Conditioning and Learning

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Abstract

Basic principles of learning are always operating and always influencing human behavior. This chapter discusses the two very fundamental forms of learning that are represented in classical (Pavlovian) and instrumental (operant) conditioning. Through them, we respectively learn to associate (1.) stimuli in the environment or (2.) our own behaviors with significant events such as rewards and punishers. The two types of learning have been intensively studied because they have powerful effects on behavior and because they provide methods that allow scientists to analyze learning processes rigorously. This chapter describes some of the most important things you need to know about classical and instrumental conditioning, and it illustrates some of the many ways they help us understand normal and disordered behavior in humans.

Learning Objectives

- Distinguish between classical (Pavlovian) conditioning and instrumental (operant) conditioning.
- Understand some important facts about each that tell us how they work.
- Understand how they work separately and together to influence human behavior in the world outside the laboratory.

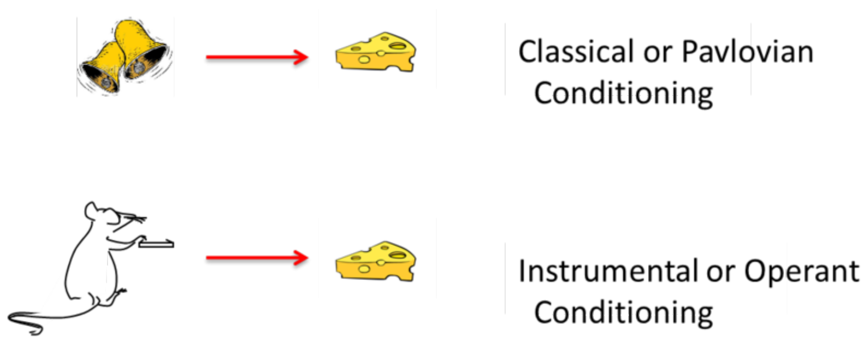
Two Types of Conditioning

Around the turn of the 20th century, scientists who were interested in understanding the behavior of animals and humans began to appreciate the importance of two very basic forms of learning. One, which was first studied by the Russian physiologist Ivan Pavlov, is known as **classical** or **Pavlovian conditioning**. In his famous experiment, Pavlov rang a bell and then gave a dog some food. Once the bell and food had been paired a few times, the dog treated the bell as a signal for food: The dog began salivating at the sound of the bell. This kind of result has been shown in the lab with a wide range of signals (e.g., tones, light, tastes, places) and with many different signaled events besides food (e.g., drugs, shocks, illness; see below). We now think that the same learning process is engaged, for example, when humans associate a drug they've taken with the environment in which they've taken it, when they associate a stimulus (e.g., a crowded bus) with an emotional event (like a sudden panic attack), and when they associate the flavor of a food with getting food poisoning some time later. Pavlovian conditioning is still widely studied for at least two reasons. First, it is a representative case in which an organism learns to associate two events, and it therefore provides a rigorous method for studying associative learning. Second, because Pavlovian conditioning is always occurring in our lives, its effects on behavior have important implications for understanding normal and disordered behavior in humans.

In a general way, Pavlovian conditioning occurs whenever neutral stimuli are associated with a psychologically significant event. The events in the experiment are often described using terms that make it possible to apply them to any situation. The food in Pavlov's experiment is called the **unconditioned stimulus (US)** because it elicits salivation unconditionally, before the experiment begins. The bell is called the **conditioned stimulus (CS)** because its ability to elicit the response is conditional on (depends on) its pairings with food. In a corresponding way, the new (learned) response to the bell is called the **conditioned response (CR)**, and the natural response to the food itself is the **unconditioned response (UR)**. Modern studies of classical conditioning use a very wide range of CSs and USs and measure a wide range of conditioned responses.

The second form of conditioning was first studied by Edward Thorndike and later extended by B. F. Skinner. It is known as **instrumental** or **operant conditioning**. This form of conditioning occurs when a behavior is associated with the occurrence of a significant event. In the best-known example, a rat learns to press a lever in a box in the laboratory (a "Skinner box") when lever-pressing produces food pellets. The behavior is an "**operant**" because it operates on the environment; it is also "instrumental" for making the food occur. The food pellet is called a **reinforcer**, because it strengthens the response it is made a consequence of. (A reinforcer is any event that does this.) Operant conditioning research studies how the effects of a behavior influence the probability it will occur again. According to the **law of effect**, when a behavior has a positive (satisfying) effect or consequence, it is likely to be repeated in the future. When a behavior has a negative (annoying) consequence, it is less likely to be repeated in the future. Effects that increase behaviors are reinforcers; effects that decrease them are **punishers**.

