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# 3

## Habituation and Sensitization

Did you know that

- reflexive or elicited behavior is not automatic and invariant but can increase or decrease as a result of experience?
- elicited behavior is determined not only by the eliciting stimulus but also by other recently encountered events that alter an individual's general level of reactivity?
- habituation effects are evident in decreased responding, whereas sensitization effects are evident in increased responding?
- habituation is specific to the eliciting stimulus, whereas sensitization reflects a general state of arousal?
- habituation is an inherent property of all elicited behavior and occurs in the S–R (stimulus–response) system?
- sensitization reflects a modulatory influence on the mechanisms of elicited behavior and occurs in the state system?

Having considered the structure of unconditioned behavior in Chapter 2, we are now ready to examine some of the ways in which behavior can be changed or modified by experience. We begin with the phenomena of habituation and sensitization because these are two of the simplest and most common mechanisms that produce behavior change. A **habituation effect** is observed

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as a decrease in the vigor of elicited behavior, whereas a **sensitization effect** as an increase in responsivity. Habituation and sensitization are important to consider early in an account of learning because these processes may occur in any of the more complex learning procedures that we consider in subsequent chapters.

Habituation and sensitization have been investigated most extensively in reflex systems. As noted in Chapter 2, a reflex is a fairly simple response that occurs in reaction to a specific eliciting stimulus. Suckling, for example, is readily elicited in a newborn infant by placing a nipple-shaped object in the infant's mouth. As we noted in Chapter 2, the concept of the reflex was originally formulated by Descartes, who assumed that reflexes have two major features. First, Descartes believed that the vigor of an elicited response is directly related to the intensity of the eliciting stimulus. In fact, he thought that the energy required for the reflex response was provided by the eliciting stimulus. Second, he believed a reflex response will always occur when its eliciting stimulus is presented. For Descartes, reflexes were invariant and inevitable reactions to eliciting stimuli.

Descartes was correct in pointing out that certain actions are triggered by eliciting stimuli. But he was wrong in characterizing reflexes as invariant and energized only by their eliciting stimuli. Nevertheless, his views continue to dominate how nonprofessionals think about reflexes. In fact, the term *reflexive* is sometimes used as a synonym for *automatic*. However, scientists have shown that this view of reflexes is incorrect. As we will see in this chapter, elicited and reflexive behavior can be remarkably flexible. Responses to an eliciting stimulus may increase (showing sensitization) or decrease (showing habituation) depending on the circumstances.

Why should reflexive behavior be modifiable? Why do we need habituation and sensitization? Basically, these processes help us avoid responding to stimuli that are irrelevant and allow us to focus on things that are important. Habituation and sensitization increase the efficiency of our interactions with the environment. Animals (human and nonhuman) live in complex environments that constantly provide many forms of stimulation. Even during an activity as seemingly uneventful as sitting quietly in a chair, a person is bombarded by visual, auditory, olfactory, tactile, and internal physiological stimuli. All of these are capable of eliciting responses, but if they all did (as Descartes originally thought), we would be reacting to lots of things that are unimportant.

Consider, for example, the **orienting response**, a reaction to a novel visual or auditory stimulus that usually involves turning toward the source of stimulus (someone entering the room, for example). However, if all the stimuli in our environment were to elicit an orienting response, we would be wasting much of our effort looking here, there, and everywhere. Many stimuli do not warrant our attention. While talking to someone in the living room, we need not orient to the sounds of a refrigerator humming in the background or a car going by in the street. Habituation and sensitization serve to modulate our responsivity. They make sure that we respond vigorously to stimuli that might be important while ignoring others.

In Chapter 2, we noted that the vigor of elicited behavior is determined by motivational factors and that the sequence of elicited responses is determined by the inherent structure of the behavior system that is activated. We also noted that the organization of a response system can be changed by learning and experience. Habituation and sensitization are the first behavioral processes we consider that serve to organize behavior based on experience.

## EFFECTS OF THE REPEATED PRESENTATION OF AN ELICITING STIMULUS

The relationships that we describe for habituation and sensitization are general characteristics that may be observed for just about any form of elicited behavior. These processes are also highly conserved evolutionarily, being evident in a wide range of species including relatively simple organisms such as roundworms, fruit flies, and zebra fish (Kepler et al., 2020). Scientists are also interested in habituation and sensitization because deficits in habituation are evident in a number of neuropsychiatric disorders, including schizophrenia, Parkinson's disease, fragile X syndrome, and autism spectrum disorder (McDiarmid et al., 2017).

