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Avoidance Learning

Did you know that

- avoidance is a form of instrumental conditioning in which the instrumental response prevents the delivery of an aversive stimulus?
- no major theory assumes that avoidance behavior is reinforced by the absence of the avoided aversive stimulus?
- although avoidance is a form of instrumental behavior, theories of avoidance learning rely heavily on concepts from Pavlovian conditioning?
- several important aspects of avoidance learning are assumed to involve learning about internal temporal cues and proprioceptive or feedback cues that accompany the avoidance response?
- avoidance behavior is strongly determined by the preexisting defensive behavior system of the organism?

Punishment is just one of the major forms of instrumental conditioning that involves aversive stimuli. Another form of aversive control is avoidance conditioning. In punishment procedures, performance of the instrumental response results in the presentation of an aversive stimulus. In **avoidance conditioning**, the instrumental response prevents or blocks the presentation of the aversive event.

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We do lots of things that prevent something bad from happening. Putting out one's hand when approaching a door prevents the discomfort of walking into a closed door; periodically checking the hot dogs on the barbeque grill prevents ending up with burnt hot dogs; slowing down while driving prevents a collision with the car in front of you; putting on a coat prevents you from getting cold when you step outside. All of these are avoidance responses, and often they are very adaptive. However, sometimes excessive avoidance responding can be highly maladaptive. Consider, for example, someone with obsessive–compulsive disorder who washes their hands 100 times a day. They may be washing their hands to avoid getting sick from germs, but excessive handwashing can also interfere with one's quality of life.

Avoidance learning is a common personal experience, and thus one might suppose that analyses of avoidance conditioning would be fairly straightforward, if not self-evident. Unfortunately, this is not the case. In fact, avoidance learning has been one of the most difficult forms of learning to analyze and explain. Because of thorny conceptual problems in avoidance learning, much of the research has been driven by theoretical rather than practical considerations. This is in sharp contrast to research on punishment, which has been dominated by practical considerations.

DOMINANT QUESTIONS IN THE ANALYSIS OF AVOIDANCE LEARNING

Avoidance procedures are clear enough: The participant performs an instrumental response that prevents the delivery of an aversive event. However, it is not clear what aspect of the avoidance procedure reinforces the instrumental response. Because a successful avoidance response prevents the delivery of the aversive stimulus, successful avoidance responses are followed by nothing. Mowrer and Lamoreaux (1942) pointed out that this raises a major theoretical question: *How can "nothing" reinforce behavior and produce learning?*

Various hypotheses and theories have been offered to explain how "nothing" can reinforce avoidance responding. The hypotheses and theories differ in various ways. However, all the major explanations reject the commonsense idea that avoidance responses occur because they prevent the delivery of the aversive event. As we shall see, several ingenious proposals have been offered without relying on the theoretically troublesome idea that "nothing" is a reinforcer.

The second major question in analyses of avoidance behavior is: *How are Pavlovian conditioning processes involved in avoidance learning?* As we have seen, Pavlovian conditioning processes have been discussed in analyses of positively reinforced instrumental behavior (see Chapter 7). However, Pavlovian conditioning concepts traditionally have not dominated thinking about positively reinforced instrumental behavior as much as they have dominated analyses of avoidance learning. Historically, avoidance learning was regarded as a special case of Pavlovian conditioning. In fact, to this day some accounts of avoidance learning regard avoidance behavior as primarily the product of Pavlovian conditioning mechanisms.

ORIGINS OF THE STUDY OF AVOIDANCE LEARNING

Avoidance learning was first investigated by the Russian scientist Vladimir Bechterev (1913), who set out to study the conditioning of motor rather than glandular responses. The procedure Bechterev devised was fairly simple. He asked human participants to place a finger on metal electrodes resting on a table. A mild current could be passed through the electrodes, and this triggered a finger withdrawal response. Thus, the unconditioned response was finger withdrawal. To turn the situation into one involving classical conditioning, Bechterev presented a brief warning stimulus immediately before the shock on each trial. As you might predict, the participants quickly learned to withdraw their fingers from the electrodes when the conditioned stimulus (CS) was presented, and this was measured as the conditioned response.

Although Bechterev considered his finger-withdrawal technique to be a convenient way to study Pavlovian conditioning, more careful analysis shows that his method was an instrumental rather than a Pavlovian procedure. Recall that the electrodes rested on the surface of a table; they were not attached to the participant's finger. Therefore, if the participant lifted his finger in response to the CS, he could avoid getting shocked. This differs from standard Pavlovian procedures, in which the occurrence of the conditioned response does not determine whether the unconditioned stimulus (US) is delivered. Bechterev had inadvertently given his participants control over presentation of the US. This made the finger-withdrawal technique an instrumental rather than a Pavlovian conditioning procedure.

CONTEMPORARY AVOIDANCE CONDITIONING PROCEDURES

Two types of procedures are used in contemporary research on avoidance behavior. The discriminated avoidance procedure is a discrete-trial procedure that involves an explicit warning signal. The nondiscriminated avoidance procedure is a free-operant procedure and does not involve an explicit warning stimulus.

