Psychology and Life
Richard J. Gerrig
Twentieth Edition

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ALWAYS LEARNING

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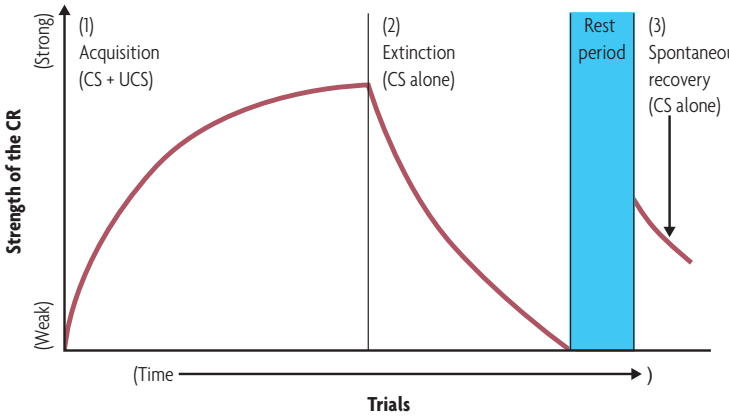

FIGURE 3 Acquisition, Extinction, and Spontaneous Recovery in Classical Conditioning

During acquisition (CS + UCS), the strength of the CR increases rapidly. During extinction, when the UCS no longer follows the CS, the strength of the CR drops to zero. The CR may reappear after a brief rest period, even when the UCS is still not presented. The reappearance of the CR is called spontaneous recovery.

classical conditioning are *reflex* responses such as salivation, pupil contraction, knee jerks, or eye blinking. A **reflex** is a response that is naturally triggered—*elicited*—by specific stimuli that are biologically relevant for the organism. Any stimulus, such as the food powder used in Pavlov's experiments, that naturally elicits a reflexive behavior is called an **unconditioned stimulus (UCS)** because learning is not a necessary condition for the stimulus to control the behavior. The behavior elicited by the unconditioned stimulus is called the **unconditioned response (UCR).**

In Pavlov's experiments, the stimuli such as lights and tones did not originally trigger the reflex response of salivation. However, over time each neutral stimulus was repeatedly paired with the unconditioned stimulus. This neutral stimulus is called the **conditioned stimulus (CS):** Its power to elicit behavior is *conditioned* on its association with the UCS. After several trials, the CS will produce a response called the **conditioned response (CR).** The conditioned response is whatever response the conditioned stimulus elicits as a product of learning—you will see several examples as this section unfolds. Let's review. Nature provides the UCS–UCR connections, but the learning produced by classical conditioning creates the CS–CR connection. The conditioned stimulus acquires some of the power to influence behavior that was originally limited to the unconditioned stimulus. Let's now look in more detail at the basic processes of classical conditioning.

Watch the Video *Classic Footage of Pavlov* on MyPsychLab

reflex An unlearned response elicited by specific stimuli that have biological relevance for an organism.

unconditioned stimulus (UCS) In classical conditioning, the stimulus that elicits an unconditioned response.

unconditioned response (UCR) In classical conditioning, the response elicited by an unconditioned stimulus without prior training or learning.

conditioned stimulus (CS) In classical conditioning, a previously neutral stimulus that comes to elicit a conditioned response.

conditioned response (CR) In classical conditioning, a response elicited by some previously neutral stimulus that occurs as a result of pairing the neutral stimulus with an unconditioned stimulus.

acquisition The stage in a classical conditioning experiment during which the conditioned response is first elicited by the conditioned stimulus.

Processes of Conditioning

Pavlov's original experiments inspired extensive study of how classically conditioned responses appear and disappear. In this section, we consider several important conclusions researchers have reached about the basic processes of classical conditioning. These conclusions have emerged from hundreds of different studies across a wide range of animal species.

Acquisition and Extinction **Figure 3** displays a hypothetical classical conditioning experiment. The first panel displays **acquisition,** the process by which the CR is first elicited and gradually increases in frequency over repeated trials. In general, the CS and UCS must be paired several times before the CS reliably elicits a CR. With systematic CS–UCS pairings, the CR is elicited with increasing frequency, and the organism may be said to have acquired a conditioned response.

