

# Learning: Principles and Applications

ESSENTIAL QUESTION • How do our experiences change our behavior?



networks

There's More Online about the principles and applications of learning.

## CHAPTER 9

### Lab Activity

*Sounds and Learning*

### Lesson 1

*Classical Conditioning*

### Lesson 2

*Operant Conditioning*

### Lesson 3

*Social Learning*

## Psychology Matters...

How do people learn new things? Behavioral psychologists are applying their animal research results to further their understanding of human behavior. Behavioral psychologists recognize that humans learn with a purpose that animals do not have. Some psychologists focus their efforts on giving people resources to help them learn more effectively. This chapter will discuss the studies of behaviorists and their application to humans in general.

◀ Is learning a new skill a matter of simple conditioning? Or is there more to learning? ▶

Purestock/Getty Images

## Lab Activity

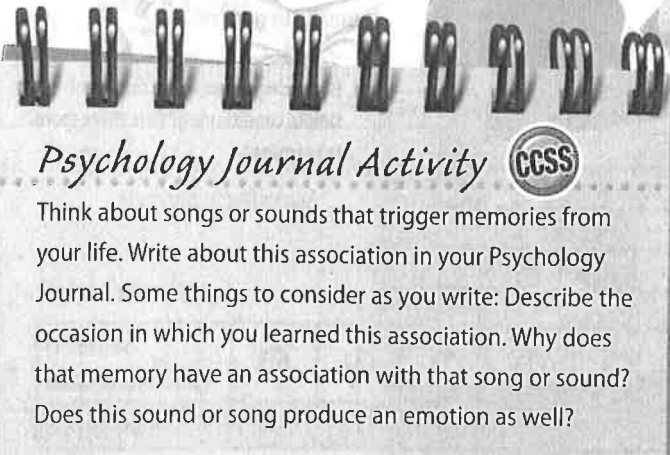
# Sounds and Learning

## THE QUESTION...

**RESEARCH QUESTION** Can you effect a preference for an image by creating an association between it and a sound?

There are many sounds we associate with either pleasant or unpleasant experiences. Think about an ice cream truck. It plays a song that lets every person, young and old, within earshot know a sweet frozen treat is just around the corner. Most come to associate the truck's song to ice cream, and ice cream is what they think of when they hear the song, even if it's not coming from the ice cream truck.

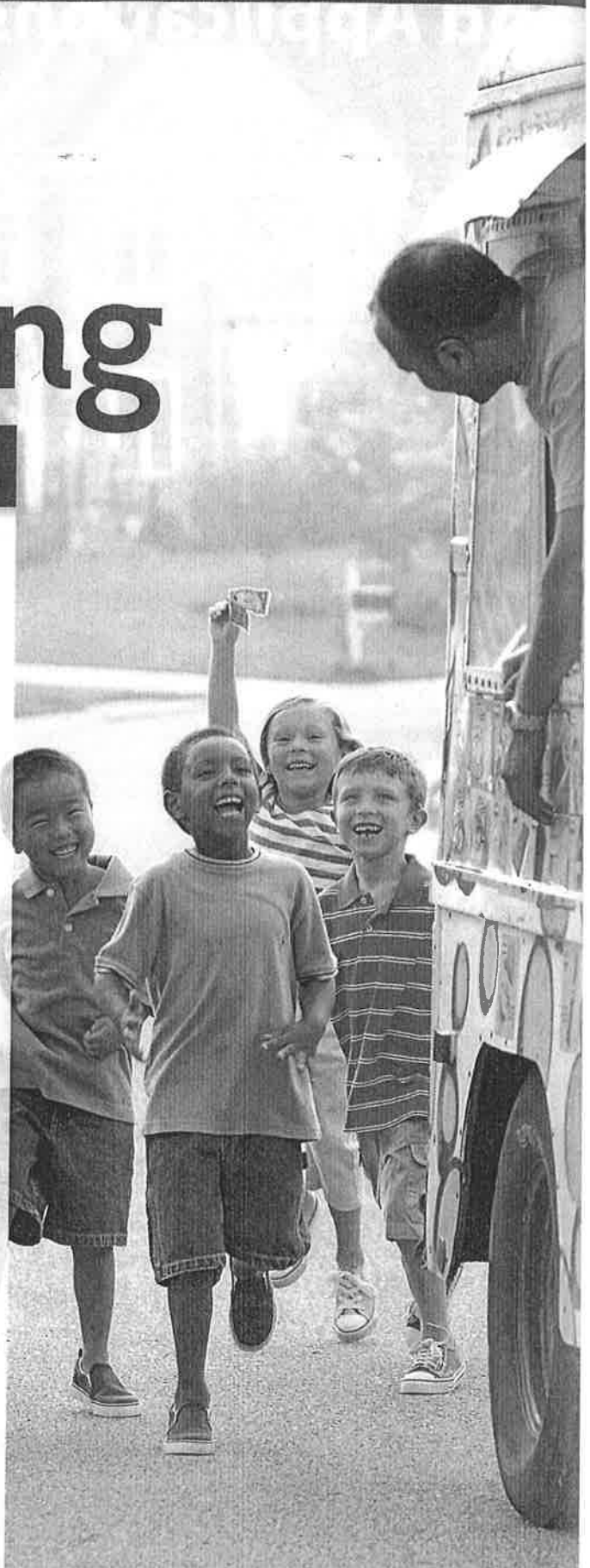
This is a type of learning that happens every day. Let's take a look at this in action by conducting an experiment in which we will attempt to effect the preferences of another person.