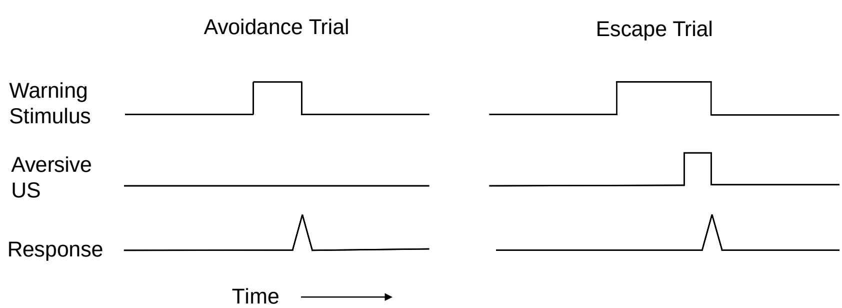
Discriminated Avoidance

Without knowing it, Bechterev invented what has come to be known as **discriminated avoidance** (sometimes also referred to as *signaled avoidance*). In a discriminated avoidance procedure, the avoidance contingency is not in effect at all times. Rather, responding prevents delivery of the aversive stimulus only during discrete periods or trials when a CS, thought of as a warning stimulus, is presented. As illustrated in Figure 12.1, what happens during these trials depends on the participant's behavior. If the participant responds before the aversive stimulus (US) occurs, the CS is turned off, and the aversive US is not delivered. This constitutes an avoidance trial. In contrast, if the participant fails to respond soon enough, the CS continues until the US occurs and then both stimuli remain until a response is made. This constitutes an escape trial. On escape trials, the participant escapes rather than avoids the aversive US.

Since Bechterev's research, the discriminated avoidance procedure has been adapted for use with laboratory animals. In fact, most of the research on the theoretical mechanisms of avoidance learning has been done with laboratory rats. Typically, the aversive US is mild electric shock delivered through a grid floor. (Shock is used because its intensity and duration can be precisely controlled.) In some experiments, rats are required to press a response lever during the CS or warning stimulus (a light or tone) to avoid receiving the shock. Other experiments employ a **shuttle box** apparatus in which the rats must move from one side of the apparatus to the other to avoid shock (see Figure 12.2). Each trial starts with presentation of a CS or warning stimulus (a tone, for example) while the rat is on one side of the apparatus. If the rat moves to the other side before the shock is delivered, the CS is turned off, and shock does not occur on that trial. If the rat does not move to the other side soon enough, the mild shock is applied and remains on until the rat escapes to the other side.

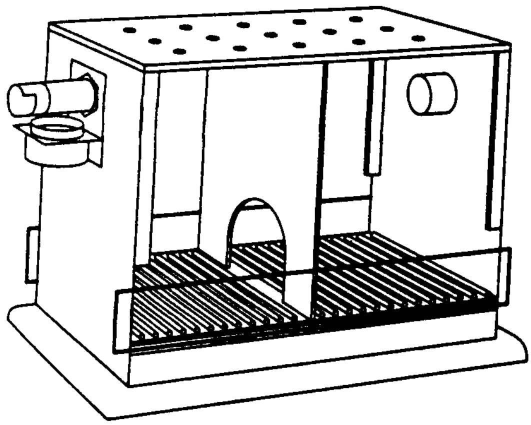
The shuttle box can be used to implement two types of avoidance procedures. In a **one-way avoidance** procedure, the participant is always placed in the same compartment at the start of each trial (e.g., the left side). Because each trial starts on the same side (left), the avoidance response always involves going in the same direction (left to right). With this procedure, the side where the participant starts each trial is always potentially dangerous, whereas the

FIGURE 12.1. Diagram of the Discriminated, or Signaled, Avoidance Procedure



Note. On an Avoidance Trial, the participant responds during the warning signal or conditioned stimulus (CS), before the unconditioned stimulus (US) is scheduled to occur. This response turns off the CS and cancels the delivery of the US. On an escape trial, the response does not occur soon enough to prevent the US. The CS is followed by the US, and both stimuli are terminated when the response occurs.

FIGURE 12.2. Shuttle Box Used in Studies of Avoidance Learning



Note. The animal must cross from one compartment to the other to avoid mild shock through the grid floor.

other side is always safe. The animal never gets shocked on the other side. These features make the one-way avoidance task rather easy to learn.

In a **two-way avoidance** procedure, trials can start while the animal is either on the left side or the right side, depending on which compartment the animal happens to occupy when the trial begins. If the rat starts on the left, it must go to the right to avoid shock. If the rat starts on the right, it must go to the left side to avoid shock. In a two-way avoidance procedure, both sides of the shuttle box are potentially dangerous. The lack of a consistently safe side makes the two-way avoidance task more difficult to learn than the one-way procedure (Theios et al., 1966). Nevertheless, in both procedures, the animal usually begins by first learning to escape shock when it occurs, but then it learns to avoid shock by responding prior shock onset. By the end of training, the animal may receive very few shocks during an entire training session.

Nondiscriminated or Free-Operant Avoidance

In discriminated avoidance procedures, responding is effective in preventing the aversive stimulus only if the response occurs during the warning stimulus before shock is scheduled to occur. Responses made during the intertrial interval have no effect. In fact, the participants may be removed from the apparatus during the intertrial interval. In contrast to such traditional discrete-trial procedures, Sidman (1953) devised a **nondiscriminated** or **free-operant avoidance** procedure (sometimes also called *unsignaled avoidance*).

