel, H. D. (1965). Instrumental inhibitory factors in classical conditioning. In W. F. Prokasy (Ed.), *Classical conditioning: A symposium*. Reprinted with permission from Ardent Media Inc.

Note: GSR = galvanic skin response; CS = conditioned stimulus.

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

Review

- Extinction, or the presentation of the CS without the UCS, will cause a reduction in CR strength; with continued CS-alone presentations, the CS will eventually fail to elicit the CR.
- The rate of extinction is influenced by the total time of exposure to the CS during extinction; the longer the exposure, the greater the extinction.

- The extinguished response will occur in a new context as long as the hippocampus remembers the context in which extinction occurred.
- Spontaneous recovery is the return of a CR following an interval between extinction and testing without additional CS–UCS pairings.
- 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 just before the 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 RESPONSE WITHOUT CONDITIONED STIMULUS–UNCONDITIONED STIMULUS PAIRINGS

3.6 Recount how a conditioned response (CR) can be acquired without pairing of the conditioned stimulus (CS) and the unconditioned stimulus (UCS).

Although many CRs are acquired through direct experience, many stimuli develop the ability to elicit a CR indirectly; that is, a stimulus that 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.

Stimulus generalization is one way that an emotional response can occur without a direct CS–UCS pairing. Stimulus generalization refers to emotional responses that occur to stimuli that are similar to the CS (Pavlov, 1927). A colleague of mine likes his sister, who has red hair. He generalizes this liking and has an initial positive feeling to other people with red hair. We will discuss stimulus generalization in detail in Chapter 10.

Higher-order conditioning, sensory preconditioning, and vicarious conditioning are three other means by which an emotional response can be elicited by a stimulus without that stimulus being paired with a biologically significant event or UCS. We look at higher-order conditioning next followed by a discussion of sensory preconditioning and vicarious conditioning.

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 Process

Pavlov (1927) observed that following several CS_1–UCS pairings, presenting the CS_1 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 CS_2–tone CS_1 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 3.11** presents a diagram of the higher-order conditioning process.

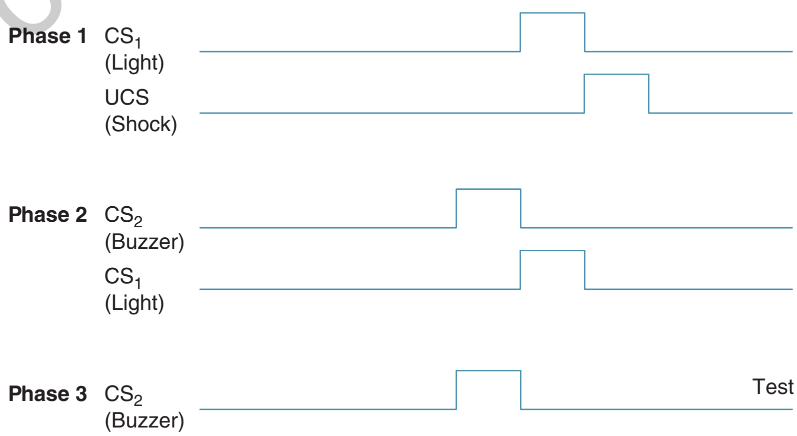
Emotions have three basic components: (1) an emotional response that is either pleasant or unpleasant; (2) the motivation to either approach or avoid the event eliciting the emotion; and (3) physiological arousal, ranging from slight to intense (Carlson & Hatfield, 1992). Littel and Franken (2012) were able to demonstrate all three components in a higher-order conditioning paradigm. They paired smoking related stimuli (CS_1) with a geometric form (CS_2) in smokers and nonsmokers. Higher-order conditioning to the geometric form (CS_2) was observed for smokers, but not in nonsmokers, for all three components of an emotion (positive emotion, physiological arousal, and desire to smoke a cigarette).

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 (1927) 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 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

FIGURE 3.11 ■ 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.



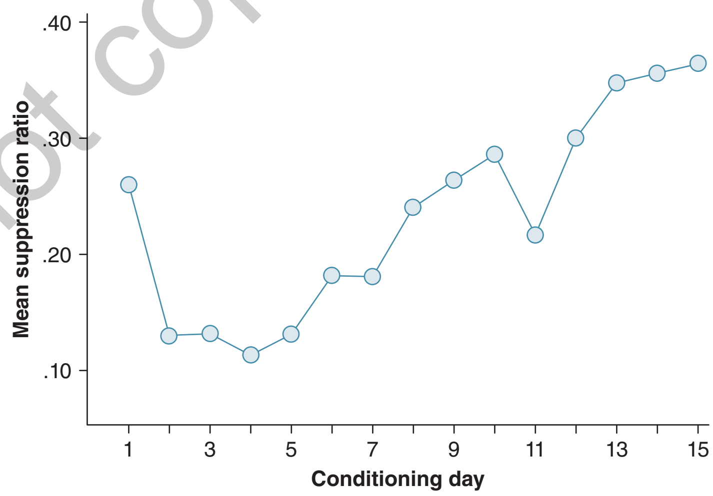
they are also conditioning the inhibition of the CR by pairing the compound stimulus (CS_2 & CS_1) in the absence of the UCS.