In classical conditioning, as in telling a good joke, *timing* is critical. The CS and UCS must be presented closely enough in time to be perceived by the organism as being related. (We will describe an exception to this rule in a later section on *taste-aversion learning.*) Researchers have studied four temporal patterns between the two stimuli, as shown in **Figure 4** (Hearst, 1988). The most widely used type of conditioning is called *delay conditioning,* in which the CS comes on prior to and stays on at least until the UCS is presented. In *trace conditioning,* the CS is discontinued or turned off before the UCS is presented. *Trace* refers to the memory that the organism is assumed to have of the CS, which is no longer present when the UCS appears. In *simultaneous conditioning,* both the CS and UCS are presented at the same time. Finally, in the case of *backward conditioning,* the CS is presented after the UCS.

Conditioning is usually most effective in a delayed conditioning paradigm, with a short interval between the onsets of the CS and UCS. However, the exact time interval between the CS and the UCS that will produce optimal conditioning depends on several factors, including the intensity of the CS and the response being conditioned. Let's focus on the response being conditioned. For muscular responses, such as eye blinks, a short interval of a second or less is best. For visceral responses, such as heart rate and salivation, however, longer intervals of 5 to 15 seconds work best.

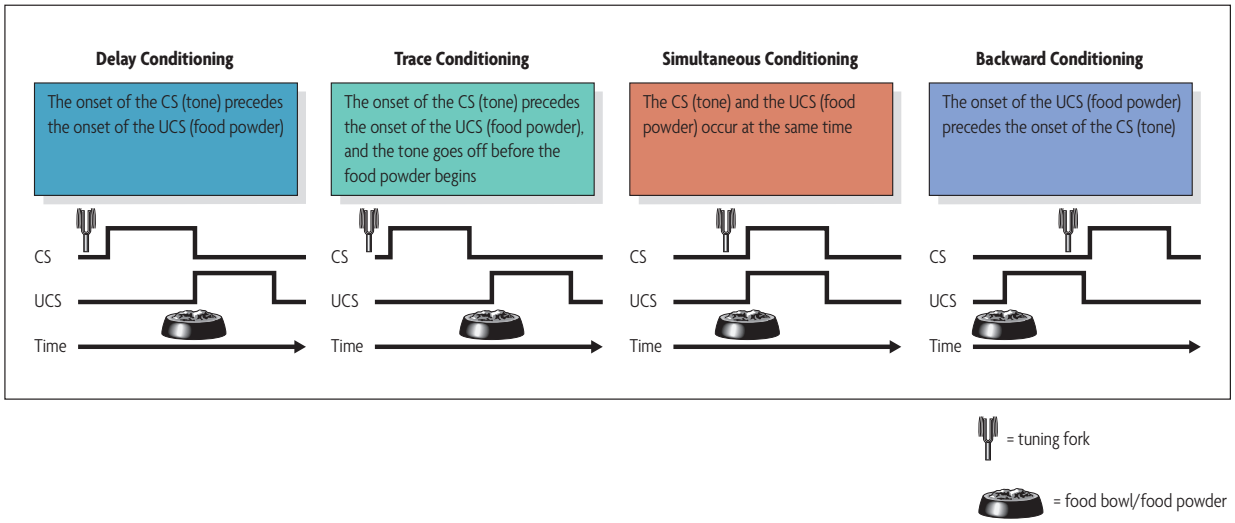

FIGURE 4 Four Variations of the CS–UCS Temporal Arrangement in Classical Conditioning

Researchers have explored the four possible timing arrangements between the CS and UCS. Conditioning is generally most effective in a delay conditioning paradigm with a short interval between the onsets of the CS and UCS.

Conditioning is generally poor with a simultaneous procedure and very poor with a backward procedure. Evidence of backward conditioning may appear after a few pairings of the UCS and CS but disappear with extended training as the animal learns that the CS is followed by a period free of the UCS. In both cases, conditioning is weak because the CS does not actually predict the onset of the UCS. (We will return to the importance of predictability, or *contingency,* in the next section.)