Sidman's (1953) free-operant procedure was developed in the Skinnerian or operant tradition. In this tradition, trials are not restricted to periods when a discrete stimulus is present, and the participant can repeat the instrumental response at any time. On a fixed-ratio schedule in a Skinner box, for example, responses made at any time count toward completion of the ratio requirement.

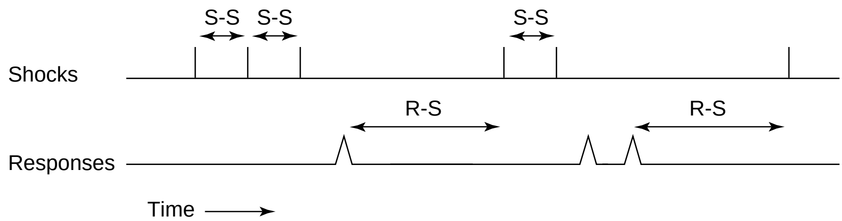
Sidman extended these features of operant methodology to the study of avoidance behavior.

In the free-operant avoidance procedure, an explicit warning stimulus is not used, and there are no discrete trials. The avoidance response may be performed at any time, and responding always provides some measure of benefit. Changing the oil in your car is an example. Changing the oil is an avoidance response that prevents engine problems. If you wait until the problems develop, you will encounter costly repairs. The best thing to do is to change the oil before any sign of engine difficulty. The recommended interval is every 3,000 miles. Thus, each oil change buys you 3,000 miles of trouble-free driving. You can change the oil after driving just 1,000 miles or drive another 800 miles before the oil change. Provided you change the oil before you have driven 3,000 miles, you always get 3,000 miles of trouble-free driving. Doing yoga or other health promotion practices are other examples of free-operant avoidance in that these activities prevent illness and can be performed at any time.

In the laboratory, free-operant avoidance procedures employ a brief shock that is programmed to occur at set intervals. For example, the shock may be scheduled to occur every 15 seconds in the absence of an avoidance response. Performance of the avoidance response creates a period of safety during which no shocks are given. The safe period may be 30 seconds. The interval between shocks in the absence of responding is called the shock–shock interval, or **S–S interval**. The period of safety created by each response is the response–shock interval, or **R–S interval** (see Figure 12.3). Whether a shock occurs at the end of the R–S interval or at the end of the S–S interval, it is not preceded by an explicit warning signal.

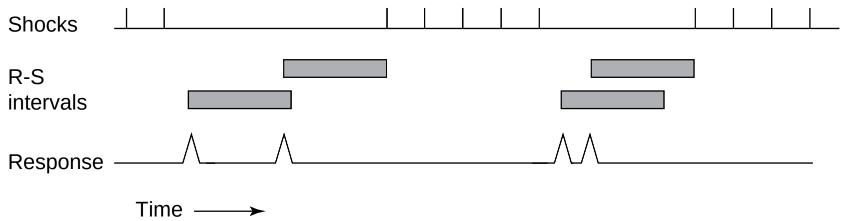
An important aspect of free-operant avoidance procedures is that the R–S interval is reset and starts over again each time the avoidance response is made. Thus, if the R–S interval is 30 seconds, each response resets the R–S interval and starts the 30-second safe period all over again. Because of this feature, each occurrence of the avoidance response provides some benefit, just as each oil change provides some benefit. However, the degree of benefit depends on exactly when the response is made.

FIGURE 12.3. Diagram of a Nondiscriminated, or Free-Operant, Avoidance Procedure



Note. As long as the animal fails to respond, a brief shock is scheduled to occur periodically, as set by the shock–shock (S–S) interval. Each occurrence of the avoidance response creates a period without shock, as set by the response–shock (R–S) interval.

FIGURE 12.4. Effect of Repeating the Avoidance Response Early or Late in an R–S Interval in a Free-Operant Avoidance Procedure



Note. The response–shock (R–S) intervals are indicated by the shaded horizontal bars. On the left, the response was repeated late in an R–S interval; on the right, the response was repeated early in an R–S interval. Notice that the total time without shocks is longer if the response is repeated late in an R–S interval.

If the participant responds when the R–S interval is already in effect, the R–S interval will start over again, and time left on the R–S clock will be lost. The net benefit of responding will depend on whether the response occurs early or late in the R–S interval (see Figure 12.4). If the participant responds late in the R–S interval, it will lose only a small amount of time remaining on the R–S clock, and the net benefit of responding will be substantial. Because of this, responding on a free-operant avoidance schedule resembles the scallop pattern of behavior that we saw in Chapter 8 on fixed-interval schedules of positive reinforcement. Not much behavior occurs at the beginning of an R–S interval, but responding accelerates as the end of the R–S interval gets closer.