When will higher-order conditioning occur? Rescorla and his associates (Holland & Rescorla, 1975; Rescorla, 1973, 1978; Rizley & Rescorla, 1972) 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 (one milliamp or one thousandth of an ampere) 0.5-second electric shock (UCS). Following first-order conditioning, the light (CS_1) was paired with a 1800-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 3.12**). 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 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.

FIGURE 3.12 ■ 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.



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.

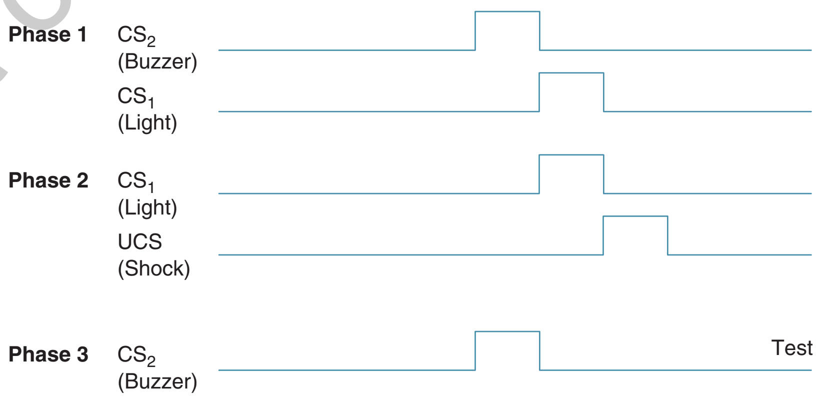
The Sensory Preconditioning Process

In sensory preconditioning, two neutral stimuli, CS_1 and CS_2, are paired (see **Figure 3.13**). Following the association of CS_1 and CS_2 (dog and neighbor), CS_1 is presented with a UCS (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 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.

FIGURE 3.13 ■ **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.**



Note: CS = conditioned stimulus.

Subsequent studies (Rizley & Rescorla, 1972; Tait, Marquis, Williams, Weinstein, & Suboski, 1969) indicate that the earlier 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 to prevent learning that the stimuli are irrelevant. We will discuss the reason that learning that a stimulus is irrelevant impairs subsequent conditioning in Chapter 4.

The Neuroscience of Higher-Order Conditioning and Sensory Preconditioning

The hippocampus appears to play an important role in the acquisition of a CR through higher-order conditioning and sensory conditioning. In support of this view, Hoang, Gilboa, Sekeres, Moscovitch, and Winocur (2014) found that hippocampal lesions impaired appetitive higher-order conditioning, while Yu, Lang, Birbaumer, and Kotchoubey (2014) reported that the hippocampus becomes active during sensory preconditioning. As the hippocampus is involved in the storage and retrieval of events, it is not surprising that the hippocampus is crucial to Pavlovian higher-order conditioning and sensory preconditioning.

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 the ability of a CS 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, 1971) also demonstrates that CRs can be acquired through vicarious conditioning experiences. Let's examine several studies that show the vicarious conditioning of a CR.

Research on Vicarious Conditioning

Berger's (1962) study 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 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. Mineka, Davidson, Cook, and Keir (1984) found that primates can learn to fear snakes after seeing another primate react fearfully to a snake. In the absence of this experience, the primates 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 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 emotional 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 CRs 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 probably no. Several sources may contribute to the intensity of the CR. 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?
- Would the intensity of Juliette's fear be equivalent to first-order conditioning with higher-order conditioning, sensory preconditioning, or vicarious conditioning?

Review

- A CS can develop the ability to elicit the CR indirectly—that is, without being directly paired with the UCS.
- Higher-order conditioning occurs when, after CS_1 and UCS pairings, a new stimulus (CS_2) is presented with the CS_1; 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.
- The hippocampus, the area of the brain involved in the storage and retrieval of events, plays a crucial role in both higher order conditioning and sensory preconditioning.
- A CR can be established through vicarious conditioning when one person observes another person experiencing the pairing of CS and UCS.