An important idea behind the study of operant conditioning is that it provides a method for studying how consequences influence "voluntary" behavior. The rat's lever-pressing for food is voluntary in the sense that the rat is free to make and repeat the response whenever it wants to. No one forces it to lever-press, and there is no stimulus, like Pavlov's bell, that directly causes it to occur. One of the lessons of operant conditioning research, though, is that voluntary behavior is strongly influenced by its consequences.



The cartoon at left summarizes the basic elements of classical and instrumental conditioning. The two types of learning differ in many ways. However, modern thinkers often emphasize the fact that they differ, as emphasized here, in what is learned. In classical conditioning, the animal behaves as if it has learned to associate a stimulus with a significant event. In operant conditioning, the animal behaves as if it has learned to associate a behavior with a significant event. Another difference is that the response in the Pavlovian situation (e.g., salivation) is elicited by a stimulus that comes before it, whereas the response in the operant case is not elicited by any particular stimulus. Instead, operant responses are said to be emitted. The word "emitted" further captures the idea that operants are essentially voluntary in nature.

Understanding classical and operant conditioning provides psychologists with many tools for understanding learning and behavior in the world outside the lab. This is in part because the two types of learning are occurring continuously throughout our lives. It has been said that "much like the laws of gravity, the laws of learning are always in effect" (Spreat & Spreat, 1982).

Useful Things to Know about Pavlovian Conditioning

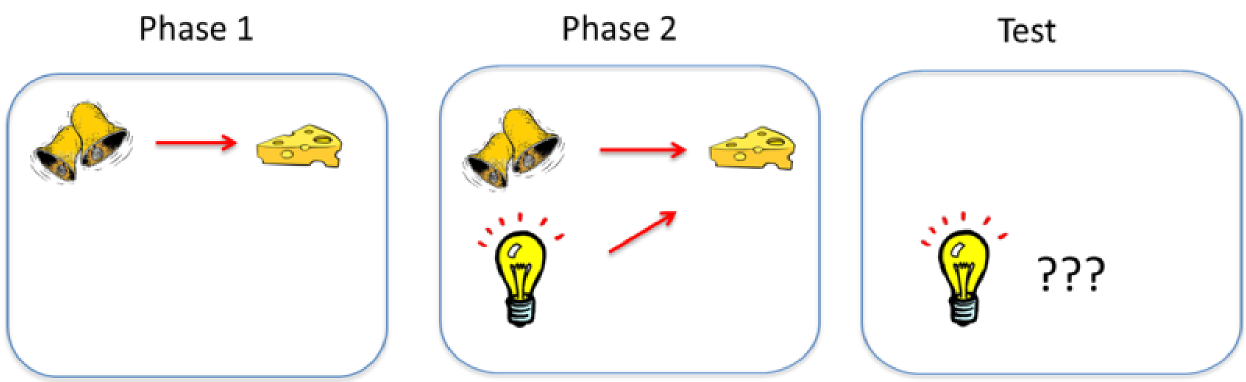
Pavlovian Conditioning Has Many Effects on Behavior

A Pavlovian CS does not merely elicit a simple, unitary reflex. Pavlov emphasized salivation because that was the only response he measured. But his bell almost certainly elicited a whole system of responses that functioned to get the organism ready for the upcoming US (food) (see Timberlake, 2001). For example, in addition to salivation, CSs that signal food elicit the secretion of gastric acid, pancreatic enzymes, and insulin (which gets blood glucose into cells). All of these responses prepare the body for digestion. The CS also elicits approach behavior and a state of excitement. And presenting a CS for food can also cause animals whose stomachs are full to eat more food if it is available. Food CSs are prevalent in modern society, and humans can likewise eat or feel hungry in response to cues associated with food, such as the sight and feel of a bag of potato chips, the sight of a restaurant logo (like the Golden Arches), or the couch in front of the television.

Classical conditioning is also involved in other aspects of eating. Flavors associated with a nutrient (such as sugar, starch, calories, or proteins) become preferred or liked. Here the flavor is the CS and the nutrient is the US. In a complementary way, flavors associated with stomach upset or illness become avoided and disliked. For example, a person who gets sick after drinking too much tequila may learn a profound dislike of the taste and odor of tequila—a phenomenon called **taste aversion conditioning**. The fact that flavors can be associated with so many consequences of eating is important for animals (including rats and humans) that often need to learn about new foods. And it is clinically relevant. For example, drugs used in chemotherapy often make cancer patients sick. As a consequence, patients often learn aversions to a food that was eaten recently, or to the chemotherapy clinic itself (see Bernstein, 1991; Scalera & Bavieri, 2009).