TWO-FACTOR THEORY OF AVOIDANCE

The oldest and most influential theory of avoidance was the **two-factor theory of avoidance learning**, originally proposed by O. H. Mowrer (Mowrer, 1947; see also N. E. Miller, 1951). Two-factor theory was developed to explain discriminated avoidance but has since been extended to free-operant avoidance as well. The two major factors in the theory are classical and instrumental conditioning processes. Two-factory theory was the dominant theoretical perspective for studies of avoidance learning for much of the 20th century. Although the intellectual origins of the theory are not always explicitly acknowledged, its main components continue to provide the foundations for both basic and translational research on avoidance learning (e.g., Boeke et al., 2017; Krypotos et al., 2018).

Let us first consider the classical conditioning component of two-factor theory. Instead of thinking about classical conditioning as being directly responsible for the avoidance response (as Bechterev thought), Mowrer proposed that classical conditioning results in the conditioning of an emotional state called fear. On trials when the avoidance response does not occur soon enough, the warning stimulus or CS is paired with the aversive US, and this results in the conditioning of fear to the warning stimulus (Fanselow & Pennington, 2018).

Conditioned fear is presumably an unpleasant or aversive state. Therefore, the reduction or elimination of fear is assumed to be reinforcing. Fear reduction brings into play the second process in the two-factor theory. On trials when the avoidance response is made, the response turns off the warning stimulus, which reduces the fear that was elicited by the warning stimulus. This fear reduction is assumed to provide reinforcement for the avoidance response. Thus, the second factor in the two-factor theory of avoidance is instrumental conditioning of the avoidance response through fear reduction.

Notice how Mowrer cleverly solved the problem of how "nothing" can be a thing that reinforces behavior. He asserted that avoidance behavior was not really reinforced by "nothing" occurring after the avoidance response; rather, the behavior was reinforced by fear reduction. Fear reduction is a form of **negative reinforcement** (removal of an aversive stimulus contingent on behavior). The instrumental response, therefore, can be considered an escape response—a response that escapes from fear. Instead of focusing on the fact that avoidance behavior prevents delivery of the aversive US, two-factor theory focuses on fear reduction as the primary outcome of avoidance behavior. It is of some interest to note that within the Skinnerian tradition, this two-process approach was not very attractive because it rested on the assumption that central emotional states could drive instrumental learning and because appeals to internal states were not generally endorsed (see also LeDoux et al., 2017).

Despite the preceding misgivings, two-factor theory provides answers to many questions about avoidance learning. The answers were innovative when they were first proposed and have shaped the course of research on avoidance conditioning ever since. According to the theory, Pavlovian and instrumental processes interact in determining avoidance behavior. Before fear reduction can provide instrumental reinforcement for the avoidance response, fear must first become conditioned to the warning stimulus. Thus, classical conditioning of fear is a prerequisite for the instrumental component of two-factor theory. The instrumental process depends on the integrity of the Pavlovian fear conditioning process.

Evidence Consistent With Two-Factor Theory

The interdependence of the Pavlovian and instrumental components of two-factor theory has several major implications. First, if Pavlovian conditioned fear is the basis for avoidance behavior, then avoidance responding should decrease with extinction of the fear that has become conditioned to the warning stimulus or CS. This prediction has been confirmed by numerous studies. In these experiments, participants receive repeated exposures to the warning stimulus or CS presented by itself after acquisition of the avoidance response. The extinction procedures are typically conducted using standard Pavlovian protocols in which participants cannot control the duration of the CS-alone presentations. Subsequent tests show that avoidance behavior is significantly reduced by Pavlovian extinction of fear (M. Baum, 1970; Schiff et al., 1972). These laboratory findings have provided the empirical basis for exposure therapy. However, from a clinical perspective, we may expect some loss of effectiveness of the extinction treatment during avoidance testing because of the phenomenon of renewal that we discussed in Chapter 10. During extinction, the participant is prevented from making the avoidance response, but this makes the extinction context different from the context of avoidance training and testing, where responding is allowed.

A second major prediction of two-factor theory is that fear reduction should be effective in reinforcing instrumental behavior even if the fear was not acquired in a signaled avoidance procedure. This prediction also has been confirmed in numerous studies called **escape-from-fear experiments**. In these studies, conditioned fear is initially established using a standard Pavlovian conditioning procedure, without an instrumental or avoidance component. For example, a tone or light may be repeatedly paired with shock under circumstances in which the participants cannot escape or avoid the shock. In the next phase of the experiment, the Pavlovian CS is presented on each trial but now the participants have the opportunity to terminate the CS by making a specified instrumental response (e.g., pressing a response lever or going from one side of a shuttle box to the other). The data of interest are the increase in the probability of the instrumental response that occurs under these circumstances. Such an increase is routinely observed, indicating that fear-reduction is an effective reinforcer for instrumental behavior (Cain & LeDoux, 2007; Esmorís-Arranz et al., 2003).

Evidence Contrary to Two-Factor Theory

Another major implication of the interdependence of Pavlovian and instrumental processes in two-factor theory is that conditioned fear and avoidance responding should be highly correlated. In particular, high levels of avoidance responding should be accompanied by high levels of fear elicited by the warning stimulus in the avoidance procedure. Interestingly, this prediction is rarely observed. The common observation is that as avoidance responding increases, fear decreases to the warning stimulus or CS that signals shock.