But what happens when the CS (for example, the tone) no longer predicts the UCS (the food powder)? Under those circumstances, the CR (salivation) becomes weaker over time and eventually stops occurring. When the CR no longer appears in the presence of the CS (and the absence of the UCS), the process of **extinction** is said to have occurred (see Figure 3, panel 2). Conditioned responses, then, are not necessarily a permanent aspect of the organism's behavioral repertory. However, the CR will reappear in a weak form when the CS is presented alone again after extinction (see Figure 3, panel 3). Pavlov referred to this sudden reappearance of the CR after a rest period, or time-out, without further exposure to the UCS as **spontaneous recovery** after extinction.

When the original pairing is renewed, postextinction, the CR becomes rapidly stronger. This more rapid relearning is an instance of *savings:* Less time is necessary to reacquire the response than to acquire it originally. Thus some of the original conditioning must be retained by the organism even after experimental extinction appears to have eliminated the CR. In other words, extinction has only weakened performance, not wiped out the original learning. This is why the original definition of learning emphasized the distinction between learning and performance.

Stimulus Generalization Suppose we have taught a dog that presentation of a tone of a certain frequency predicts food powder. Is the dog's response specific to only that stimulus? If you think about this question for a moment, you will probably not be surprised that the answer is no. In general, once a CR has been conditioned to a particular CS, similar stimuli may also elicit the response. For example, if conditioning was to a high-frequency tone, a slightly lower tone could also elicit the response. A child bitten by a big dog is likely to respond with fear even to smaller dogs. This automatic extension of responding to stimuli that have never been paired with the original UCS is called **stimulus generalization.** The more similar the new stimulus is to the original CS, the stronger the response will be. When response strength is measured for each of a series of increasingly dissimilar stimuli along a given dimension, as shown in **Figure 5**, a *generalization gradient* is found.

The existence of generalization gradients should suggest to you the way classical conditioning serves its function in everyday experience. Because important stimuli rarely occur in exactly the same form every time in nature, stimulus generalization builds in a similarity safety factor by extending the range of learning beyond the original specific experience. With this feature, new but comparable events can be

extinction In conditioning, the weakening of a conditioned association in the absence of a reinforcer or unconditioned stimulus.

spontaneous recovery The reappearance of an extinguished conditioned response after a rest period.

stimulus generalization The automatic extension of conditioned responding to similar stimuli that have never been paired with the unconditioned stimulus.

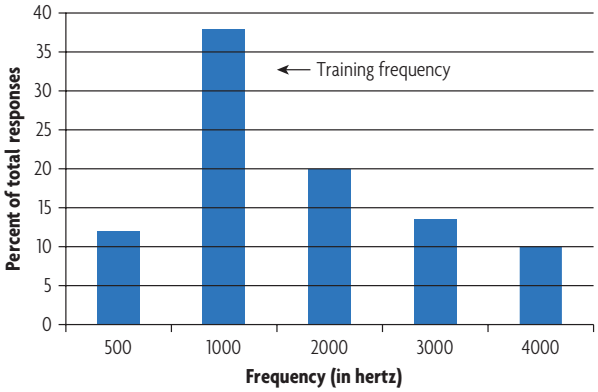

FIGURE 5 Stimulus Generalization Gradients

Rabbits were trained so that they produced a conditioned response (they closed their outer eyelid) when they heard a 1000 hertz tone (Siegel et al., 1968). During an extinction phase, the rabbits were tested on the training tone as well as tones that varied in distance from that tone. Tones more similar to the training tone produced more conditioned responses than those further away.

Data from Siegel, S., Hearst, E., George, N., & O'Neal, E. (1968). Generalization gradients obtained from individual subjects following classical conditioning. *Journal of Experimental Psychology, 78,* 171–174.

recognized as having the same meaning, or behavioral significance, despite apparent differences. For example, even when a predator makes a slightly different sound or is seen from a different angle, its prey can still recognize and respond to it quickly.

Stimulus Discrimination In some circumstances, however, it is important that a response be made to only a very small range of stimuli. An organism should not, for example, exhaust itself by fleeing too often from animals that are only superficially similar to its natural predators. **Stimulus discrimination** is the process by which an organism learns to respond differently to stimuli that are distinct from the CS on some dimension (for example, differences in hue or in pitch). An organism's discrimination among similar stimuli (tones of 1,000, 1,200, and 1,500 Hz, for example) is sharpened with discrimination training in which only one of them (1,200 Hz, for example) predicts the UCS and in which the others are repeatedly presented without it. Early in conditioning, stimuli similar to the CS will elicit a similar response, although not quite as strong. As discrimination training proceeds, the responses to the other, dissimilar stimuli weaken: The organism gradually learns which event-signal predicts the onset of the UCS and which signals do not.

stimulus discrimination A conditioning process in which an organism learns to respond differently to stimuli that differ from the conditioned stimulus on some dimension.