Pavlovian conditioning occurs with many other significant events. If an experimenter sounds a tone just before applying a mild shock to a rat's feet, the tone will elicit fear or anxiety after one or two pairings. Similar **fear conditioning** plays a role in creating many anxiety disorders in humans, such as phobias and panic disorders, where people associate cues (like closed spaces or a shopping mall) with panic or other emotional trauma (see Mineka & Zinbarg, 2006). Here, the CS comes to trigger an emotion. Pavlovian conditioning can also occur whenever we ingest drugs. That is, whenever a drug is taken, it can be associated with the cues that are present at the same time (e.g., rooms, odors, drug paraphernalia). Drug cues have an interesting property: They elicit responses that often "compensate" for the upcoming effect of the drug (see Siegel, 1989). For example, morphine suppresses pain, but the response elicited by cues associated with morphine make us more sensitive to pain. Such **conditioned compensatory responses** decrease the impact of the drug on the body. This has many implications. A drug user will be most "tolerant" to the drug in the presence of cues that have been associated with the drug (because they elicit compensatory responses). Overdose is therefore more likely if the drug is taken in the absence of those cues (see Siegel, Hinson, Krank, & McCully, 1982). Conditioned compensatory responses (which include heightened pain sensitivity and decreased body temperature, among others) might also be uncomfortable and motivate the drug user to take the drug to reduce them. This is one of several ways in which Pavlovian conditioning might be involved in drug addiction and dependence.

A final effect of Pavlovian cues is that they motivate ongoing operant behavior (see Balleine, 2005). In the presence of drug-associated cues, a rat will work harder (lever-press more) for a drug reinforcer. In the presence of food-associated cues, a rat (or an overeater) will work harder for food. And in the presence of fear cues, a rat (or a human with an anxiety disorder) will work harder to avoid situations that might lead to trauma. Pavlovian CSs thus have many effects that can contribute to important behavioral phenomena.



The Learning Process

As mentioned earlier, Pavlovian conditioning provides a method to study basic learning processes. Somewhat counterintuitively, studies show that pairing a CS and a US together is not sufficient for an association to be learned between them. Consider an effect called **blocking** (see Kamin, 1969). In this effect, an animal first learns to associate one CS, call it stimulus A, with a US. In the cartoon below, the sound of a bell is paired with food. Once the association is learned, in a second phase, a second stimulus B is presented along with A, and the two stimuli are paired with the US together. In the cartoon, a light is added and turned on with the bell. Surprisingly, tests of conditioned responding to B alone then show that the animal has learned very little about B. The earlier conditioning of A "blocks" conditioning of B when B is merely added to A. The reason? Stimulus A already predicts the US, so the US is not surprising when it occurs with Stimulus B. Learning depends on such a surprise, or a discrepancy between what occurs on a conditioning trial and what is already predicted by cues that are present on the trial. To learn something in Pavlovian learning, there must first be some **prediction error**.

Blocking and other related effects indicate that the learning process tends to discover the most valid predictors of significant events and ignore the less useful ones. This is common in the real world. For example, Americans often fail to learn the color of a Canadian $20 bill when they take a trip and handle money in Canada. In America, the most valid predictor of the value of the $20 bill is perhaps the number that is printed on it. In Canada, the number occurs together with a unique color. Because of blocking, Americans often don't learn the color of the $20 bill. (It turns out that the Canadian $20 bill is green.) The number gives them all the information they need; there is no prediction error for the learning process to correct.

Classical conditioning is strongest if the CS and US are intense or salient. It is also best if the CS and US are relatively new and the organism hasn't been exposed to them a lot before. It is also especially strong if the organism's biology has prepared it to associate a particular CS and US. For example, rats and humans are naturally inclined to associate an illness with a flavor, rather than with a light or tone. (This sorting tendency, which is set up by evolution, is called **preparedness**.) There are many factors that affect the strength of classical conditioning, and these have been the subject of much research and theory (see Rescorla & Wagner, 1972; Pearce & Bouton, 2001). Behavioral neuroscientists have also used classical conditioning to investigate many of the basic brain processes that are involved in learning (see Fanselow & Poulos, 2005; Thompson & Steinmetz, 2009).

Erasing Pavlovian Learning

After conditioning, the response to the CS can be eliminated if the CS is presented repeatedly without the US. This effect is called **extinction**, and the response is said to become “extinguished.” Extinction is important for many reasons. For one thing, it is the basis for many therapies that clinical psychologists use to eliminate maladaptive and unwanted behaviors. For instance, a person who has a debilitating fear of spiders will be systematically exposed to spiders (without a traumatic US) to gradually extinguish the fear. Here, the spider is a CS, and repeated exposure to it without an aversive consequence causes extinction.

Realistic use of extinction in the clinic must accept one important fact about it, however. This is that extinction does not necessarily destroy the original learning (see Bouton, 2004). For example, if time is allowed to pass after extinction has occurred, presentation of the CS can evoke some responding again. This is called **spontaneous recovery**. Another important phenomenon is the **renewal effect**: After extinction, if the CS is tested in a new **context**, such as a different room or location, responding can also return. These effects have been interpreted to suggest that extinction inhibits rather than erases the learned behavior, and this inhibition is mainly expressed in the context in which it is learned (see “context” in the Key Vocabulary section below).