*Psychology Journal Activity*



Think about songs or sounds that trigger memories from your life. Write about this association in your Psychology Journal. Some things to consider as you write: Describe the occasion in which you learned this association. Why does that memory have an association with that song or sound? Does this sound or song produce an emotion as well?



## FINDING THE ANSWER...

**HYPOTHESIS** Because pleasant sounds make people feel happy, people will prefer an image paired with a pleasant sound more than an image paired with an unpleasant sound.

### THE METHOD OF YOUR EXPERIMENT

**MATERIALS** abstract images; mp3s or other sound files of pleasant sounds such as the ocean, light rainfall, or children's laughter, and unpleasant sounds such as an alarm, buzzer, or crash

**PROCEDURE** Using the Internet search engine of your choice, find at least four abstract images from the same artist or from a group of artists with a similar style. Ready your selected images for display by creating a digital or print slideshow. In a quiet room, present the images one at a time to your participant. As you show the first image, play one of your pleasant sound files. Then, switch to your second image and play one of your unpleasant sound files. Alternate pleasant and unpleasant sounds for the remainder of your images, using a different pleasant or unpleasant sound file for each image. Make certain both the pleasant and unpleasant sounds are played at the same volume.

**DATA COLLECTION** After you have presented all of the images to your participant, ask them which image is their favorite. Keep track of preferred images that are paired with a pleasant sound.

### ANALYSIS & APPLICATION

1. Did your data support the hypothesis?
2. What conclusions can you draw about learning from this experiment?
3. How could you alter this experiment to test the hypothesis in a different way?

## networks

### ONLINE LAB RESOURCES

#### Online you will find:

- An **interactive lab experience**, allowing you to put principles from this chapter into practice in a digital psychology lab environment. This chapter's lab will include an experiment allowing you to explore issues related to learning and to training animals.
- A **Skills Handbook** that includes a guide for using the scientific method, creating experiments, and analyzing data.
- A **Notebook** where you can complete your Psychology Journal and record and analyze data from your experiment.

- DIAGRAM Pavlov's Dog
- GRAPHIC ORGANIZER
- SELF-CHECK QUIZ



## LESSON 1

# Classical Conditioning

Reading **HELPDESK**

### Academic Vocabulary

- process
- demonstrate

### Content Vocabulary

- classical conditioning
- neutral stimulus
- unconditioned stimulus
- unconditioned response
- conditioned stimulus
- conditioned response
- generalization
- discrimination
- extinction

### TAKING NOTES:

#### Key Ideas and Details

**SEQUENCING** Use a graphic organizer like the one below to record the process of classical conditioning.

Classical Conditioning

**ESSENTIAL QUESTION** • How do our experiences change our behavior?

## IT MATTERS BECAUSE

Have you ever heard the beginning of a catchy tune on a television commercial and found yourself singing along? The tune and the advertisement are so connected that you cannot hear the music without remembering the words. When you are shopping for the type of item advertised, the tune you remember will make that product feel familiar.

## Pavlov's Dog

**GUIDING QUESTION** What did Pavlov's discovery demonstrate?

A memorable advertising jingle is an example of the way advertisers use psychological principles. Studies have shown that pairing a product with pleasant sensations, such as memorable music, motivates consumers to choose that product. Add a catchy jingle that carries the product's name and you may find yourself buying it without stopping to think.

This conscious or unconscious training of our behaviors is known as conditioning. Russian physiologist Ivan Pavlov was the first to document in great detail conditioning as we know it. Today, we call the types of conditioning documented by Pavlov classical conditioning. In **classical conditioning**, a person's or animal's old response to a prompt or stimulus becomes attached to a new prompt or stimulus. This can be done even if the second stimulus has little to no similarity to the first. Classical conditioning is an example of a relatively permanent change in a behavioral tendency that results from experience. This is one type of learning.

