IT'S NOT JUST ABOUT SALIVATING DOGS!

Pavlov, I. P. (1927). *Conditioned reflexes*. London: Oxford University Press.

Have you ever walked into a dentist's office where the odor of the disinfectant made your teeth hurt? If you have, it was probably because the odor triggered an association that had been conditioned in your brain between that smell and your past experiences at the dentist. When you hear "The Star Spangled Banner" played at the Olympic Games, does your heart beat a little faster? This happens to most Americans. Does the same thing happen when you hear the Italian national anthem? Unless you were raised in Italy, most likely it does not, because you have been conditioned to respond to one anthem, but not to the other. And why do some people squint and become nervous if you inflate a balloon near them? It is because they have been conditioned to associate the expanding balloon with something fearful (such as a loud pop). These are just a few of countless human behaviors that exist because of a process known as *classical conditioning*.

The classical conditioning theory of learning was developed and articulated nearly 100 years ago in Russia by one of the most familiar names in the history of psychology, Ivan Petrovich Pavlov (1849-1946). Unlike most of the research presented in this book, Pavlov's name and his basic ideas of learning by association are widely recognized in popular culture (there is even a Rolling Stones song that referred to "salivatin' like Pavlov's dogs"). However, how he came to make his landmark discoveries and the true significance of his work are not so widely understood.

While Pavlov's contribution to psychology was one of the most important ever made, he was not a psychologist at all, but rather a prominent Russian physiologist studying digestive processes. For his research on digestion he was awarded the Nobel Prize for science. But the discoveries that dramatically changed his career, and the history of psychology, began virtually by accident. It is important to note that in the late 1800s, psychology was a very young science and considered by many to be less than a true science. Therefore, Pavlov's decision to make such a radical turn from the more solid and respected science of physiology to psychology was a risky career move. He wrote about the dilemma facing a physiologist whose work might involve studying the brain:

> It is logical that in its analysis of the various activities of living matter, physiology should base itself on the more advanced and more exact sciences, physics and chemistry. But if we attempt an approach from this science of psychology ... we shall be building our superstructure on a science that has no claim to exactness . . . . In fact, it is still open to discussion whether psychology is a natural science, or whether it can be regarded as a science at all. (p. 3)

Looking back on Pavlov's discoveries, it was fortunate for the advancement of psychological science and for our understanding of human behavior that he took the risk and made the career change.

Pavlov's physiological research involved the use of dogs as subjects for studying the role of salivation on digestion. He or his assistants would introduce various food or nonfood substances into a dog's mouth and observe the rate and amount of salivation. In order to measure salivation scientifically, minor surgery was performed on the dogs so that a salivary duct was redirected through an incision in the dog's cheek and connected to a tube that would collect the saliva. Throughout this research, Pavlov made many new and interesting discoveries. For example, he found that when a dog received moist food, only a small amount of saliva would be produced, compared with a heavy flow when dry food was presented. The production of saliva under these varying conditions was regarded by Pavlov as a reflex, that is, a response that occurs automatically to a specific stimulus without the need for any learning. If you think about it, salivation is purely reflexive for humans, too. Suppose I ask you, as you read this sentence, to salivate as heavily as you can. You cannot do it. But if you are hungry and find yourself sitting in front of your favorite food, you will salivate whether you want to or not!

So, Pavlov experimented with various stimuli to determine just how "intelligent" these salivary glands were. As the research continued, he began to notice certain events that were totally unexpected. The dogs began to salivate before any food reached their mouths and even before the odor of food was present. After a while, the dogs were salivating at times when no digestive stimulus was present at all. Somehow, the reflexive action of the salivary glands had been altered through the animals' experience in the lab: "Even the vessel from which the food has been given is sufficient to evoke an alimentary reflex [of salivation] complete in all its details; and, further, the secretion may be provoked even by the sight of the person who has brought the vessel, or by the sound of his footsteps" (p. 13).

This was the crossroads for Pavlov. He had observed digestive responses occurring to stimuli seemingly unrelated to digestion, and pure physiology could not provide an explanation for this. The answer had to be found in *psychology*.