APPLICATIONS OF PAVLOVIAN CONDITIONING

3.7 Describe the use of systematic desensitization to eliminate a phobia.

We discuss two applications of Pavlovian conditioning in this chapter. The first involves the use of Pavlovian conditioning principles to eliminate phobias or irrational fears. This procedure, called systematic desensitization, has been used for over 50 years to eliminate the fears of people with phobias. The second application, which involves extinction of a person's craving for a drug, has only recently been used to treat drug addiction.

Systematic Desensitization

Recall that Juliette is extremely frightened of nighttime darkness. This fear causes Juliette to refuse invitations to go out at night. What can be done to allow Juliette to go out at night with minimal or no fear? Systematic desensitization, a therapy developed by Joseph Wolpe (1958), could allow Juliette to no longer be afraid of darkness.

Systematic desensitization 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 anxiety. His treatment is based on Pavlovian conditioning principles and represents an important application of Pavlovian conditioning. Let's examine this technique to discover how Pavlovian conditioning can alleviate extreme fear.

Special Collections, USC Libraries, University of Southern California

Joseph Wolpe (1915–1997)

Wolpe received his doctorate in medicine from the University of Witwatersrand. During World War II, Wolpe worked as a psychiatrist in the South African Army. His failure to successfully treat soldiers suffering from "war neuroses," or post-traumatic stress disorder (PTSD), led Wolpe to develop systematic desensitization therapy. Wolpe taught at Stanford University and the University of Virginia for 9 years before spending 23 years teaching at Temple University School of Medicine. Wolpe served as president of the Association for Advancement of Behavior Therapy in 1967. The American Psychological Association awarded Wolpe its Distinguished Scientific Award for the Applications of Psychology in 1979.

Wolpe suggested that Pavlovian conditioning could be used to treat human phobic behavior. He based this idea on three lines of evidence: (1) Sherrington's (1906) statement that an animal can experience only one emotional state at a time—a phenomenon Wolpe termed **reciprocal inhibition**, (2) Mary Cover Jones's (1924) report 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 candy, and (3) Wolpe's own research using cats.

The Contribution of Mary Cover Jones

In 1924, Mary Cover Jones developed an effective technique to eliminate fears. Jones observed that Peter, a 3-year-old boy, was quite frightened of white rabbits. When Peter was at ease, she brought the rabbit into the same room while Peter was eating candy, keeping enough distance between the rabbit and Peter that the child was not alarmed. She then moved the rabbit closer and closer to Peter, allowing him to grow accustomed to it in gradual steps. Eventually, the child was able to touch and hold the formerly fear-inducing animal.

According to Mary Cover Jones, this procedure she used with Peter had eliminated his fear by conditioning a positive emotional response to the rabbit, produced by eating candy. The elimination of fear by the acquisition of a fear-inhibiting emotional response occurs through the conditioning of an opponent or antagonistic response, a process that Pavlov (1927) called **counterconditioning**. Approximately 30 years later, Jones's study played an important role in the development of an effective treatment of human phobic behavior.

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

Mary Cover Jones (1896–1987)

Cover Jones studied with John B. Watson and received her doctorate from Columbia University. Considered a pioneer in the field of behavior therapy, her counterconditioning of a fear of rabbits in 3-year-old Peter played a central role in the development of systematic desensitization. When her husband, Harold Jones, accepted a position as director of Research at the Institute for Child Welfare at the University of California, she took a position as research associate at the institute, where she remained for 20 years conducting longitudinal studies of child development. She later served on the faculty at the University of California, Berkeley, for 8 years prior to her retirement. She received the G. Stanley Hall Award for Distinguished Contribution to Developmental Psychology by the American Psychological Association in 1968.

Source: Center for the History of Psychology, Archives of the History of American Psychology—The University of Akron.

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 earlier, counterconditioning is the process of establishing a CR that competes with a previously acquired response.

Wolpe then 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: (1) relaxation, (2) assertion, and (3) sexual responses. We limit our discussion in this chapter to the use of relaxation.

Wolpe's (1958) 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 Edmund 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. The patient tenses and relaxes each major muscle group in a specific sequence.

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 (1973) labeled **cue-controlled relaxation**, promotes the development of a conditioned relaxation response that enables a word cue to elicit relaxation promptly; the patient then uses the cue to inhibit any anxiety occurring during therapy.

The desensitization treatment consists of four separate stages: (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. The patient writes descriptions of the scenes on index cards and then ranks them from those that produce low anxiety to those that produce high anxiety.

Paul (1969) identified two major types of hierarchies: (1) thematic and (2) spatial–temporal. In a **thematic hierarchy**, 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.