For an organism to perform optimally in an environment, the processes of generalization and discrimination must strike a balance. You don't want to be overselective—it can be quite costly to miss the presence of a predator. You also don't want to be overresponsive—if you are fearful of every shadow, you will waste time and energy to dispel your worry. Classical conditioning provides a mechanism that allows creatures to react efficiently to the structure of their environments.

Focus on Acquisition

In this section, we will examine more closely the conditions that are necessary for classical conditioning to take place. So far, I have *described* the acquisition of classically conditioned responses, but I have not yet *explained* it. Pavlov believed that classical conditioning resulted from the mere pairing of the CS and the UCS. In his view, if a response is to be classically conditioned, the CS and the UCS must occur close together in time—that is, be *temporally contiguous.* But as you will see next, contemporary research has modified that view.

Pavlov's theory dominated classical conditioning until the mid-1960s, when **Robert Rescorla** (1966) conducted a very telling experiment using dogs as subjects. Rescorla designed an experiment using a tone (the CS) and a shock (the UCS). For one group of animals the CS and UCS were merely contiguous—which, if Pavlov were correct, would be sufficient to produce classical conditioning. For the other group of animals, the tone reliably predicted the presence of the shock.

Featured Study

In the first phase of the experiment, Rescorla trained dogs to jump a barrier from one side of a shuttlebox to the other to avoid an electric shock delivered through the grid floor (see **Figure 6***). If the dogs did not jump, they received a shock; if they did jump, the shock was postponed. Rescorla used the frequency with which dogs jumped the barrier as a measure of fear conditioning.*

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Why might a child who has been frightened by one dog develop a fear response to all dogs?

When the dogs were jumping across the barrier regularly, Rescorla divided his subjects into two groups and subjected them to another training procedure. To the random group, the UCS (the shock) was delivered randomly and independently of the CS (the tone) (see **Figure 7***). Although the CS and the UCS often occurred close together in time—they were, by chance, temporally contiguous—the UCS was as likely to be delivered in the absence of the CS as it was in its presence. Thus the CS had no predictive value. For the contingency group, however, the UCS always followed the CS. Thus, for this group, the sounding of the tone was a reliable predictor of the delivery of the shock.*

Once this training was complete, the dogs were put back into the shuttlebox, but this time with a twist. Now the tone used in the second training procedure occasionally sounded, signaling shock. What happened? **Figure 8**, *indicates that dogs exposed to the contingent (predictable) CS–UCS relation jumped more frequently in the presence of the tone than did dogs exposed only to the contiguous (associated) CS–UCS relation. Contingency was critical for the signal to serve the dogs as a successful cue for the shock.*

Thus, in addition to the CS being contiguous—occurring close in time—with the UCS, the CS must also *reliably predict* the occurrence of the UCS in order for classical conditioning to occur (Rescorla, 1988). This finding makes considerable sense. After all, in natural situations, where learning enables organisms to adapt to changes in their environment, stimuli come in clusters and not in neat, simple units, as they do in laboratory experiments.

There's one last requirement for a stimulus to serve as a basis for classical conditioning: It must be *informative* in the environment. Consider an experimental situation in which rats have learned that a tone predicts a shock. Now, a light is added into the situation so that both the light and tone precede the shock. However, when the light is subsequently presented alone, the rats do not appear to have learned that the light predicts the shock (Kamin, 1969). For these rats, the previous conditioning to the tone in the first phase of the experiment *blocked* any subsequent conditioning that could occur to the light. From the rat's point of view, the light may as well not have existed; it provided no additional information beyond that already given by the tone. The requirement of informativeness explains why conditioning occurs most rapidly when the CS stands out against the many other stimuli that may also be present in an environment. A stimulus is more readily noticed the more *intense* it is and the more it *contrasts* with other stimuli.