The decrease in fear that accompanies mastery of an avoidance procedure has been well documented in studies with both laboratory animals (Mineka, 1979) and human participants (e.g., Lovibond et al., 2008). Studies with people provide some insight into why this occurs. Human participants report a decrease in the expectation of shock as they gain proficiency in making the avoidance response. Once you know how to prevent the shock, you have little expectation that shock will occur if you respond correctly, and therefore your level of fear declines.

Common experience also suggests that little, if any, fear exists once an avoidance response becomes well learned. Steering a car so that it does not drift off the road is basically avoidance behavior. A competent driver avoids letting the car get too close to the side of the road or too close to another lane of traffic by making appropriate steering adjustments. Even though these adjustments are avoidance responses, proficient drivers are perfectly relaxed and show little fear as they steer their car under normal traffic conditions.

Successful steering, in a sense, becomes a habit for experienced drivers. This suggests that extensively trained avoidance responses may also become habitual. Indeed, neurobiological analyses have indicated that the neural circuitry of avoidance behavior has much in common with the neural bases of habitual instrumental behavior that we discussed in Chapter 7 (Cain, 2019; LeDoux et al., 2017). This continues to be an interesting area of research ripe for future development.

CONDITIONED TEMPORAL CUES IN AVOIDANCE LEARNING

Findings that are difficult to explain in terms of the two-factor theory of avoidance have encouraged modifications and additions to the theory. Efforts to integrate new findings with the theory have often involved postulating internal stimuli and ascribing important functions to these internal cues. Free-operant avoidance procedures have been a special challenge because they lack an explicit warning stimulus, which plays a major role in two-factor theory. To overcome this difficulty, investigators have suggested that internal cues related to the passage of time serve as warning stimuli in free-operant or nondiscriminated avoidance procedures (Anger, 1963).

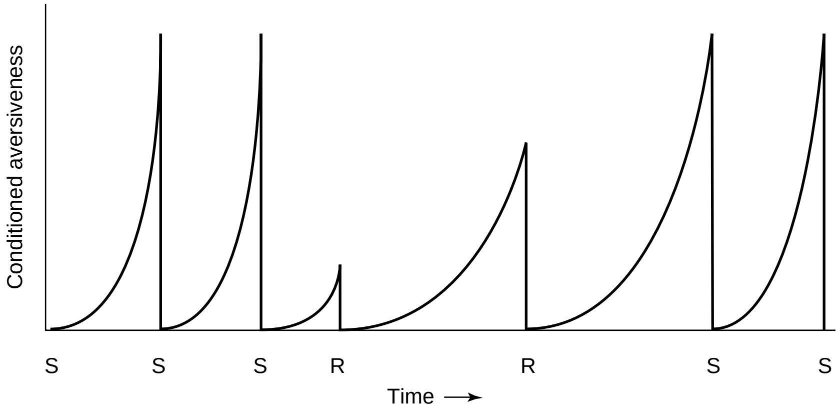
We saw in Chapter 8 that with fixed-interval schedules, the passage of time comes to signal the availability of a positive reinforcer. A similar idea is applicable to free-operant avoidance schedules. Free-operant avoidance schedules consist of S–S and S–R intervals, both of which are fixed in duration. Therefore, the passage of time can come to signal when the next shock will occur.

Time stimuli are referred to as **temporal cues**. Animals (including people) are quite good at responding based on the passage of time (Church, 2012; Crystal, 2012). Temporal cues characteristic of the beginning of the S–S and R–S intervals are never paired with shock. If shock occurs, it always occurs at the end of the S–S or R–S interval. These late temporal cues are paired with shock and therefore acquire conditioned aversive properties. Each avoidance response starts a new R–S interval and reduces the conditioned aversiveness of the end of the previous S–S or R–S interval (see Figure 12.5). In this way, a response can result in reduction of conditioned fear and satisfy the instrumental component of two-factor theory even in a free-operant avoidance procedure.

SAFETY SIGNALS AND AVOIDANCE LEARNING

The next mechanism of avoidance learning that we consider goes significantly beyond two-factor theory to introduce a third factor that contributes to the learning and maintenance of avoidance responses, namely safety signal reinforcement. A **safety signal** is a stimulus that signals the absence of an

FIGURE 12.5. The Presumed Conditioned Aversiveness of Temporal Cues During R–S and S–S Intervals in a Free-Operant Avoidance Procedure



Note. Notice the low levels of conditioned aversiveness at the beginning of each S–S and R–S interval and high levels of aversiveness at the end of these intervals. Each occurrence of the response always reduces the conditioned aversiveness of temporal cues because each response starts a new R–S interval. R = occurrence of the avoidance response; S = occurrence of a brief shock.

aversive US or a period of safety. We previously encountered safety signals in our discussion of conditioned inhibition in Chapter 5. In contrast to a conditioned excitatory stimulus, which signals the impending delivery of a US, a conditioned inhibitor signals the absence of the US. Safety signals can be internal cues, like temporal cues, that reliably indicate a period of safety. Safety signals can also be external cues, such as a teddy bear or parent who makes a child feel safe when visiting the dentist.