This does not mean that extinction is a bad treatment for behavior disorders. Instead, clinicians can make it effective by using basic research on learning to help defeat these relapse effects (see Craske et al., 2008). For example, if extinction therapies are conducted in the contexts where a person might be in most danger of relapsing (at work, for example), the success of therapy can be enhanced.

Useful Things to Know about Instrumental Conditioning

Most of the things that affect the strength of Pavlovian conditioning also affect the strength of instrumental learning, where we learn to associate our actions with their outcomes. As before, the bigger the reinforcer (or punisher), the stronger the learning. And if an instrumental behavior is no longer reinforced, it will also extinguish. Most of the rules of associative learning that apply to classical conditioning also apply to instrumental learning. But other facts about instrumental learning are also worth knowing.

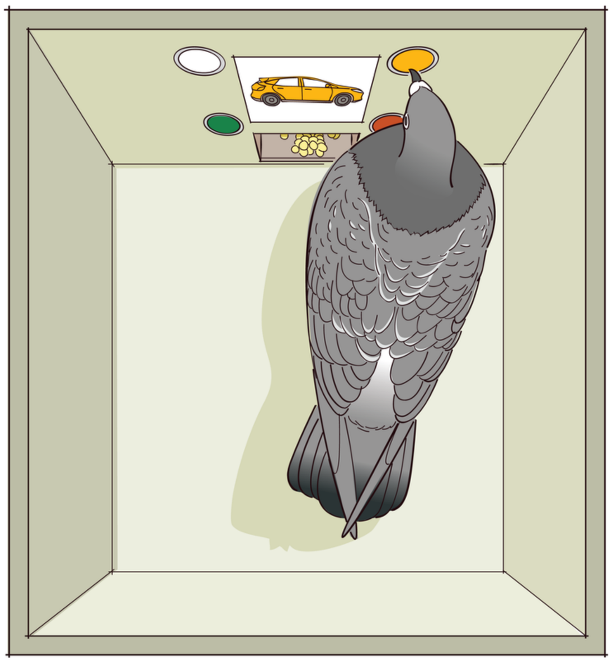
Instrumental Responses Come Under Stimulus Control

As you know, the classic operant response in the laboratory is lever-pressing in rats reinforced by food. However, things can be arranged so that lever-pressing only produces pellets when a particular stimulus is present. For example, lever-pressing can be reinforced only when a light in the Skinner box is turned on—when the light is off, lever-pressing is not reinforced. The rat soon learns to discriminate the light-on and light-off conditions, and responds only in the presence of the light (responses in light-off are extinguished). The operant is now said to be under **stimulus control**. In the real world, stimulus control is probably the rule. For example, different behaviors are reinforced while you are in a classroom, at the beach, or at a party, and your behavior adjusts accordingly.

The stimulus controlling the operant response is called a **discriminative stimulus**. It can be associated directly with the response or the reinforcer (see below). However, it usually does not elicit the response the way a Pavlovian CS does. Instead, it is said to "set the occasion for" the operant response. For example, a canvas put in front of an artist does not elicit painting behavior or compel her to paint. It allows, or sets the occasion for, painting to occur.

Stimulus-control techniques are widely used in the laboratory to study perception and other psychological processes in animals. Notice that the rat in the situation described above would not be able to respond appropriately in light-on and light-off conditions if it could not see the light. Using this logic, experiments using stimulus-control methods have tested how well animals can see colors, hear ultrasounds, and detect magnetic fields, for example. The methods can also be used to study "higher" cognitive processes. For example, pigeons can learn to peck at different buttons in a Skinner box when pictures of flowers, cars, chairs, or people are shown on a miniature TV screen (see Wasserman, 1995). Pecking button 1 (and no other) is reinforced in the presence of an image of flowers, pecking button 2 (and no other) is reinforced in the presence of a chair, and so on. Pigeons can learn the discrimination readily, and under the right conditions, they will also peck the correct button when shown pictures of new flowers, cars, chairs, and people that they have never seen before. The birds have learned to **categorize** the sets of stimuli. Stimulus-control methods can be used to study how such categorization is learned.