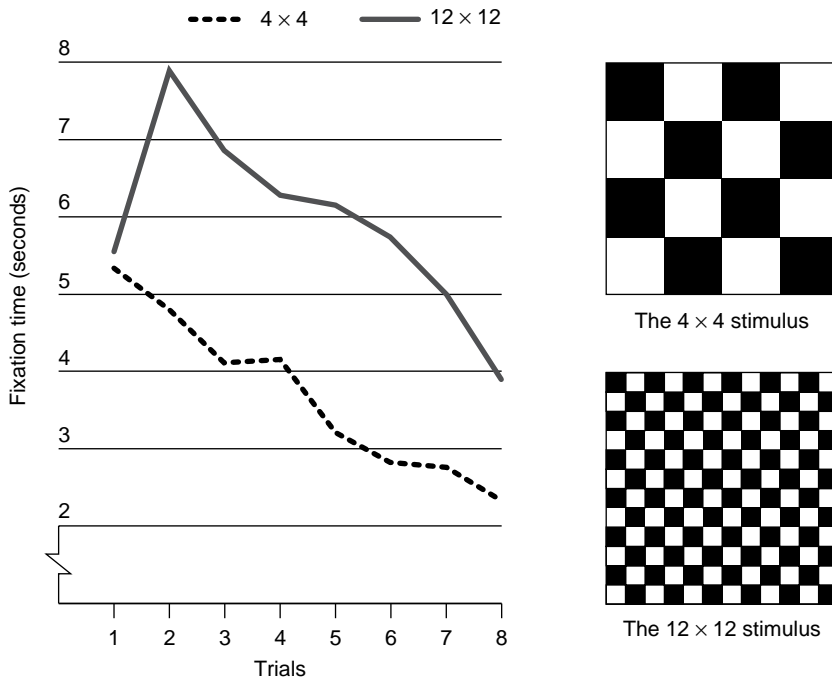
Habituation procedures are widely used in studies of infant visual attention (Colombo & Mitchell, 2009; Kavšek, 2013). The basic experimental method involves having an infant sit comfortably in front of a screen that is used to present various visual stimuli. When a stimulus appears on the screen, the infant looks or orients at the display. The infant's visual attention is measured by measuring how long its eyes remain fixated on the stimulus before the infant shifts their gaze elsewhere. How long the infant looks at the stimulus depends on what the stimulus is and how often it has been presented. (For a study of habituation of eye movements in adults, see Bonetti & Turatto, 2019.)

Figure 3.1 shows the results of a simple experiment that was conducted with two groups of 4-month-old babies (Bashinski et al., 1985). For each group, a 10-second visual stimulus was presented eight times, with a 10-second interval between trials. The complexity of the visual stimulus differed for the two groups. One group got a  $4 \times 4$  checkerboard pattern. The other group got a more complex  $12 \times 12$  checkerboard pattern. Notice that the duration of the visual fixation elicited by each stimulus was not invariant or "automatic." Rather, fixation time changed in different ways depending on the stimulus. With the complex  $12 \times 12$  pattern, fixation increased from Trial 1 to Trial 2, then declined thereafter. With the simpler  $4 \times 4$  pattern, visual fixation declined from each trial to the next.

Habituation was evident throughout the experiment with the  $4 \times 4$  checkerboard pattern. Habituation was also evident with the  $12 \times 12$  pattern from Trial 2 to Trial 8, but sensitization occurred from Trial 1 to Trial 2.

Another common experimental preparation for the study of habituation and sensitization involves the startle response. The **startle response** is a sudden movement or flinch caused by a novel stimulus. If someone popped a balloon

**FIGURE 3.1. Visual Fixation Time for Two Groups of Infants Presented With a Visual Stimulus on Eight Successive Trials**



*Note.* The stimulus was a 12 × 12 checkerboard pattern for one group and a 4 × 4 checkerboard pattern for the other group. From “Determinants of Infant Visual Fixation: Evidence for a Two-Process Theory,” by H. S. Bashinski, J. S. Werner, and J. W. Rudy, 1985, *Journal of Experimental Child Psychology*, 39(3), p. 588 ([https://doi.org/10.1016/0022-0965\(85\)90058-X](https://doi.org/10.1016/0022-0965(85)90058-X)). Copyright 1985 by Elsevier. Reprinted with permission.

behind you (making a brief loud noise), you would suddenly hunch your shoulders and pull in your neck. Startle is a common human reaction in a variety of cultures (Simons, 1996). The sudden movement that characterizes the startle reflex can easily be measured, which has encouraged numerous studies of habituation and sensitization of the startle reflex in a variety of species (e.g., Davis et al., 2008; Kirshenbaum et al., 2019).