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 in the test area. Others may have a different hierarchy; when taking the exam, they experience the most fear. As each individual's phobic response is highly idiosyncratic and dependent on that person's unique learning experience, a hierarchy must be specially

TABLE 3.1 ■ Thematic Hierarchy

Level	Scene
1	Discussing a prospective interview with an agent, R. C., in your office; client in question is stalling on his payment, and you must tell R. C. what to do
2	Working in your office on Monday morning; the prepared-for regularly scheduled sales meeting in a few minutes
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	Conducting 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.

TABLE 3.2 ■ Spatial-temporal Hierarchy

Level	Scene
1	Recalling it is 4 days before an examination
2	Remembering it is 3 days before an examination
3	Recalling it is 2 days before an examination
4	Remembering it is 1 day before an examination
5	Recalling it is the night before an examination
6	Noticing that the examination paper lies face down before the student
7	Awaiting the distribution of examination papers
8	Standing 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.

constructed for each person. 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 from the edges of these places.

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 and colleagues (1987) suggested that the first exposure be quite brief (5 seconds). The duration of the imagined scene can then be slowly increased as the 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. Counterconditioning at 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 must 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 treat 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.

Let's consider the use of systematic desensitization to treat a child with a dental phobia. Unfortunately, many people have an unrealistic fear of dentists, which can prevent them from receiving needed treatment, which can lead to serious problems like tooth decay and periodontal disease. McMullen, Mahfood, Francis, and Bubenik (2017) used systematic desensitization to treat the dental phobia of a young boy and found that the child was able to seek appropriate dental care, which was maintained over 3 years after the treatment was given.

The use of systematic desensitization to treat dental phobias is one class of phobias utilizing systematic desensitization. And the range of phobias successfully 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 to successfully treat phobic behavior (Hersen & Rosqvist, 2005).

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 et al., 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 whether 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 and colleagues (1995) 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, Rothbaum, Hodges, Anderson, Price, and Smith (2002) reported that a virtual reality environment was as effective as a standard exposure treatment for fear of flying, while Garcia-Palacios, Hoffman, Carlin, Furness, and Botella (2002) found that a virtual reality environment can be used to treat a spider phobia (see **Figure 3.14**). Other studies have reported that virtual reality represents an effective treatment for post-traumatic stress disorder (PTSD) that resulted from combat (Reger et al., 2011) and a motor vehicle accident (Wiederhold & Wiederhold, 2010).

Some young children develop a fear of going to school as a result of aversive events occurring at school such as being bullied by classmates or having to get undressed to practice sports. Gutiérrez-Maldonado, Magallón-Neri, Rus-Calafell, and Peñaloza-Salazar (2009) reported that virtual reality therapy represents an effective means of reducing a child's fear of going to school.

FIGURE 3.14 ■ A virtual-reality environment for the treatment of arachnophobia, or a fear of spiders.

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Many individuals have a fear of social interactions. Gebara, Barros-Neto, Gertsenchtein, and Lotufo-Neto (2016) found that virtual reality treatment significantly reduced social anxiety in individuals who had been diagnosed with a social phobia, while Anderson, Edwards, and Goodnight (2017) found that virtual reality therapy successfully reduced social fears in individuals diagnosed with a social anxiety disorder and that treatment success was maintained on a 4- to 6-year follow-up assessment.

Virtual reality therapy has been found to be effective for the treatment of fear of public speaking (Harris, Kemmerling, & North, 2002). The effectiveness of virtual reality to reduce the fear of public speaking is not short-lived as Safir, Wallach, and Bar-Zvi (2012) reported that the significant decrease in fear following virtual therapy treatment for a fear of public speaking was maintained on a 1-year follow-up evaluation. Further, Lister, Piercey, and Joordens (2010) found that a 3-D virtual reality environment was especially effective in reducing a person's fear of public speaking.

Virtual reality therapy does seem to have an advantage over the use of imagery in treatment. Rus-Calafell, Gutiérrez-Maldonado, Botella, and Baños (2013) compared the use of virtual reality versus imaginal exposure in individual with a fear of flying. While both treatment successfully reduced fear of flying during treatment, the individuals receiving the virtual reality exposure experienced less fear during an actual flight.

While virtual reality is a relatively new technology, it does appear to represent an effective methodology to reduce phobias (Morina, Ijntema, Meyerbroker, & Emmelkamp, 2015). As the technology improves, it seems highly likely that its use will become more widespread.

Our discussion indicates that systematic desensitization is a very effective treatment for unrealistic fears. It seems highly likely that should Juliette seek systematic desensitization treatment, her fear of nighttime darkness could be eliminated and she could then go out at night.