Operant Conditioning Involves Choice

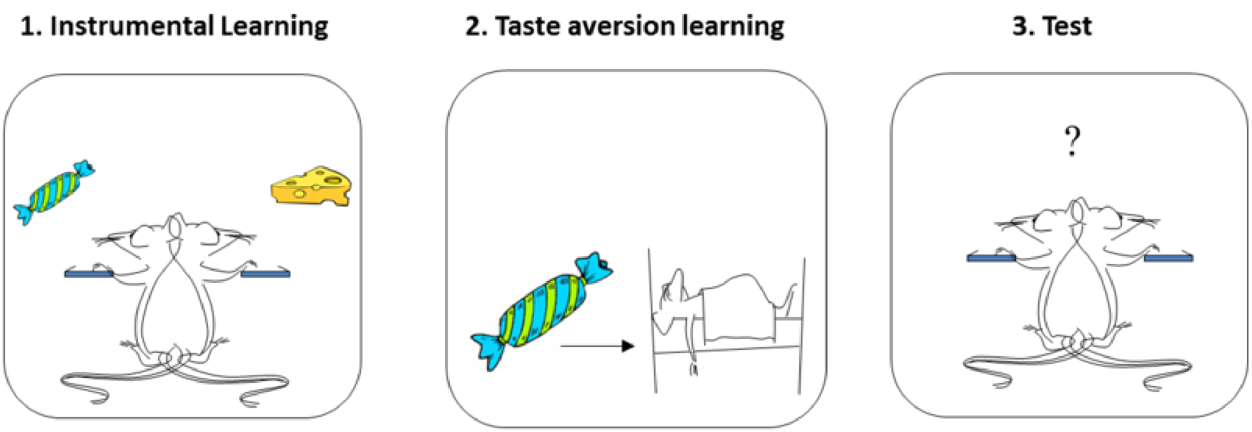


Another thing to know about operant conditioning is that making the response always requires you to choose that behavior over others. The student who drinks beer on Thursday nights chooses to drink instead of staying at home and studying with his girlfriend. The rat chooses to press the lever instead of sleeping or scratching its ear in the back of the box. The alternative behaviors are each associated with their own reinforcers. And the tendency to perform a particular action depends exquisitely on both the reinforcers earned for it and the reinforcers earned for its alternatives.

To investigate this idea, choice has been studied in the Skinner box by making two levers available for the rat (or two buttons available for the pigeon), each of which has its own reinforcement or payoff rate. A thorough study of choice in situations like this has led to a rule called the **quantitative law of effect** (see Herrnstein, 1970), which can be understood without going into quantitative detail. The law acknowledges the fact that the effects of reinforcing one behavior depend crucially on how much reinforcement is earned for the behavior's alternatives. In general, a given reinforcer will be less reinforcing if there are many alternative reinforcers in the environment. For this reason, alcohol, sex, or drugs may be less likely to be extremely powerful reinforcers, and create risky excesses in behavior, if a person's environment is also full of other sources of reinforcement.

Cognition in Instrumental Learning

Modern research also indicates that reinforcers do more than merely strengthen or "stamp in" the behaviors they are a consequence of. (This was Thorndike's original view.) Instead, animals learn about the specific consequences of each behavior, and will perform a behavior depending on how much they currently want—or "value"—its consequence.



Images courtesy of Bernard W. Balleine

This idea is best illustrated by a phenomenon called the **reinforcer devaluation effect** (see Colwill & Rescorla, 1986). A rat is first trained to perform two instrumental actions (e.g., pressing a lever on the left and on the right), each paired with a different reinforcer (e.g., a sweet sucrose solution or a food pellet). At the end of this training, the rat presses both levers, back and forth. In a second phase, one of the reinforcers (e.g., the sucrose) is then separately paired with illness. This conditions a taste aversion to the sucrose. In a final test, the rat is returned to the Skinner box and allowed to press either lever freely. No reinforcers are presented during this test, so behavior during testing can only result from the rat's memory of what it learned before. Importantly, the rat chooses not to perform the response that once produced the reinforcer that it now has an aversion to. This means that the rat has learned and remembered the reinforcer associated with each response, and can combine that knowledge with the knowledge that the reinforcer is now "bad." Reinforcers do not merely stamp in responses; the animal learns much more than that. The behavior is said to be "**goal-directed**" (see Dickinson & Balleine, 1994), because it is influenced by the current value of its associated goal (the reinforcer).

Things are different, however, if the rat first performs the instrumental actions frequently and repeatedly. Eventually, an action that depends on the animal's knowledge of the response-reinforcer association becomes automatic and routine. That is, the goal-directed action can become a **habit**. One way we know this is to repeat the reinforcer devaluation experiment just described with instrumental responses that have been given extensive and repeated practice (see Holland, 2004). After all the practice, the instrumental response is no longer sensitive to reinforcer devaluation: Even after a strong aversion is learned to sucrose, the rat continues to perform the response that used to produce it, quite impervious to its past consequences! The rat just responds automatically. Habits are very common in human experience. You do not need to think much about how to make your coffee in the morning or how to brush your teeth. Instrumental behaviors can eventually become habitual. This lets us get the job done while being free to think about other things.