Pavlov's discovery of the principle of classical conditioning was accidental. Around the turn of the twentieth century, Pavlov had been studying the **process** of, or steps involved in, digestion. Pavlov wanted to understand how a dog's stomach prepares to digest food when something is placed in its mouth. Then he noticed that the mere sight or smell of food was enough to start a hungry dog salivating. Pavlov became fascinated with how the dog anticipated the food and how salivation occurred before the food was presented, and he decided to investigate.

Pavlov began his experiments by ringing a tuning fork and then immediately placing some meat powder on the dog's tongue. He chose the tuning fork because it was a **neutral stimulus**—that is, one that

initially had nothing to do with the dog's salivating response to the meat. After only a few meal times that were paired with the tuning fork, the dog started salivating as soon as it heard the sound, even if the food was not placed in its mouth. Pavlov demonstrated that a neutral stimulus (tuning fork's ring) can cause a formerly unrelated response. This occurs if it is presented regularly just before the stimulus (food) that normally brings about that response (salivation).

Pavlov used the term *unconditioned* to refer to stimuli and to the automatic, involuntary responses they caused. Such responses include blushing, shivering, being startled, or salivating. In the experiment, food was the **unconditioned stimulus (US)**—an event that leads to a certain, predictable response usually without any previous training. Food normally causes salivation. A dog does not have to be taught to salivate when it smells meat. The salivation is an **unconditioned response (UR)**—a reaction that occurs naturally and automatically when the unconditioned stimulus is presented, in other words, a reflex.

Under normal conditions, the sound of a tuning fork would not cause salivation. The dog had to be taught, or conditioned, to associate this sound with food. An ordinarily neutral event that, after training, leads to a response such as salivation is termed a **conditioned stimulus (CS)**. The salivation it causes is a **conditioned response (CR)**. A conditioned response is learned. A wide variety of events may serve as conditioned stimuli for salivation—the sight of food, an experimenter entering the room, the sound of a tone, or a flash of light. A number of different reflex responses that occur automatically following an unconditioned stimulus (US) can be conditioned to occur following the correct conditioned stimulus (CS).

#### READING PROGRESS CHECK

**Summarizing** Why did Pavlov's dog salivate at the sound of the tuning fork?

## General Principles of Classical Conditioning

**GUIDING QUESTION** *When does extinction occur?*

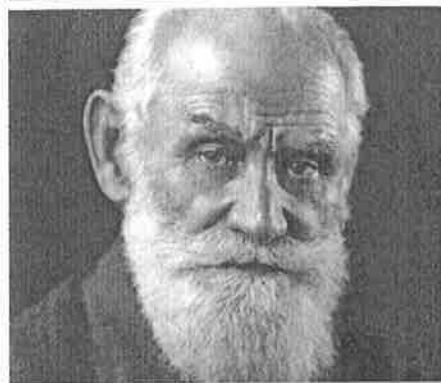
The learning present in classical conditioning helps animals and humans adapt to the environment. It also helps humans and animals correct mistakes and avoid danger. Psychologists and researchers have investigated why and in what circumstances classical conditioning occurs. The basic principles they have established lead to a greater understanding of classical conditioning.

### Acquisition

Acquisition of a classically conditioned response generally occurs gradually. With each pairing of the conditioned stimulus (CS) and the unconditioned stimulus (US), the conditioned response (CR)—or learned response—is strengthened. In Pavlov's experiment, the more frequently the tuning fork was paired with the food, the more often the tone brought about salivation—the conditioned response.

The timing of the association between the conditioned stimulus (the tone) and the unconditioned stimulus (food) also influences learning. Pavlov tried several different conditioning procedures in which he varied the time between presenting the conditioned stimulus and the unconditioned stimulus. He found that classical conditioning was most reliable and effective when the conditioned stimulus was presented just before the unconditioned stimulus. He found that presenting the conditioned stimulus (CS) about half a second before the unconditioned stimulus (US) would yield the strongest associations between the tuning fork and the meat. The sound predicted the meat powder for the dog, so it began to salivate in anticipation when the tuning fork sounded.

## Profiles in Psychology



**Ivan Petrovich Pavlov**  
(1849–1936)

Born in central Russia, Pavlov obtained a doctoral degree in science from the University of St. Petersburg. In 1897 he began his own research into digestion and blood circulation. Pavlov's original work actually began as a study of digestion, for which he won the Nobel Prize in 1904. Pavlov discovered that salivation and the action of the stomach were closely linked to reflexes in the autonomic nervous system. By studying conditioned reflexes, it became possible to examine human behavior objectively, instead of resorting to subjective methods.