You can see that classical conditioning is more complex than even Pavlov originally realized. A neutral stimulus will become an effective CS only if it is both appropriately contingent and informative. But now let's shift your attention a bit. We want to identify real-life situations in which classical conditioning plays a role.

FIGURE 6 A Shuttlebox

Rescorla used the frequency with which dogs jumped over a barrier as a measure of fear conditioning.

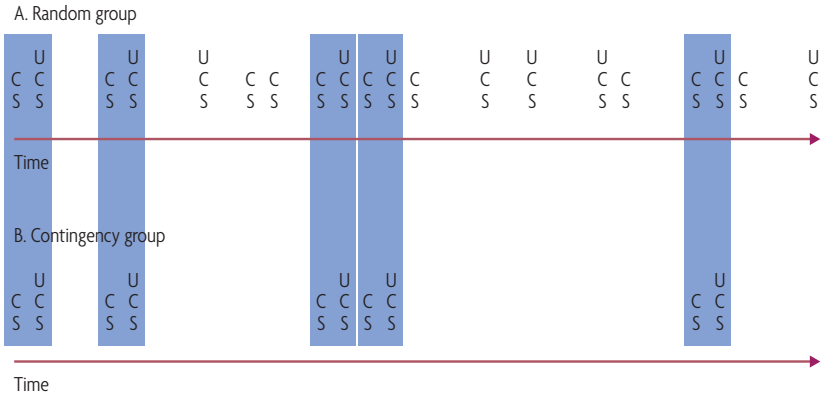

FIGURE 7 Rescorla's Procedure for Demonstrating the Importance of Contingency

For the random group, 5-second tones (the CS) and 5-second shocks (the UCS) were distributed randomly through the experimental period. For the contingency group, the dogs experienced only the subset of tones and shocks that occurred in a predictive relationship (the onset of the CS preceded the onset of the UCS by 30 seconds or less). Only the dogs in the contingency group learned to associate the CS with the UCS.

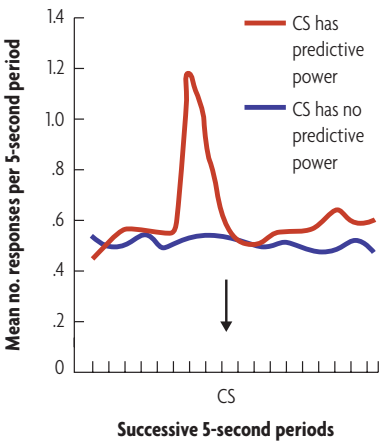

FIGURE 8 The Role of Contingency in Classical Conditioning

The arrow indicates the onset and offset of the 5-second CS tone. Rescorla demonstrated that dogs trained under the contingent CS–UCS relation showed more jumping (and thus conditioned fear) in the presence of the tone than did dogs trained under the contiguous but noncontingent CS–UCS relation.

Applications of Classical Conditioning

Your knowledge of classical conditioning can help you understand significant everyday behavior. In this section, we help you recognize some real-world instances of emotions and preferences as the products of this form of learning. We also explore the role classical conditioning plays in the unfolding of drug addiction.

Emotions and Preferences Earlier we asked you to think about your experience at a horror movie. In that case, you (unconsciously) learned an association between scary music (the CS) and certain likely events (the UCS—the kinds of things that happen in horror movies that cause reflexive revulsion). If you pay careful attention to events in your life, you will discover that there are many circumstances in which you can't quite explain why you are having such a strong emotional reaction or why you have such a strong preference about something. You might take a step back and ask yourself, "Is this the product of classical conditioning?"

Consider these situations (Rozin & Fallon, 1987; Rozin et al., 1986):

- Do you think you'd be willing to eat fudge that had been formed into the shape of dog feces?
- Do you think you'd be willing to drink a sugar-water solution if the sugar was drawn from a container that you knew was incorrectly labeled poison?
- Do you think you would be willing to drink apple juice into which a sterilized cockroach had been dipped?

If each of these situations makes you say "No way!" you are not alone. The classically conditioned response—feelings of disgust or danger—wins out over the knowledge that the stimulus is really OK. Because classically conditioned responses are not built up through conscious thought, they are also hard to eliminate through conscious reasoning!