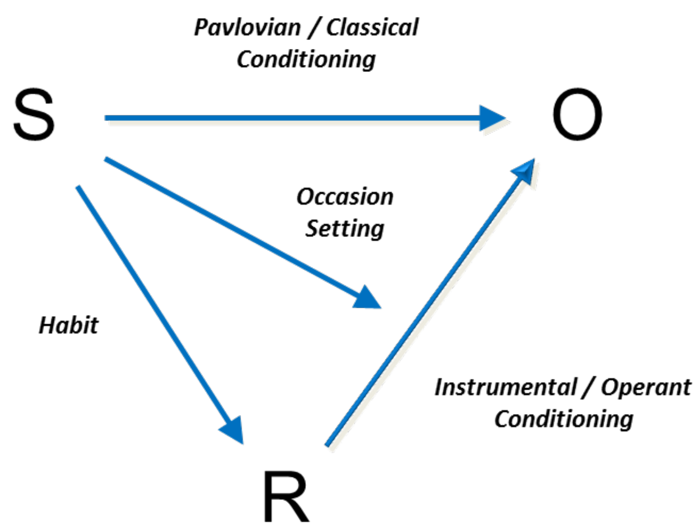
Putting Pavlovian and Instrumental Conditioning Together

Pavlovian and operant conditioning are usually studied separately. But outside the laboratory, they are almost always occurring at the same time. For example, a person who is reinforced for drinking alcohol or eating excessively learns these behaviors in the presence of certain stimuli—a pub, a set of friends, a restaurant, or possibly the couch in front of the TV. These stimuli are also available for association with the reinforcer. In this way, Pavlovian and operant conditioning are always intertwined.

The figure below summarizes this idea, and helps review what we have discussed in this chapter. Generally speaking, any reinforced or punished operant behavior (R) is paired with an outcome (O) in the presence of some stimulus or set of stimuli (S).

The figure illustrates the types of associations that can be learned in this very general scenario. For one thing, the organism will learn to associate the response and the outcome (R – O). This is instrumental learning. The learning process here is probably similar to the one in Pavlovian conditioning, with all its emphasis on surprise and prediction error. And as we discussed while considering the reinforcer devaluation effect, once R – O is learned, the organism will be ready to perform the response if the outcome is desired or valued. The value of the reinforcer can also be influenced by other reinforcers earned for other behaviors in the situation. These factors are at the heart of instrumental learning.

Second, the organism can also learn to associate the stimulus with the reinforcing outcome (S – O). This is the Pavlovian conditioning component, and as we have seen, it can have many consequences on behavior. For one thing, the stimulus will come to evoke a system of responses that help the organism prepare for the reinforcer (these are not shown in the figure). The drinker may undergo changes in body temperature, and the eater may salivate and have an increase in insulin secretion. In addition, the stimulus will evoke approach (if the outcome is positive) or movement away (if the outcome is negative). Presenting the stimulus will also motivate (invigorate) the instrumental response.



The third association in the diagram is the one between the stimulus and the response (S – R). As discussed above, after a lot of practice, the stimulus may begin to elicit the response directly. This is habit learning, where the response occurs relatively automatically, without much mental processing of the relation between the action and the outcome and the outcome's current value.

The final link in the figure is one between the stimulus and the response-outcome association [S – (R – O)]. More than just entering into a simple association with the R or the O, the stimulus can signal that the R – O relationship is now in effect. This is what we mean when we say that the stimulus can "set the occasion" for the operant response: It sets the occasion for the response-reinforcer relationship. Through this mechanism, the painter might begin to paint when given the right tools and the opportunity enabled by the canvas.

The canvas theoretically signals that the behavior of painting will now be reinforced by positive consequences.

The figure provides a framework that you can use to understand almost any learned behavior you observe in yourself, your family, or your friends. If you would like to understand it more deeply, consider taking a course on learning in the future, which will give you a fuller appreciation of how Pavlovian learning, instrumental learning, habit learning, and occasion setting actually work and interact.

Outside Resources

Article: Rescorla, R. A. (1988). Pavlovian conditioning: It's not what you think it is. American Psychologist, 43, 151–160.

Book: Bouton, M. E. (2007). Learning and behavior: A contemporary synthesis. Sunderland, MA: Sinauer Associates.

Book: Bouton, M. E. (2009). Learning theory. In B. J. Sadock, V. A. Sadock, & P. Ruiz (Eds.), Kaplan & Sadock's comprehensive textbook of psychiatry (9th ed., Vol. 1, pp. 647–658). New York, NY: Lippincott Williams & Wilkins.

Book: Domjan, M. (2010). The principles of learning and behavior (6th ed.). Belmont, CA: Wadsworth.

Discussion Questions

1. Describe three examples of Pavlovian (classical) conditioning that you have seen in your own behavior, or that of your friends or family, in the past few days.

2. Describe three examples of instrumental (operant) conditioning that you have seen in your own behavior, or that of your friends or family, in the past few days.

3. Drugs can be potent reinforcers. Discuss how Pavlovian conditioning and instrumental conditioning can work together to influence drug taking.

4. In the modern world, processed foods are highly available and have been engineered to be highly palatable and reinforcing. Discuss how Pavlovian and instrumental conditioning can work together to explain why people often eat too much.