Pavlov distrusted the new science of psychiatry. He did think, though, that conditioned reflexes could explain the behavior of psychotic people. He believed that those who withdrew from the world may associate all stimuli with possible injury or threat.

#### CRITICAL THINKING

##### **Identifying Cause and Effect**

How did Pavlov connect his work with dogs to the understanding of psychotic people?

**classical conditioning** a learning procedure in which associations are made between a neutral stimulus and an unconditioned stimulus

**process** a series of actions or operations directed toward a specific end

**neutral stimulus** a stimulus that does not initially elicit any part of an unconditioned response

**unconditioned stimulus (US)** an event that elicits a certain predictable response typically without previous training

**unconditioned response (UR)** an organism's automatic (or natural) reaction to a stimulus

**conditioned stimulus (CS)** a once-neutral event that elicits a given response after a period of training in which it has been paired with an unconditioned stimulus

**conditioned response (CR)** the learned reaction to a conditioned stimulus

**generalization** responding similarly to a range of similar stimuli

**discrimination** the ability to respond differently to similar but distinct stimuli

**extinction** the gradual disappearance of a conditioned response when the conditioned stimulus is repeatedly presented without the unconditioned stimulus

## Generalization and Discrimination

In the same set of experiments, Pavlov also explored the processes that are known as generalization and discrimination. **Generalization** occurs when an animal responds, or reacts, to a second stimulus similar to the original CS without prior training with the second stimulus. When Pavlov conditioned a dog to salivate at the sight of a circle (the CS), he found that the dog would salivate when it saw another geometric figure as well. However, the more closely the figure resembled the circle, such as an oval, the more the dog would salivate. The dog had generalized its response to include a similar stimulus. Pavlov was later able to do the opposite, teaching the dog to respond only to the circle by always pairing meat powder with the circle but never pairing it with the oval. In this way Pavlov had taught the dog **discrimination**—the ability to respond in different ways to different stimuli.

Generalization and discrimination are complementary processes and are part of your everyday life. Both may occur spontaneously in some situations, and both can be taught in others. For example, assume a friend has come to associate the sound of a dentist's drill (the conditioned stimulus) with a fearful reaction (the conditioned response). After several exposures to a dentist's drill, your friend may find that he or she has generalized this uncomfortable feeling to the sound of other, nondental drills. Later, your friend may learn to discriminate between the sound of a dentist's drill and other drills.

## Extinction and Spontaneous Recovery

A classically conditioned response, like any other behavior, is subject to change. Pavlov discovered that if he stopped presenting food after the sound of the tuning fork, the sound gradually lost its effect on the dog. After he repeatedly struck the tuning fork without giving food, the dog no longer associated the sound with the arrival of food—the sound of the tuning fork no longer caused the salivation response. Pavlov called this effect **extinction** because the conditioned response had gradually died out. The conditioned response was no longer a reliable predictor of the arrival of food.

Even though a classically conditioned response may be extinguished, this does not mean that the conditioned response has been completely unlearned. If a rest period is given following extinction, the conditioned response may reappear when the conditioned stimulus is presented again but not followed by an unconditioned stimulus. This spontaneous recovery does not bring the conditioned response back to original strength, however. Pavlov's dogs produced much less saliva during spontaneous recovery than they did at the end of their original conditioning. Alternating lengthy rest periods and the tone without food caused more rapid loss of salivation each time and less recovery the next time the conditioned stimulus was presented.

A good example of extinction and spontaneous recovery can occur if you are involved in a car accident. Following the accident it may at first be difficult to drive again. You might even find it difficult to open the door and get into the car. As you approach the car, your hands begin to shake and your knees get shaky as well. Your heartbeat even increases as you get nearer. After a few days, opening the door and getting into the car do not bother you as much. Several months go by and the fear of the car and the accident have been extinguished. One day, several months later, as you begin to approach the car, your heart begins to race and your knees and hands begin to shake. You have had a spontaneous recovery of the fear reaction.