One of the most extensively studied real-world products of classical conditioning is *fear conditioning* (Hartley et al., 2011; Linnman et al., 2011). In the earliest days of behaviorism, John Watson and his colleague Rosalie Rayner sought to prove that many fear responses could be understood as the pairing of a neutral stimulus with something naturally fear provoking. To test their idea, they experimented on an infant who came to be called Little Albert.

Watch the **Video** *Classic Footage of Little Albert* on **MyPsychLab**

Featured Study

Watson and Rayner (1920) trained Albert to fear a white rat he had initially liked, by pairing its appearance with an aversive UCS—a loud noise just behind him created by striking a large steel bar with a hammer. The unconditioned startle response and the emotional distress to the noxious noise formed the basis of Albert's learning to react with fear to the appearance of the white rat. His fear was developed in just seven conditioning trials. The emotional conditioning was then extended to behavioral conditioning when Albert learned to escape from the feared stimulus. The infant's learned fear then generalized to other furry objects, such as a rabbit, a dog, and even a Santa Claus mask!

Albert's mother, a wet nurse at the hospital where the study was conducted, took him away before the researchers could try to treat the experimentally conditioned fear. Researchers in psychology are guided by important ethical principles. Those principles make them look back at Watson and Rayner's experiment with grave discomfort: No ethical researcher would ever replicate an experiment of this type.

Because Watson and Rayner never made Albert's true identity public, people have always wondered what happened to him in later life. One team of researchers carried out some detective work with archival materials (Beck et al., 2009). Based

Courtesy of Prof. Ben Harris, University of New Hampshire

How did John Watson and Rosalie Rayner condition Little Albert to fear small, furry objects?

on that work, they have argued that Albert was an infant whose actual name was Douglas Meritte who, quite unfortunately, died in 1925. However, other researchers remain unconvinced by that identification (Powell, 2011).

Fear conditioning has a powerful impact on people's lives. A single traumatic event can condition you to respond with strong physical, emotional, and cognitive reactions—perhaps for a lifetime. Therapists have designed treatments for these types of fears that are intended to counter the effects of classical conditioning.

We don't want to leave you with the impression that only negative responses are classically conditioned. In fact, we suspect that you will also be able to interpret responses of happiness or excitement as instances of classical conditioning. Certainly toilers in the advertising industry hope that classical conditioning works as a positive force. They strive, for example, to create associations in your mind between their products (for example, jeans, sports cars, and soft drinks) and passion. They expect that elements of their advertisements—"sexy" individuals or situations—will serve as the UCS to bring about the UCR—feelings of sexual arousal. The hope then is that the product itself will be the CS, so that the feelings of arousal will become associated with it. To find more examples of the classical conditioning of positive emotions, you should monitor your life for circumstances in which you have a rush of good feelings when you return, for instance, to a familiar location.

Learning to be a Drug Addict Consider this scenario. A man's body lies in a Manhattan alley, a half-empty syringe dangling from his arm. Cause of death? The coroner called it an overdose, but the man had ordinarily shot up far greater doses than the one that had supposedly killed him. This sort of incident baffled investigators. How could an addict with high drug tolerance die of an overdose when he didn't even get a full hit?

Some time ago, Pavlov (1927) and later his colleague Bykov (1957) pointed out that tolerance to opiates can develop when an individual anticipates the pharmacological action of a drug. Contemporary researcher **Shepard Siegel** refined these ideas. Siegel suggested that the setting in which drug use occurs acts as a conditioned stimulus for a situation in which the body learns to protect itself by preventing the drug from having its usual effect. When people take drugs, the drug (UCS) brings about certain physiological responses to which the body responds with countermeasures intended to reestablish homeostasis. The body's countermeasures to the drug are the unconditioned response (UCR). Over time, this *compensatory response* also becomes the conditioned response. That is, in settings ordinarily associated with drug use (the CS), the body physiologically prepares itself (the CR) for the drug's expected effects. Tolerance arises because, in that setting, the individual must consume an amount of the drug that overcomes the compensatory response before starting to get

Image Courtesy of The Advertising Archives

Image Courtesy of The Advertising Archives

How do advertisers exploit classical conditioning to make you feel "passion" toward their products?