5. How does blocking challenge the idea that pairings of a CS and US are sufficient to cause Pavlovian conditioning? What is important in creating Pavlovian learning?

6. How does the reinforcer devaluation effect challenge the idea that

reinforcers merely “stamp in” the operant response? What does the effect tell us that animals actually learn in operant conditioning?

Vocabulary

Blocking
In classical conditioning, the finding that no conditioning occurs to a stimulus if it is combined with a previously conditioned stimulus during conditioning trials. Suggests that information, surprise value, or prediction error is important in conditioning.

Categorize
To sort or arrange different items into classes or categories.

Classical conditioning
The procedure in which an initially neutral stimulus (the conditioned stimulus, or CS) is paired with and an unconditioned stimulus (or US). The result is that the conditioned stimulus begins to elicit a conditioned response (CR). Classical conditioning is nowadays considered important as both a behavioral phenomenon and as a method to study simple associative learning. Same as Pavlovian conditioning.

Conditioned compensatory response
In classical conditioning, a conditioned response that opposes, rather than is the same as, the unconditioned response. It functions to reduce the strength of the unconditioned response. Often seen in conditioning when drugs are used

as unconditioned stimuli.

Conditioned response (CR)
The response that is elicited by the conditioned stimulus after classical conditioning has taken place.

Conditioned stimulus (CS)
An initially neutral stimulus (like a bell, light, or tone) that elicits a conditioned response after it has been associated with an unconditioned stimulus.

Context
Stimuli that are in the background whenever learning occurs. For instance, the Skinner box or room in which learning takes place is the classic example of a context. However, "context" can also be provided by internal stimuli, such as the sensory effects of drugs (e.g., being under the influence of alcohol has stimulus properties that provide a context) and mood states (e.g., being happy or sad). It can also be provided by a specific period in time—the passage of time is sometimes said to change the "temporal context."

Discriminative stimulus
In operant conditioning, a stimulus that signals whether the response will be reinforced. It is said to "set the occasion" for the operant response.

Extinction

Decrease in the strength of a learned behavior that occurs when the conditioned stimulus is presented without the unconditioned stimulus (in classical conditioning) or when the behavior is no longer reinforced (in instrumental conditioning). The term describes both the procedure (the US or reinforcer is no longer presented) as well as the result of the procedure (the learned response declines). Behaviors that have been reduced in strength through extinction are said to be "extinguished."

Fear conditioning

A type of classical or Pavlovian conditioning in which the conditioned stimulus (CS) is associated with an aversive unconditioned stimulus (US), such as a foot shock. As a consequence of learning, the CS comes to evoke fear. The phenomenon is thought to be involved in the development of anxiety disorders in humans.

Goal-directed behavior

Instrumental behavior that is influenced by the animal's knowledge of the association between the behavior and its consequence and the current value of the consequence. Sensitive to the reinforcer devaluation effect.

Habit
Instrumental behavior that occurs automatically in the presence of a stimulus and is no longer influenced by the animal's knowledge of the value of the reinforcer. Insensitive to the reinforcer devaluation effect.

Instrumental conditioning
Process in which animals learn about the relationship between their behaviors and their consequences. Also known as operant conditioning.

Law of effect
The idea that instrumental or operant responses are influenced by their effects. Responses that are followed by a pleasant state of affairs will be strengthened and those that are followed by discomfort will be weakened. Nowadays, the term refers to the idea that operant or instrumental behaviors are lawfully controlled by their consequences.

Operant
A behavior that is controlled by its consequences. The simplest example is the rat's lever-pressing, which is controlled by the presentation of the reinforcer.

Operant conditioning

See instrumental conditioning.

Pavlovian conditioning

See classical conditioning.

Prediction error

When the outcome of a conditioning trial is different from that which is predicted by the conditioned stimuli that are present on the trial (i.e., when the US is surprising). Prediction error is necessary to create Pavlovian conditioning (and associative learning generally). As learning occurs over repeated conditioning trials, the conditioned stimulus increasingly predicts the unconditioned stimulus, and prediction error declines. Conditioning works to correct or reduce prediction error.

Preparedness

The idea that an organism's evolutionary history can make it easy to learn a particular association. Because of preparedness, you are more likely to associate the taste of tequila, and not the circumstances surrounding drinking it, with getting sick. Similarly, humans are more likely to associate images of spiders and snakes than flowers and mushrooms with aversive outcomes like shocks.

Punisher

A stimulus that decreases the strength of an operant behavior when it is made a consequence of the behavior.

Quantitative law of effect

A mathematical rule that states that the effectiveness of a reinforcer at strengthening an operant response depends on the amount of reinforcement earned for all alternative behaviors. A reinforcer is less effective if there is a lot of reinforcement in the environment for other behaviors.