### READING PROGRESS CHECK

**Identifying** What are the general principles behind classical conditioning?

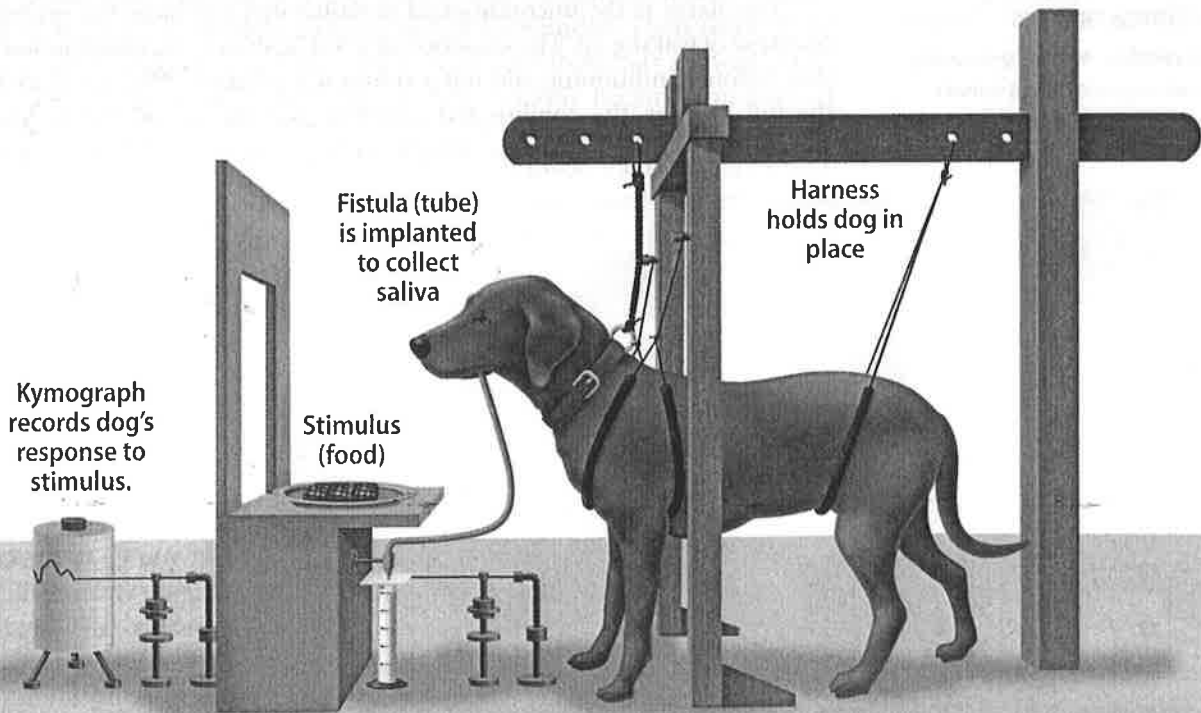
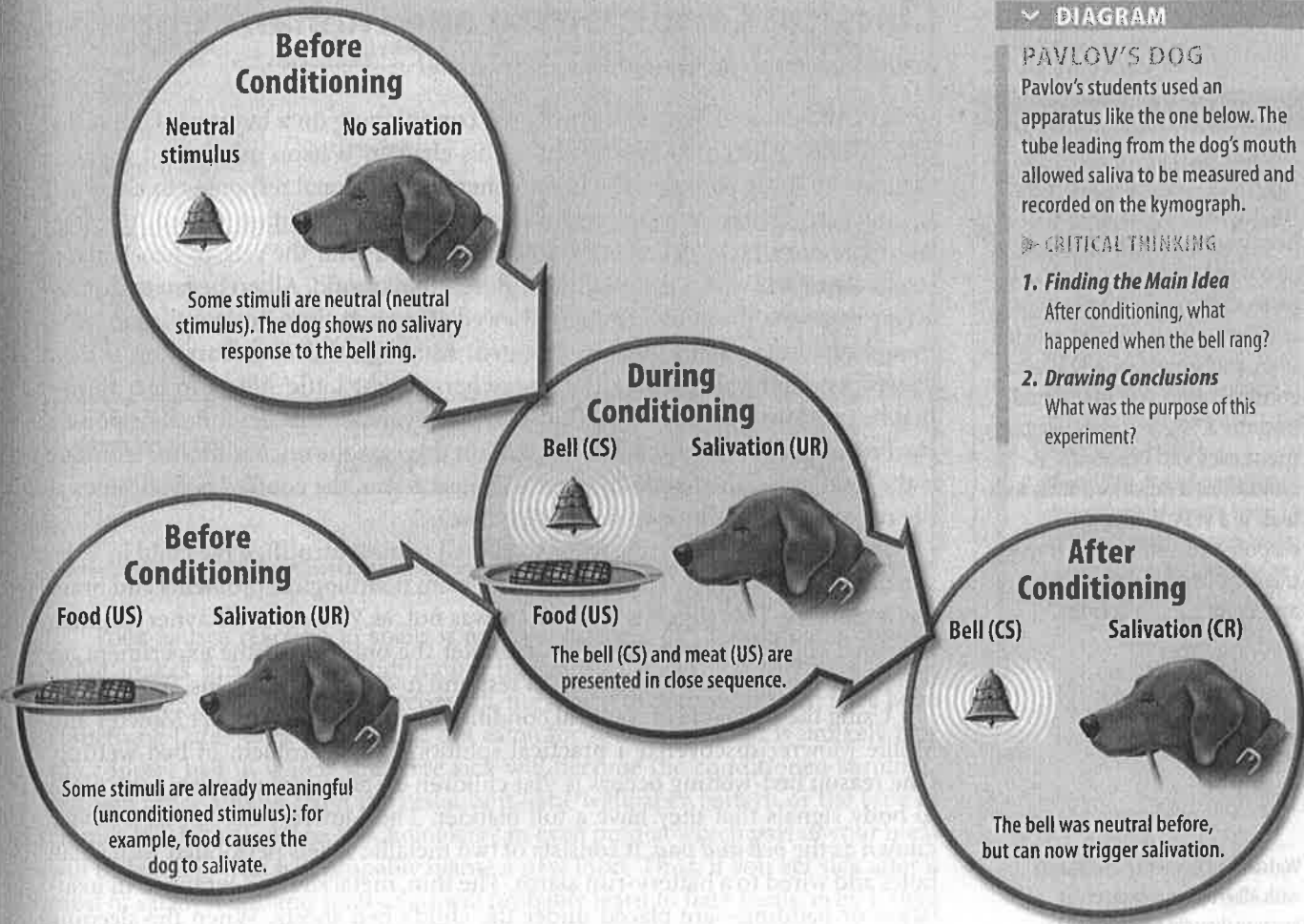
DIAGRAM