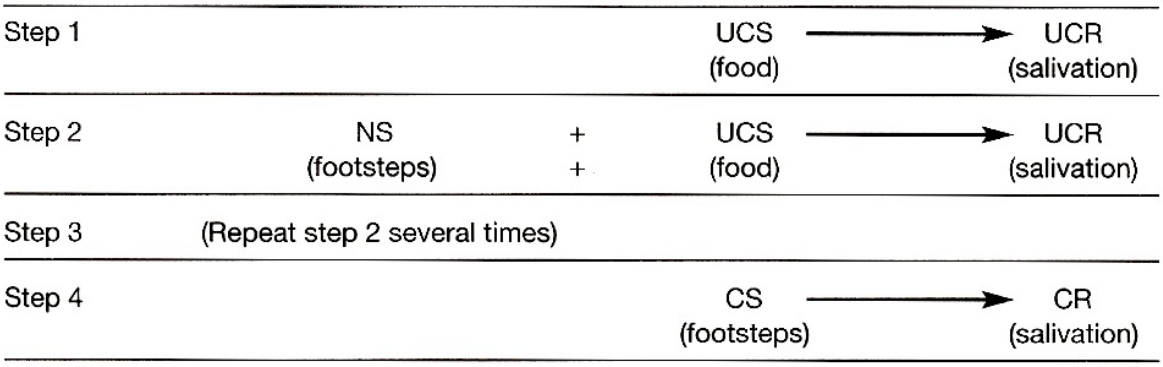
THEORETICAL PROPOSITIONS

Pavlov theorized that the dogs had learned from experience in the lab to expect food following the appearance of certain signals. While these *signal stimuli* do not naturally produce salivation, the dogs came to associate them with food, and thus responded to them with salivation. Consequently, Pavlov determined that there must be two kinds of reflexes.

Unconditioned reflexes are inborn and automatic, require no learning, and are generally the same for all members of a species. Salivating when food enters the mouth, jumping at the sound of a loud noise, and the dilation of your pupils in low light are examples of unconditioned reflexes. *Conditioned reflexes*, on the other hand, are acquired through experience or learning and may vary a great deal among individual members of a species. A dog salivating at the sound of footsteps, or you feeling pain in your teeth when you smell dental disinfectant, are conditioned reflexes.

Unconditioned reflexes are formed by an *unconditioned stimulus* (UCS) producing an *unconditioned response* (UCR). In Pavlov's studies, the UCS was food and the UCR was salivation. *Conditioned reflexes* consist of a *conditioned stimulus* (CS), such as the footsteps, producing a *conditioned response* (CR), salivation. You will notice that the response in both of these examples is salivation, but when the salivation results from hearing footsteps, it is conditioning that produced it.

The question Pavlov wanted to answer was this: Since conditioned reflexes are not inborn, exactly how are they acquired? He proposed that if a particular stimulus in the dog's environment was often present when the dog was fed, this stimulus would become associated in the dog's brain with food; it would signal the approaching food. Prior to being paired with the food, the environmental stimulus did not produce any important response. In other words, to the dogs, it was a *neutral stimulus* (NS). When the dogs first arrived at the lab, the assistant's footsteps might have produced a response of curiosity (Pavlov called it the "What is it?" response), but hearing the footsteps certainly would not have caused the dogs to salivate. The footsteps, then, were a neutral stimulus. However, over time, as the dogs heard the same footsteps just prior to being fed every day, they would begin to associate the sound with food. Eventually, according to the theory, the footsteps alone would cause the dogs to salivate. So, Pavlov proposed that the process by which a neutral stimulus becomes a conditioned stimulus could be diagrammed as follows:



Now that he had a theory to explain his observations, Pavlov began a series of experiments to prove that it was correct. It is commonly believed that Pavlov conditioned dogs to salivate at the sound of a bell. But as you will see, his early experiments involved a metronome.

METHOD AND RESULTS

Pavlov was able to build a special laboratory at the Institute of Experimental Medicine in Petrograd (which became Leningrad and has now returned to its original name of St. Petersburg) with funds donated by "a keen and public-spirited Moscow businessman." This soundprooflab allowed for complete isolation of the subjects from the experimenters and from all extraneous stimuli during the experimental procedures. Therefore, a specific

stimulus could be administered and responses could be recorded without any direct contact between the experimenters and the animals.