In an avoidance procedure, periods of safety are best predicted by the occurrence of the avoidance response. After all, avoidance behavior cancels the delivery of the next scheduled shock. We know from biology that the movements of muscles and joints that are involved in making responses can give rise to internal **proprioceptive cues**. The proprioceptive cues that are produced by an avoidance response are followed by a predictable period without the aversive US, a predictable period of safety. As we saw in Chapter 5, stimuli that reliably predict the absence of a US may acquire Pavlovian conditioned inhibitory properties. Therefore, proprioceptive cues generated by avoidance responses, or even an internal representation of the response (Mackintosh, 1983), may also acquire Pavlovian conditioned inhibitory properties.

The safety signal explanation of avoidance learning is based on these ideas. According to the safety signal hypothesis, the sensations of making the avoidance response acquire Pavlovian conditioned inhibitory properties and thereby become signals for safety. In a situation involving potential danger, safety signals are assumed to be reinforcing. According to the safety signal account, avoidance behavior is positively reinforced by safety signals that are generated by avoidance responses (Dinsmoor, 2001).

In laboratory experiments, the safety signal account has been evaluated by introducing an external stimulus (e.g., a brief tone) when the participant performs the avoidance response. If the safety signal hypothesis is correct, such an environmental stimulus should acquire conditioned inhibitory properties. Moreover, these conditioned inhibitory properties should make the external stimulus effective as a positive reinforcer for instrumental behavior. Both these predictions have been confirmed (e.g., Fernando et al., 2014). (For a review of human studies of safety signal learning, see Laing & Harrison, 2021.)

The safety signal process is not incompatible with the two-factor theory of avoidance and need not be viewed as an alternative to it. Rather, positive reinforcement through conditioned inhibitory safety signals may be considered a third factor in avoidance learning that operates in combination with classical conditioning of fear and instrumental reinforcement through fear reduction. Moreover, this third factor may help explain why avoidance responding persists after extensive training, well after conditioned fear of the warning stimulus has subsided. Avoidance learning is sufficiently complex to involve all three of these processes.

EXTINCTION OF AVOIDANCE BEHAVIOR

Extinction is fairly simple after positive reinforcement: You allow the instrumental response to occur, but you no longer present the reinforcer. The common outcome is a substantial decline in responding. The situation is considerably more complicated with avoidance conditioning. One approach to the extinction of avoidance behavior is to simply turn off the shock apparatus that provided the aversive US during avoidance training. Unfortunately, just turning off the source of the shock rarely works to extinguish avoidance responding. Investigators discovered early on that avoidance responding can persist for hundreds of trials after the shock apparatus is deactivated (Solomon et al., 1953). Why does that happen?

As we discussed earlier, there are two sources of reinforcement for the avoidance response. One is the reduction of conditioned fear that occurs when the avoidance response terminates the warning signal or CS, and this most likely occurs early in training. The second source of reinforcement comes from the conditioned inhibitory properties of stimuli produced by the avoidance response that signal a period free from shock. Neither of these sources of reinforcement are eliminated when the shock source is deactivated after avoidance conditioning.

To eliminate fear reduction as a source of reinforcement for avoidance behavior, we would have to extinguish the conditioned fear that is elicited by the warning stimulus (or CS). That can be accomplished by providing repeated exposures to the CS presented by itself. However, the participants cannot be permitted to terminate the CS. Highly trained individuals tend to respond quickly to turn off the warning stimulus. If they are allowed to do that, they will not receive enough exposure to the warning stimulus to extinguish much of the conditioned fear. Therefore, blocking the avoidance response is frequently a required component of fear extinction following avoidance training (M. Baum, 1970). In studies with human participants, blocking the avoidance response causes a return of fear and a return of the expectation of shock (Lovibond et al., 2008). This no doubt makes the absence of shock more salient and thereby facilitates extinction.

The second source of reinforcement for avoidance responding is provided by the safety signal properties of cues related to making the avoidance response. These safety signal properties are much more difficult to extinguish than conditioned fear. As we have noted, safety signals are essentially conditioned inhibitory stimuli because they signal a shock-free period. We know a lot more about extinction of conditioned excitatory stimuli than we know about extinction of conditioned inhibitors. Recall in Chapter 6 that we reviewed studies showing that repeatedly presenting a conditioned inhibitor or safety signal by itself (without a US) does not extinguish its inhibitory properties (Witcher & Ayres, 1984; Zimmer-Hart & Rescorla, 1974). Extinction of safety signals may also be difficult because we may not have direct access to the safety signals that are involved in avoidance learning. If these are proprioceptive stimuli related to making the avoidance response, they are not available to direct experimental control.

Another major complication is that safety signals can prevent extinction of fear in an avoidance procedure. Extinction requires the unexpected absence of the reinforcer (see Chapter 10). To extinguish the warning stimulus in an avoidance situation, the warning stimulus would have to be followed by the unexpected absence of shock. The presence of a safety signal makes the absence of shock entirely predicted and therefore blocks extinction of the warning stimulus (Lovibond et al., 2009; Sloan & Telch, 2002).