A sudden but soft sound may cause you to startle the first few times it occurs, but you will quickly stop responding to the sound. Similar results are obtained with mild tactile stimuli. When you first put on a comfortable pair of shoes, you feel the gentle pressure of the shoes against your feet. However, even though the tactile pressure remains, your reaction quickly habituates; soon you will be entirely unaware that you are wearing the shoes.

If the tactile stimulus is more intense (because the shoe does not fit well), it will be more difficult to get used to it, and the pattern of responding may be similar to what we saw in Figure 3.1, with the visual attention of infants to a 12 × 12 checkerboard pattern. In such cases, responding increases at first and then declines. Similar results are obtained with the startle reflex if the eliciting stimulus is an intense tone.

If the eliciting stimulus is very intense, repetitions of the stimulus may result in a sustained increase in responding. If there is a pebble in your shoe creating intense pressure, your irritation will increase with continued exposure to that stimulus, and this will last as long as the pebble remains in your shoe. Similarly, a sustained increase in the startle response may occur if the eliciting stimulus is an intense noise. Soldiers and civilians in a war zone may never get used to the sound of nearby gunfire.

As these examples illustrate, elicited behavior can change in a variety of ways with repetitions of the eliciting stimulus. Sometimes the response shows a steady decline or habituation effect. In other cases, a sensitization effect occurs at first, followed by a decline in responding. Elicited behavior can also show evidence of sustained sensitization.

### **Characteristics of Habituation Effects**

Numerous factors have been found to influence the course of habituation and sensitization effects. Here we consider some of the major variables.

#### **Effects of Stimulus Change**

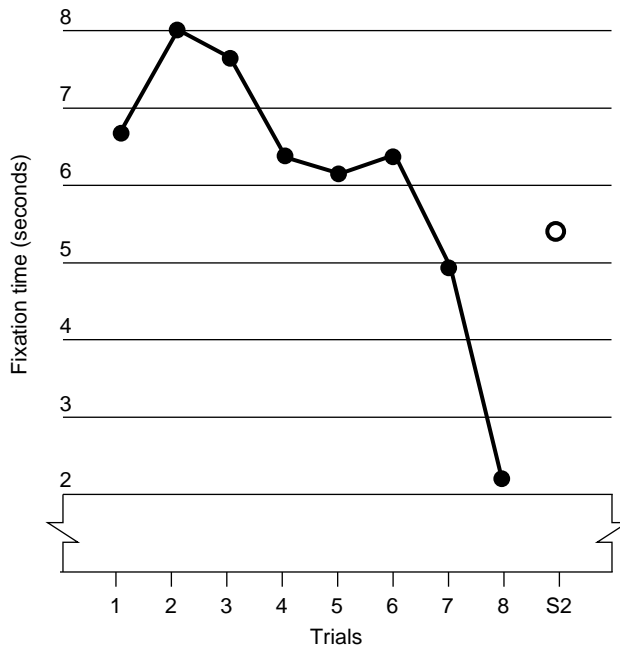
Perhaps the most important feature of habituation is that it is specific to the particular stimulus that has been presented repeatedly. If the habituated stimulus is changed, responding will recover, with the degree of recovery determined by how similar the new stimulus is to the habituated one. Stimulus specificity is a defining feature of habituation (Rankin et al., 2009). If a new stimulus is presented following habituation, the habituated response will recover.

The stimulus specificity of habituation is illustrated in Figure 3.2. Infants were first presented with a  $12 \times 12$  checkerboard pattern for eight trials. As in the earlier study, visual orientation at first increased and then showed a strong habituation effect. After Trial 8, the infants were tested with a  $4 \times 4$  checkerboard pattern. This new visual stimulus caused a significant recovery of the visual orienting response.

The stimulus specificity of habituation turns out to be a useful feature because it helps to rule out fatigue as a possible cause of habituation. Response fatigue is an obvious culprit when responding declines with repeated stimulations. However, if habituation were due to fatigue, participants would continue to show low levels of responding when the eliciting stimulus was changed. The recovery of responding that occurs with a change in the eliciting stimulus rules out response fatigue and is one of the pieces of evidence indicating that habituation reflects a change in the central nervous system rather than a change in peripheral motor mechanisms.