PAVLOV'S DOG

Pavlov's students used an apparatus like the one below. The tube leading from the dog's mouth allowed saliva to be measured and recorded on the kymograph.

CRITICAL THINKING

1. **Finding the Main Idea**  
After conditioning, what happened when the bell rang?
2. **Drawing Conclusions**  
What was the purpose of this experiment?



## More ABOUT...

### Classical Conditioning

Have you ever noticed how movie directors use music in their movies? Did you ever hear a song and then think about either the movie it was from or the person you were with when you saw the movie? If so, you experienced classical conditioning. The music had become a “signal” that triggers memories and emotions. A conditioned emotion, such as fear, is a very difficult response to extinguish. It may trigger physical, cognitive, and emotional reactions.

Watson and Rayner’s experiments with Albert were controversial because they did not attempt to correct the fear response they created in the child.

#### ► CRITICAL THINKING

**Speculating** Why did the researchers design an experiment that created a negative response, rather than a positive response?



## Classical Conditioning and Human Behavior

**GUIDING QUESTION** How do people develop taste aversions?

John B. Watson and Rosalie Rayner used conditioning on a human infant in the case of Little Albert, the case study in this chapter. Watson questioned the role that conditioning played in the development of emotional responses in children. He and Rayner attempted to condition an 11-month-old infant named Albert to fear laboratory rats. At first Albert happily played with the rats. When Watson struck a steel bar with a hammer to produce a loud sound, Albert began to display a fear response. Eventually Albert showed fear each time he saw the rat even though the loud sound was not repeated. Although this demonstration is now viewed as unethical (because the researchers taught Little Albert to fear things that he previously had no fear of), it provided evidence that emotional responses can be classically conditioned in humans. In this case the unconditioned stimulus is the loud noise, the unconditioned response is fear, the conditioned stimulus is the rat, and the conditioned response is fear.

In a 2012 study, researchers have claimed to have identified the child in Watson and Rayner’s study. This boy suffered from neurological problems and brain abnormalities. This suggests that Albert was not, as Watson and Rayner claimed, a normal child. However, this does not alter the outcome of the experiment, in which the subject was conditioned to respond to a specific stimulus.

Using the principle of classical conditioning in 1938, O. Hobart Mowrer and Mollie Mowrer discovered a practical solution to the problem of bed-wetting. One reason bed-wetting occurs is that children do not wake up during the night to body signals that they have a full bladder. The Mowrers developed a device known as the *bell and pad*. It consists of two metallic sheets perforated with small holes and wired to a battery-run alarm. The thin, metal sheets—wrapped in insulation or padding—are placed under the child’s bed sheets. When the sleeping child moistens the sheet with the first drops of urine, the circuit closes, causing the alarm to go off and wake the child. The child can then use the bathroom.

The alarm is the unconditioned stimulus that produces the unconditioned response of waking up. The sensation of a full bladder is the conditioned stimulus that, before conditioning, did not produce wakefulness. After several pairings of the full bladder, the conditioned stimulus, and the alarm, the unconditioned stimulus, the child is able to awaken to the sensation of a full bladder without the

help of the alarm. This technique has proven to be a very effective way of treating bed-wetting problems.