For the reasons noted, turning off the source of the aversive US in an avoidance situation is not an effective procedure for extinguishing avoidance behavior. Another strategy for extinguishing avoidance responding might be to change the procedure so that the avoidance response no longer prevents the aversive US. Unfortunately, such a modification will maintain conditioned fear to the warning stimulus, and as we have seen, this is a strong source of motivation for avoidance responding. Given these complications, extinguishing avoidance behavior remains an ongoing challenge for behavior therapy (Urcelay & Prével, 2018).

AVOIDANCE LEARNING AND UNCONDITIONED DEFENSIVE BEHAVIOR

As we noted in Chapter 2, learning procedures do not operate on a tabula rasa but are superimposed on preexisting behavioral tendencies that an organism brings to the learning situation. Learned responses are the product of an interaction between the conditioning procedures used and the organism's preexisting behavioral structure. The two-factor theory and safety signal mechanisms of avoidance described earlier are based on a simple view of what an organism brings to an aversive conditioning situation. These learning mechanisms just require that a stimulus be aversive. Given an unconditioned aversive stimulus, fear can become conditioned to cues that predict the aversive event, safety can become conditioned to cues that predicts the absence of the aversive event, and fear reduction and safety can serve as reinforcers for any instrumental response.

Species-Specific Defense Reactions

As it turns out, the preexisting behavioral tendencies organisms bring to an avoidance conditioning situation are much more complex than what we just described. Exposure to an aversive event activates a rich behavioral repertoire that has evolved to enable organisms to cope with danger quickly and effectively. Some years ago, Robert Bolles (1970) pointed out that an animal being pursued by a predator must avoid the danger successfully the first time; if it does not, it may not be alive for a second or third trial. Because dangerous situations require effective coping without much practice, Bolles suggested that organisms respond to aversive situations with a hierarchy of unconditioned defensive responses, which he called **species-specific defense reactions** (**SSDRs**).

SSDRs are responses such as freezing, fleeing, and fighting. Bolles suggested that which particular SSDR occurs depends on the nature of the aversive stimulus and the response opportunities provided by the environment. If a familiar and effective means of escape is available, the animal is likely to flee when it encounters the aversive stimulus. Without a familiar escape route, freezing will be the predominant defensive response. In social situations, fighting may predominate.

SSDRs do not have to be learned and occur the first time an aversive stimulus is encountered. Therefore, they dominate the organism's behavior during early stages avoidance training. This makes it difficult to use aversive conditioning procedures to condition responses that are not related to an SSDR. Running, for example, is more compatible with SSDRs than rearing. It is not surprising, then, that it is much easier to condition running as an avoidance response in rats than to condition rearing on hind legs (Bolles, 1969).

The Predatory Imminence Continuum

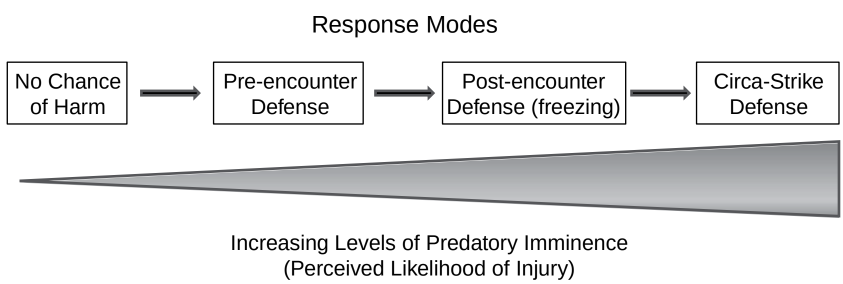
The concept of SSDRs encouraged investigators to consider in greater detail the structure of the defensive behavior system that is activated in aversive conditioning situations. These ideas are related to the behavior systems theory we considered in Chapter 2 and applied to discussions of learned performance in foraging for food and in searching for a potential sexual partner. When applied to the predatory defense system, these considerations led to the idea that unconditioned defensive behaviors depend not only on whether an aversive stimulus is encountered but also on the likelihood, or imminence, of that encounter. The perceived likelihood of encountering danger or encountering a predator is called **predatory imminence.** Animals act differently when they perceive a low likelihood of injury or attack compared with when the likelihood of injury or attack is high. Variations in the defensive responses that are elicited by different degrees of perceived danger constitute the predatory imminence continuum (Fanselow, 1994; Fanselow et al., 2019).

The predatory imminence continuum has been investigated most extensively in laboratory rats. Rats are preyed on by hawks and snakes. Different modes of defensive behavior are activated depending on the rat's perceived likelihood of injury or attack from a predator (see Figure 12.6). If there is no chance that the rat will encounter a predator, it will go about its business of finding food and taking care of its young. The pre-encounter response mode is activated if, during the course of its foraging, a rat wanders into an area where there is some chance of finding a snake, but the snake has not been encountered yet. In the pre-encounter mode, the rat may move to a safer area. If a safer area is not available, the rat will become more cautious in its foraging. It will venture out of its burrow less often, and it will eat larger meals when it does go out (Fanselow et al., 1988).

If the pre-encounter defensive responses are not successful and the rat encounters the snake, the post-encounter response mode will be activated. In the post-encounter mode, freezing is the predominant response because freezing decreases the likelihood of being detected. Finally, if this defensive behavior is also unsuccessful and the rat is actually attacked by the snake, the circa-strike mode will be activated. In the circa-strike mode, the rat will suddenly leap into the air and strike out at the snake (see Figure 12.6).