Tests with novel stimuli are routinely carried out in studies of habituation with infants (Colombo & Mitchell, 2009; Kavšek, 2013). Infants can stop looking at a visual stimulus for a variety of reasons. They may become tired or fussy or may fall asleep. To be sure that they are still paying attention and actively participating in the experiment, novel test stimuli are introduced. The results

**FIGURE 3.2. Stimulus Specificity of Habituation**



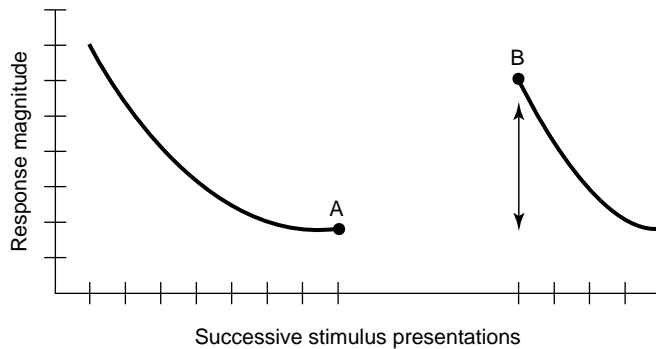
*Note.* A  $12 \times 12$  checkerboard pattern (S1) was presented to infants on each of the first eight trials, resulting in habituation of the visual fixation response. On the next trial, the stimulus was changed to a  $4 \times 4$  checkerboard pattern (S2). This change caused a substantial recovery of the visual fixation behavior. From “Determinants of Infant Visual Fixation: Evidence for a Two-Process Theory,” by H. S. Bashinski, J. S. Werner, and J. W. Rudy, 1985, *Journal of Experimental Child Psychology*, 39(3), p. 587 ([https://doi.org/10.1016/0022-0965\(85\)90058-X](https://doi.org/10.1016/0022-0965(85)90058-X)). Copyright 1985 by Elsevier. Reprinted with permission.

of the experiment are considered valid only if the novel stimulus produces recovery of the habituated response.

Investigators have taken advantage of the stimulus specificity of habituation to study a wide range of issues in infant perception and cognition. For example, investigators have studied whether infants perceive an angle as consisting of two independent lines or respond to the relation between those lines (Cohen & Younger, 1984). They have also examined whether infants are more likely to remember the category an object belongs to rather than the object’s perceptual features (Kibbler & Leslie, 2019). Other studies have used the habituation paradigm to study infant reasoning about occluded objects (Aguiar & Baillargeon, 2002) and various aspects of infant music perception (Hannon & Trehub, 2005; Plantinga & Trainor, 2009).

### Effects of Time Without Stimulation

Habituation effects are often temporary. They dissipate or are lost as time passes without presentation of the eliciting stimulus. A loss of the habituation effect is evident in a recovery of responding. This is illustrated in Figure 3.3.

**FIGURE 3.3. Spontaneous Recovery of a Habituated Response**

Note. A period of rest without stimulus presentations occurred between Points A and B, which caused a recovery of the habituated response. Data are hypothetical.

Because the response recovery is produced by a period without stimulation (a period of rest), the phenomenon is called **spontaneous recovery**.

Spontaneous recovery is a common feature of habituation (Rankin et al., 2009). If your roommate turns on the radio while you are studying, you may notice the radio at first but then you will come to ignore the sound if it is not too loud. However, if the radio is turned off for an hour or two and then comes back on, you will notice it again. The degree of spontaneous recovery is related to the duration of the period without the radio playing. Longer periods without presentation of the eliciting stimulus result in greater recovery of the response. Less and less spontaneous recovery occurs with repetitions of the spontaneous recovery procedure. How much of a rest period is required to observe spontaneous recovery of habituation varies across different situations. For example, habituation of the novelty response to taste shows little spontaneous recovery even after a week or two.

Animals, including people, are cautious about ingesting food or drink that has an unfamiliar flavor. This phenomenon is known as **flavor neophobia** (Reilly, 2018). Flavor neophobia probably evolved because things that taste new or unfamiliar may well be poisonous. With repeated exposure to a new taste, the neophobic response becomes attenuated. Coffee, for example, often elicits an aversion response in a child who tastes it for the first time. However, after drinking coffee without ill effect, the child's neophobic response will become diminished or habituated. Once that has occurred, the habituation is likely to be long-lasting. Having become accustomed to the flavor of coffee, a person is not likely to experience a neophobic response even if they go a couple of weeks without having it.