### Taste Aversions

Suppose you go to a fancy restaurant. You decide to try an appetizer you have never eaten, for instance, snails. Then suppose that, after dinner, you go to a concert and become violently ill. You will probably develop a taste aversion; you may never be able to look at another snail without feeling at least a little nauseated.



Conditioned Stimulus	Conditioned Response	Unconditioned Stimulus	Unconditioned Response
Dentist/ sound of drill	Tension	Drill	Tension
Product (soda pop)	Favorable feeling	Catchy jingle or slogan	Favorable feeling
Flashing police car lights	Distress	Speeding ticket	Distress

Your nausea reaction to snails is another example of classical conditioning. What makes this type of conditioning interesting to learning theorists is that when people or other animals become ill, they seem to decide, “It must have been something I ate,” even if they have not eaten for several hours. It is unlikely that the concert hall in which you were sick will become the conditioned stimulus, nor will other stimuli from the restaurant—the wallpaper pattern or the type of china used. What is more, psychologists can even predict which part of your meal will be the CS—you will probably blame a new food. Thus, if you get sick after a meal of salad, steak, and snails, you will probably learn to hate snails, even if they are really not the cause of your illness.

John Garcia and R.A. Koelling first **demonstrated** this phenomenon with rats. The animals were placed in a cage with a tube containing flavored water. Whenever a rat took a drink, lights flashed and clicks sounded. Then, some of the rats were given an electric shock after they drank. All these rats showed traditional classical conditioning—the lights and the sounds became conditioned stimuli, and the rats tried to avoid them in order to avoid a shock. The other rats were not shocked but were injected with a drug that made them sick after they drank and the lights and sounds occurred. These rats developed an aversion not to the lights or the sounds but only to the taste of the flavored water.

This special relationship between food and illness was used in a study that made coyotes avoid sheep by giving them a drug to make them sick when they ate sheep. This application is important because sheep farmers in the western United States would like to eliminate the coyotes that threaten their flocks, while naturalists are opposed to killing the coyotes. If coyotes could be trained to hate the taste of sheep, they would rely on other food sources and thus learn to coexist peacefully with sheep.

In summary, classical conditioning helps animals and humans predict what is going to happen. It provides information that may be helpful to their survival. Learning associated with classical conditioning may aid animals in finding food or help humans avoid pain or injury. Avoiding foods that cause sickness helps animals and humans. For example, parents may condition an infant to avoid a danger such as electrical outlets by shouting “NO!” and startling the infant each time he approaches an outlet. The infant fears the shouts of the parents, and eventually the infant fears the outlet even when the parents are not there.

← TABLE

**EXAMPLES OF COMMON CONDITIONED RESPONSES**

If you have pets and feed them canned food, what happens when you use the can opener? You may notice that your pets may come running even when you are opening a can of peas.

► **CRITICAL THINKING**

- 1. Interpreting** Why do you feel distress at the mere sight of flashing police lights?
- 2. Theorizing** If you became sick after eating your favorite candy and a less favorite candy, to which would you most likely develop an aversion? Why?

**demonstrate** to show something clearly by giving evidence

TABLE &gt;

## CLASSICAL CONDITIONING VS. OPERANT CONDITIONING

All conditioning involves establishing relationships between two events. The two forms of conditioning, though, use very different procedures to reach their goals.

### ► CRITICAL THINKING

- 1. Synthesizing** Apply the three steps (stimulus, response, and environment) to the development of a taste aversion.
- 2. Identifying Central Issues** What role does the learner's environment play in each type of conditioning?

Classical Conditioning	Operant Conditioning
1. The response triggered by the stimulus is an involuntary response.	1. The voluntary response causes a reinforcing stimulus
2. Always a specific stimulus (US) that elicits a certain response	2. No identifiable stimulus; learner must first respond, then behavior is reinforced
3. US does not depend upon learner's response	3. Reinforcement depends upon learner's response behavior
4. Environment elicits response from learner	4. Learner actively operates on its environment

## Behaviorism

Classical conditioning is an example of a behaviorist theory. Behaviorism is the attempt to understand behavior and mental states in terms of relationships between observable stimuli and observable responses. Behaviorists are psychologists who study only those behaviors that they can observe and measure. Behaviorists are not concerned with unobservable mental processes. They emphasize actions instead of thoughts. According to behaviorists, a person's environment is what determines how they will behave. Due to their emphasis on behavior, behaviorists define psychology as the scientific study of behavior, not the study of behavior and mental processes. Opponents of behaviorism disagree with this approach because it does not account for a person's feelings, their thoughts, or their will when it comes to their responses.