An encounter with shock in the laboratory is thought to activate the highest level of predatory imminence, the circa-strike response mode. The warning stimulus or CS that occurs before the aversive US will activate an earlier response mode, depending on the CS–US interval that is used. With a short CS–US interval, the post-encounter mode will be conditioned to the CS, and the CS will elicit the freezing behavior that is characteristic of that mode. A long

FIGURE 12.6. The Predatory Imminence Continuum



Note. Different modes of defensive behavior are activated at different levels of predatory imminence. When predatory imminence is zero, there is no chance of harm. In the pre-encounter mode, harm is possible but the predator has not been detected. In the post-encounter mode, the predator has been detected but has not attacked yet. In the circa-strike mode the predator has made physical contact with its prey.

CS–US interval will activate less predatory imminence, and the CS will come to elicit anxiety rather than freezing (Waddell et al., 2006). Safety signals, by contrast, should elicit recuperative and self-care responses because they signal the total absence of a potential predator. These considerations illustrate that when organisms learn about an aversive situation, their behavior is heavily influenced by the preexisting organization of their defensive behavior system (Hoffman et al., 2022).

Species-specific defense responses and the predatory imminence continuum encourage us to keep in mind that animals developed various defensive strategies through evolution to meet challenges to their survival in their natural habitat. This suggests that a comprehensive understanding of defensive behavior will require studying fear and avoidance learning in more complex and ecologically valid environments. Research along those lines is starting to be carried out (Kim & Jung, 2018; Schuessler et al., 2020).

SUMMARY

Studies of avoidance learning originated in studies of classical conditioning and relied on discrete-trial methods in which a warning signal or CS ended in a brief shock unless the avoidance response was made. Subsequently, free-operant avoidance procedures were developed that did not employ explicit warning signals but seemed to rely on internal temporal cues. Regardless of which method is used, avoidance learning is puzzling because the consequence of an avoidance response is that nothing happens. How can "nothing" motivate learning or reinforce a response?

The first major explanation of avoidance learning, two-factor theory, assumed that avoidance behavior is the result of a dynamic interaction between classical and instrumental conditioning. Classical conditioning occurs when the participant fails to make the avoidance response and receives the aversive US. On the other hand, instrumental conditioning occurs when the avoidance response is made because this terminates the warning signal and reduces conditioned fear. Subsequent research identified a third factor, safety signal learning, that also contributes to avoidance learning. Cues that accompany the omission of the US in an avoidance procedure become safety signals or conditioned inhibitors of fear that provide positive reinforcement for the avoidance response.

Much of the experimental evidence on avoidance learning is compatible with two-factor theory supplemented by safety signal learning, especially when temporal and proprioceptive cues are taken into account. These mechanisms are difficult to disengage, creating unusual problems for attempts to extinguish avoidance responding. Furthermore, the role of "habits" in avoidance learning is only just beginning to receive experimental attention. Another source of complication in the study of avoidance learning is that animals have evolved a rich unconditioned defensive behavioral repertoire to deal with aversive events. The current view is that unconditioned species-specific defense reactions are organized along a predatory imminence continuum, with different defensive response modes activated by different levels of perceived danger (i.e., predatory imminence). A complete account of avoidance learning will need to explain how a particular avoidance conditioning procedure becomes integrated into the pre-existing defensive behavior system of the organism.

SUGGESTED READINGS

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Fanselow, M. S. (2018). The role of learning in threat imminence and defensive behaviors. *Current Opinion in Behavioral Sciences*, *24*, 44–49. https://doi.org/10.1016/j.cobeha.2018.03.003

Krypotos, A.-M., Vervliet, B., & Engelhard, I. M. (2018). The validity of human avoidance paradigms. *Behaviour Research and Therapy*, *111*, 99–105. https://doi.org/10.1016/j.brat.2018.10.011

Laing, P. A. F., & Harrison, B. J. (2021). Safety learning and the Pavlovian conditioned inhibition of fear in humans: Current state and future directions. *Neuroscience & Biobehavioral Reviews*, *127*(10), 659–674. https://doi.org/10.1016/j.neubiorev.2021.05.014

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Urceley, G. P., & Prével, A. (2018). Extinction of instrumental avoidance. *Current Opinion in Behavioral Science*, *2018*(26), 165–171. https://doi.org/10.1016/j.cobeha.2019.01.018

TECHNICAL TERMS

avoidance conditioning, page 189
discriminated avoidance, page 191
shuttle box, page 192
one-way avoidance, page 192
two-way avoidance, page 193
nondiscriminated avoidance, page 193
free-operant avoidance, page 193
S–S interval, page 194
R–S interval, page 194
two-factor theory of avoidance learning, page 195
negative reinforcement, page 196
escape-from-fear experiments, page 197
temporal cues, page 198
safety signal reinforcement, page 198
proprioceptive cues, page 199
species-specific defense response (SSDR), page 202
predatory imminence, page 203

For chapter summaries and practice quizzes, visit https://www.apa.org/pubs/books/essentials-conditioning-learning-fifth-edition (see the Student Resources tab).