After Pavlov had established this controlled research environment, the procedure was quite simple. Pavlov chose food as the unconditioned stimulus. As explained previously, food will elicit the unconditioned response of salivation. Then Pavlov needed to find a neutral stimulus that was, for the dogs, completely unrelated to food. For this he used the sound of the metronome. Over several conditioning trials, the dog was exposed to the ticking of the metronome and then was immediately presented with food. "A stimulus which was neutral of itself had been superimposed upon the action of the inborn alimentary reflex. We observed that, after several repetitions of the combined stimulation, the sounds of the metronome had acquired the property of stimulating salivary secretion" (p. 26). In other words, the metronome had become a conditioned stimulus for the conditioned response of salivation.

Pavlov and his associates elaborated on this preliminary finding by using different unconditioned and neutral stimuli. For example, they presented the odor of vanilla (NS) to the subjects prior to placing a lemon juice-like solution in the dog's mouth (the UCS). The juice caused heavy salivation (UCR). After 20 repetitions of the pairing, the vanilla alone produced salivation. For a visual test, the dogs were exposed to an object that began to rotate just prior to the presentation of food. After only five pairings, the rotating object by itself (CS) caused the dogs to salivate (CR).

The importance and application of Pavlov's work extends far beyond salivating dogs. His theories of classical conditioning explained a major portion of human behavior and helped to launch psychology as a true science.

SIGNIFICANCE OF THE FINDINGS

The theory of classical conditioning (also called Pavlovian conditioning) is universally accepted and has remained virtually unchanged since its conception through Pavlov's work. It is used to explain and interpret a wide range of human behavior, including where phobias come from, why you dislike certain foods, the source of your emotions, how advertising works, why you feel anxiety before a job interview or an exam, and what arouses you sexually. Several later studies dealing with some of these applications are discussed here.

Classical conditioning focuses on reflexive behavior: those behaviors that are not under your voluntary control. Any reflex can be conditioned to occur to a previously neutral stimulus. You can be classically conditioned so that your left eye blinks when you hear a doorbell, your heart rate increases at the sight of a flashing blue light, or you experience sexual arousal when you eat strawberries. The doorbell, blue light, and strawberries were all neutral in relation to the conditioned responses until they somehow became associated with unconditioned stimuli for eye blinking (i.e., a puff of air into the eye), heart rate increase (i.e., a sudden loud noise), and sexual arousal (i.e., romantic caresses).

To experience firsthand the process of classical conditioning, here is an experiment you can perform on yourself. All you will need is a bell, a mirror, and a room that becomes completely dark when the light is switched off, to serve as your temporary laboratory. The pupils of your eyes dilate and constrict reflexively according to changes in light intensity. You have no voluntary control over this, and you did not have to learn how to do it. If I say to you, "Please dilate your pupils now," you would be unable to do so. However, when you walk into a dark theater, they dilate immediately. Therefore, a decrease in light would be considered an unconditioned stimulus for pupil dilation, the unconditioned response. In your *lab*, ring the bell and immediately after, turn off the light. Wait in the total darkness about 15 seconds and turn the light back on. Wait another 15 seconds and repeat the procedure: bell ... light off ... wait 15 seconds ... light on .... Repeat this pairing of the neutral stimulus (the bell) with the unconditioned stimulus (the darkness) 10 to 20 times, making sure that the bell *only* rings just prior to the sudden darkness. Now, with the lights on, watch your eyes closely in the mirror, and ring the bell. You will see your pupils dilate slightly even though there is no change in light! The bell has become the conditioned stimulus and pupil dilation the conditioned response.

RELATED RESEARCH AND RECENT APPLICATIONS

Two other studies presented in this book, rest directly on Pavlov's theory of classical conditioning. In the next article, John B. Watson conditioned 11- month-old little Albert to fear a white rat (and other furry things) by employing the same principles Pavlov used to condition salivation in dogs. By doing so, Watson demonstrated how emotions, such as fear, are formed. Later, Joseph Wolpe developed a therapeutic technique for treating intense fears (phobias) by applying the concepts of classical conditioning. His work was based on the idea that

the association between the conditioned stimulus and the unconditioned stimulus must be broken in order to reduce the fearful response.