We will discuss another behaviorist learning theory, operant conditioning, in the next lesson. Classical conditioning is a process by which a stimulus that previously did not elicit a response comes to elicit a response after it is paired with a stimulus that naturally elicits a response. In contrast, operant conditioning is a process by which the consequences of a response affect the likelihood that the response will occur again.

### ✓ READING PROGRESS CHECK

**Explaining** Give an example of classical conditioning in everyday life.

## LESSON 1 REVIEW



### Reviewing Vocabulary

- 1. Identifying** What is the difference between a neutral stimulus and an unconditioned stimulus?
- 2. Understanding Relationships** How are generalization and discrimination related to classical conditioning?

### Using Your Notes

- 3. Describing** Use the notes you have taken throughout the lesson to describe the process of classical conditioning.

### Answering the Guiding Questions

- 4. Explaining** Under what conditions might a conditioned response become extinct?
- 5. Summarizing** How do people develop taste aversions?

### Writing Activity

- 6. Informative/Explanatory** You have a friend who inhales noisily when standing next to you and then puffs air into your eye. You discover that you now blink when you hear your friend inhale. Write a description of this process, identifying and describing the neutral stimulus, the US, UR, CS, and CR in your behavior.

# Case Study



## The Case of Little Albert

Winter, 1919–1920

**Introduction:** Through research with an infant, John B. Watson and Rosalie Rayner concluded that there are only a few instinctive reflexes and innate emotions in human infants. Using one of those innate emotions, fear of loud sounds, Watson and Rayner made discoveries about the conditioning of human behavior and emotional reactions.

**Hypothesis:** Most human behaviors and emotional reactions are built up of conditioned responses. (When an emotionally exciting object stimulates the subject simultaneously with an object not emotionally exciting, the latter object may in time arouse the same emotional reaction as the former object.)

**Method:** Watson and Rayner presented Albert, a 9-month-old boy, with many objects, including a rat, blocks, a rabbit, a dog, a monkey, masks with and without hair, cotton, wool, and burning newspapers. Albert showed no fear of any of these objects—they were all neutral stimuli for the fear response.

When Albert was 11 months old, Watson and Rayner conditioned him to fear rats. They began by placing a furry white rat in front of him. Each time Albert reached out to touch it, one of Watson's assistants would strike a metal bar with a hammer behind Albert. The first time the metal bar was struck, Albert fell forward and buried his head in a pillow. The next time he reached for the rat and the bar was struck, Albert began to whimper. The noise, the unconditioned stimulus, brought about a naturally unconditioned response, fear. After only a few such pairings, the rat became a conditioned stimulus that elicited a conditioned response, fear.

Five days after Watson and Rayner conditioned Albert to fear rats, they presented him with blocks, a rabbit, a rat, and a dog, each alone. They also showed him a number of other stimuli, including a Santa Claus mask. Albert reacted fearfully to all but the blocks. His conditioned fear response generalized to include the rabbit and all of the white furry objects he was shown, but not to any dissimilar toys.

**Results:** One of the most frequent criticisms of the experiment was that Watson and Rayner taught a child to be fearful. In their published findings, Watson and Rayner dismissed this concern.

### PRIMARY SOURCE

*“At first there was considerable hesitation upon our part in making the attempt to set up fear reactions experimentally. A certain responsibility attaches to such a procedure. We decided finally to make the attempt, comforting ourselves by the reflection that such attachments would arise anyway as soon as the child left the sheltered environment of the nursery for the rough and tumble of the home. We did not begin this work until Albert was eleven months, three days of age.”*

—“Conditioned Emotional Reactions,” by John B. Watson and Rosalie Rayner

The researchers also made no attempt to extinguish Albert's conditioned fears. The Little Albert study cannot be repeated today because of the ethical standards of the APA. One of Watson's students, Mary Cover Jones, developed an extinction procedure called counterconditioning to reduce people's existing fears. Jones helped Peter, a boy who was fearful of rabbits, eliminate his fear by pairing the feared object (the rabbit) with pleasant experiences, such as eating ice cream or receiving special attention.

### Analyzing the Case Study

- 1. Interpreting** Did the results of Watson and Rayner's experiment support their hypothesis? Explain.
- 2. Making Connections** How did Albert's response become generalized?
- 3. Drawing Conclusions** How were the principles of classical conditioning used to reduce Peter's fear of rabbits?
- 4. Analyzing Ethical Issues** What defense did Watson and Rayner give for their decision to experiment on Albert? Do you consider their justification valid?

PHOTOS: (TOP) COURTESY OF THE UNIVERSITY OF CHICAGO; (MIDDLE) COURTESY OF THE UNIVERSITY OF CHICAGO; (BOTTOM) COURTESY OF THE UNIVERSITY OF CHICAGO