Extinction of Drug Craving

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

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 CR. The **conditioned withdrawal response** produces a drug craving, which then motivates use of the drug; 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 Pescor (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, such as 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 but he or she must also extinguish the conditioned withdrawal reactions that 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.

Thewissen, Snijders, Havermans, van den Hout, and Jansen (2006) provided support for the role of context-induced drug craving. In their study, smokers were exposed to a cue predicting smoking availability and another cue signaling smoking unavailability in one context. The cue associated with smoking availability was extinguished in a second context. The researchers reported that smokers continued to experience a urge to smoke in the first context but not the second context. Similarly, Conklin, Robin, Perkins, Salked, and McClernon (2008) reported that distal cues, or environments in which smoking occurs, can elicit strong cravings even when proximal cues such as a lit cigarette are absent.

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 and colleagues (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 and colleagues 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.

Other researchers also have reported that exposure to drug-related stimuli reduced drug craving and consumption (Higgins, Budney, & Bickel, 1994; Kasvikis, Bradley, Powell, Marks, & Gray, 1991). However, the therapeutic success often is relatively short lived; that is, drug craving returned with a subsequent reinstatement of drug use (O'Brien, Childress, Ehrman, & Robbins, 1998).

Why does drug craving and drug use often return? Di Ciano and Everitt (2002) suggested that spontaneous recovery of drug craving occurs following extinction and results in the relapse of drug taking seen in treatment studies. To support this view, they trained rats to self-administer cocaine and then extinguished the cues present during cocaine consumption. After a 7-day extinction period, rats were tested after either 1 or 28 days. While the level of response to cocaine was significantly reduced 1 day after extinction, responding significantly increased on the 28-day test. Di Ciano and Everitt assumed that spontaneous recovery of drug craving was responsible for the resumption of drug use on the 28-day test. They also suggest that for an extinction procedure to be more effective, the spontaneous recovery of drug craving needs to be eliminated, perhaps by repeated extinction trials over a longer period of time.

Another way to reduce spontaneous recovery is through the use of deepened extinction, or extinction in which drug-related cues are presented together during extinction (Kearns, Tunstall, & Weiss, 2012). Kearns, Tunstall, and Weiss first trained rats to self-administer cocaine during which a tone, click, and light stimuli were presented. During the first extinction period, each of stimuli was extinguished individually. In a second extinction period, one of the auditory stimuli was extinguished with the light, while the other auditory stimuli was extinguished alone. Following the second extinction session, rats remained in the home cages for a 1-week rest period. Kearns, Tunstall, and Weiss found less spontaneous recovery and greater responding to the auditory stimuli compounded with the light during extinction than to the auditory stimulus presented alone. These results suggest that reducing spontaneous recovery should enhance the effectiveness of extinction of drug craving and drug use. It would appear that for extinction to eliminate drug craving, not only must sufficient exposure to drug-related cues occur during extinction to reduce drug craving but also to prevent spontaneous recovery of drug craving following extinction.

Before You Go On

- How might systematic desensitization be used to overcome Juliette's fear of nighttime darkness?
- What might prevent systematic desensitization from eliminating Juliette's fear of nighttime darkness?

Review

- Systematic desensitization is 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 patient then imagines the least feared stimulus for a brief time, with the time increased until the feared stimulus can be imagined without any discomfort, and 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.
- 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.

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 CR, CS, UCR, and UCS 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 Tamiko and Mia show.
3. Todd 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 Todd's craving. How might Todd eliminate his craving? What problems might Todd encounter? How can he avoid these problems?

Key Terms

asymptotic level 41
backward conditioning 50
basolateral amygdala 42
blocking 57
central amygdala 45
cerebellum 50
conditioned emotional response 47
conditioned inhibition 62
conditioned stimulus (CS)–unconditioned stimulus (UCS) interval 52
conditioned withdrawal response 77
contrapreparedness 54
corticomedial amygdala 58
counterconditioning 71
cue-controlled relaxation 72
cue predictiveness 55
delayed conditioning 49
disinhibition 63
external inhibition 63
extinction of a conditioned response (CR) 60
eyeblink conditioning 46
fear conditioning 47
flavor aversion 48
higher-order conditioning 65
hippocampus 50
inhibition 50
inhibition of delay 63
lateral amygdala 45
phobia 71
preparedness 54
reciprocal inhibition 71
salience 54
sensory preconditioning 68
simultaneous conditioning 50
spatial–temporal hierarchy 73
spontaneous recovery 62
stimulus narrowing 59
suppression ratio 47
systematic desensitization 72
temporal conditioning 50
thematic hierarchy 73
trace conditioning 49
vicarious conditioning 69