This line of research on classical conditioning and phobias continues to the present. For example, studies have found that children whose parents have phobias may develop the same phobias to objects such as snakes and spiders through "vicarious" conditioning from mom and dad without any direct exposure to the feared object (Fredrikson, Annas, & Wik, 1997). Moreover, Pavlov's discoveries continue to be used to treat phobias in adults and children alike (e.g., King et al., 2000).

The countless applications of Pavlov's theory in the psychological and medical literature are far too numerous to summarize in any detail here. Instead, a few additional examples of the more notable findings are discussed.

A common problem that plagues ranchers around the world is that of predatory animals, usually wolves and coyotes, killing and eating their livestock. In the early 1970s, studies were conducted that attempted to apply Pavlovian conditioning techniques to solve the problem of the killing of sheep by coyotes and wolves without the need for killing the predators (see Gustafson et al., 1974). Wolves and coyotes were given pieces of mutton containing small amounts of lithium chloride (UCS), a chemical that if ingested makes an animal sick. When the animals ate the meat, they became dizzy, with severe nausea and vomiting (UCR). After recovering, these same hungry predators were placed in a pen with live sheep. The wolves and coyotes began to attack the sheep (CS), but as soon as they smelled their prey, they stopped and stayed as far away from the sheep as possible. When the gate to the pen was opened, the wolves and coyotes actually ran away from the sheep! Based on this and other related research, ranchers commonly use this method of classical conditioning to keep wolves and coyotes away from their herds.

A potentially vital area of research involving classical conditioning is in the field of behavioral medicine. Studies have indicated that the activity of the immune system can be altered using Pavlovian principles. Ader and Cohen (1985) gave mice water flavored with saccharine (mice love this water). They then paired the saccharine water with an injection of a drug that weakened the immune system of the mice. Later, when these conditioned mice were given the saccharine water but no injection, they showed signs of immunosuppression, a weakening of the immune response. Research is underway to study if the reverse is also possible, if immune *enhancing* responses may be classically conditioned. Overall, research is demonstrating that classical conditioning may indeed hold great promise for increasing the effectiveness of immune system responses in humans (Miller & Cohen, 2001). Just imagine: one day soon, you may be able to strengthen your resistance to illness by exposing yourself to a *nonmedical* conditioned stimulus. For example, imagine you feel the beginnings of a cold or the flu, so you slide your special classically conditioned "immune response enhancement music disk" into your CD player. As the music fills the room, your resistance rises as a conditioned response to this stimulus and stops the disease in its tracks.

As a demonstration of the continuing impact of Pavlov's discoveries on today's psychological research, consider the following. Since the previous edition of this book (2000-2003), more than 300 scientific articles cited Pavlov's work that forms the basis for this discussion. One especially fascinating recent study demonstrated how your psychological state at the time of conditioning and extinction may playa part in the treatment of classically conditioned irrational fears, called phobias (Mystkowski et al., 2003). Researchers used desensitization techniques to treat participants who were terrified of spiders. Some received the treatment after ingesting caffeine while others ingested a placebo. A week later, all subjects were retested-some receiving caffeine and others a placebo. Those who were given the placebo during treatment, but received real caffeine at the follow-up, *and* those who had received real caffeine during treatment, but received a placebo at the follow-up, experienced a relapse of the fear response. However, subjects who were in the same drug condition, either caffeine or placebo, at treatment *and* follow-up, displayed a much lower return of their fear. This finding implies that if a classically conditioned behavior is placed on extinction, it may return if the conditioned stimulus is encountered in a different context from where the extinction took place.

CONCLUSION

These examples demonstrate how extensive Pavlov's influence has been on many scientific and research disciplines. For psychology in particular, few scientists have had as much impact in any single discipline. Classical conditioning is one of the fundamental theories on which modern psychology rests. Without Pavlov's contributions, behavioral scientists still might have uncovered most of these principles over the decades. It is unlikely, however, that such a cohesive, elegant, and well-articulated theory of the conditioned reflex would ever

have existed if Pavlov had not made the decision to risk his career and venture into the untested, uncharted, and highly questionable science of nineteenth-century psychology.

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