Reinforcer

Any consequence of a behavior that strengthens the behavior or increases the likelihood that it will be performed it again.

Reinforcer devaluation effect

The finding that an animal will stop performing an instrumental response that once led to a reinforcer if the reinforcer is separately made aversive or undesirable.

Renewal effect
Recovery of an extinguished response that occurs when the context is changed after extinction. Especially strong when the change of context involves return to the context in which conditioning originally occurred. Can occur after extinction in either classical or instrumental conditioning.

Spontaneous recovery
Recovery of an extinguished response that occurs with the passage of time after extinction. Can occur after extinction in either classical or instrumental conditioning.

Stimulus control
When an operant behavior is controlled by a stimulus that precedes it.

Taste aversion learning
The phenomenon in which a taste is paired with sickness, and this causes the organism to reject—and dislike—that taste in the future.

Unconditioned response (UR)
In classical conditioning, an innate response that is elicited by a stimulus before (or in the absence of) conditioning.

Unconditioned stimulus (US)

In classical conditioning, the stimulus that elicits the response before conditioning occurs.

Reference List

Balleine, B. W. (2005). Neural basis of food-seeking: Affect, arousal, and reward in corticostratolimbic circuits. Physiology & Behavior, 86, 717–730.

Bernstein, I. L. (1991). Aversion conditioning in response to cancer and cancer treatment. Clinical Psychology Review, 11, 185–191.

Bouton, M. E. (2004). Context and behavioral processes in extinction. Learning & Memory, 11, 485–494.

Colwill, R. M., & Rescorla, R. A. (1986). Associative structures in instrumental learning. In G. H. Bower (Ed.), The psychology of learning and motivation, (Vol. 20, pp. 55–104). New York, NY: Academic Press.

Craske, M. G., Kircanski, K., Zelikowsky, M., Mystkowski, J., Chowdhury, N., & Baker, A. (2008). Optimizing inhibitory learning during exposure therapy. Behaviour Research and Therapy, 46, 5–27.

Dickinson, A., & Balleine, B. W. (1994). Motivational control of goal-directed behavior. Animal Learning & Behavior, 22, 1–18.

Fanselow, M. S., & Poulos, A. M. (2005). The neuroscience of mammalian associative learning. Annual Review of Psychology, 56, 207–234.

Herrnstein, R. J. (1970). On the law of effect. Journal of the Experimental Analysis of Behavior, 13, 243–266.

Holland, P. C. (2004). Relations between Pavlovian-instrumental transfer and reinforcer devaluation. Journal of Experimental Psychology: Animal Behavior Processes, 30, 104–117.

Kamin, L. J. (1969). Predictability, surprise, attention, and conditioning. In B. A. Campbell & R. M. Church (Eds.), Punishment and aversive behavior (pp. 279–296). New York, NY: Appleton-Century-Crofts.

Mineka, S., & Zinbarg, R. (2006). A contemporary learning theory perspective on the etiology of anxiety disorders: It's not what you thought it was. American Psychologist, 61, 10–26.

Pearce, J. M., & Bouton, M. E. (2001). Theories of associative learning in animals. Annual Review of Psychology, 52, 111–139.

Rescorla, R. A., & Wagner, A. R. (1972). A theory of Pavlovian conditioning: Variations in the effectiveness of reinforcement and nonreinforcement. In A. H. Black & W. F. Prokasy (Eds.), Classical conditioning II: Current research and theory (pp. 64–99). New York, NY: Appleton-Century-Crofts.

Scalera, G., & Bavieri, M. (2009). Role of conditioned taste aversion on the side effects of chemotherapy in cancer patients. In S. Reilly & T. R. Schachtman (Eds.), Conditioned taste aversion: Behavioral and neural processes (pp. 513–541). New York, NY: Oxford University Press.

Siegel, S. (1989). Pharmacological conditioning and drug effects. In A. J. Goudie & M. Emmett-Oglesby (Eds.), Psychoactive drugs (pp. 115–180). Clifton, NY: Humana Press.

Siegel, S., Hinson, R. E., Krank, M. D., & McCully, J. (1982). Heroin “overdose” death: Contribution of drug associated environmental cues. Science, 216, 436–437.

Spreat, S., & Spreat, S. R. (1982). Learning principles. In V. Voith & P. L. Borchelt (Eds.), Veterinary clinics of North America: Small animal practice (pp. 593–606). Philadelphia, PA: W. B. Saunders.

Thompson, R. F., & Steinmetz, J. E. (2009). The role of the cerebellum in classical conditioningof discrete behavioral responses. Neuroscience, 162, 732–755.

Timberlake, W. L. (2001). Motivational modes in behavior systems. In R. R. Mowrer & S. B. Klein (Eds.), Handbook of contemporary learning theories (pp. 155–210). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Wasserman, E. A. (1995). The conceptual abilities of pigeons. American Scientist, 83, 246–255.

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