Habituation effects have been classified according to whether they exhibit spontaneous recovery. Cases in which substantial spontaneous recovery occurs are called **short-term habituation**, whereas cases in which significant spontaneous recovery does not occur are called **long-term habituation**. Short-term and long-term habituation are not mutually exclusive. Sometimes both effects are observed. Long-term habituation effects are genuine learning effects

because they satisfy the criterion of being long-lasting (Hall & Rodríguez, 2020). In contrast, short-term habituation effects provide less convincing evidence of learning because they are less enduring.

### **Effects of Stimulus Frequency and Intensity**

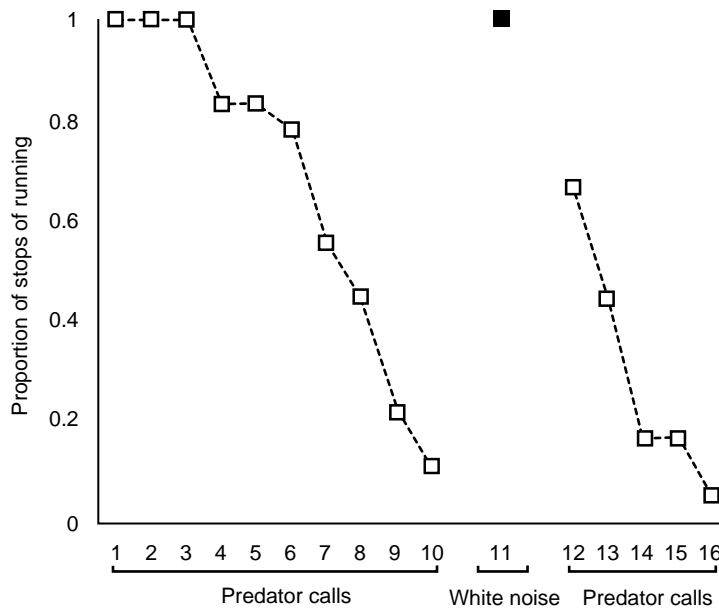
Stimulus frequency and intensity are two of the most obvious features of a habituation procedure. Unfortunately, the effects of these variables are a bit complicated depending on whether one measures short-term or long-term habituation. The frequency of a stimulus refers to how often the stimulus is repeated in a given period of time—how often the stimulus occurs per minute, for example. With higher stimulus frequencies, there is less rest time between stimulus repetitions. The duration of rest between stimulations influences responding because of the phenomenon of spontaneous recovery. Higher stimulus frequencies permit less spontaneous recovery between trials, with the result that responding declines more rapidly. This is evident in a larger short-term habituation effect (Bonetti & Turatto, 2019). However, tests for long-term habituation show the opposite result—namely, less habituation caused by more frequent stimulus presentations (Davis, 1970).

Varying the intensity of the eliciting stimulus also produces a pattern of results that is a bit complicated. In general, responding declines more slowly if the eliciting stimulus is more intense (Rankin et al., 2009). For example, laboratory rats are slower to lose their neophobic response to a strong flavor than to a weak flavor (Domjan & Gillan, 1976). However, repeated presentations of a high-intensity stimulus can result in more substantial habituation than repeated presentations of a low-intensity stimulus if such habituation training is followed by a test with a wide range of stimulus intensities in both cases (Davis & Wagner, 1968).

### **Effects of Exposure to a Second Stimulus**

One of the remarkable features of a habituated response is that it is not determined only by the eliciting stimulus. The level of responding is also influenced by other stimuli the organism encounters at the time. In particular, exposure to a novel stimulus can result in recovery of responding when the previously habituated stimulus is reintroduced. This phenomenon is called **dishabituation** (Rankin et al., 2009).

The results of an experiment on dishabituation conducted with newly hatched chicks are summarized in Figure 3.4. The chicks were permitted to run in a running wheel. Periodically, the call of a predator (a red-tailed hawk) was presented, which caused the chicks to freeze and stop running. Repetitions of the predator call resulted in rapid habituation of the freezing response. On Trial 11, the auditory stimulus was changed to white noise. This resulted in a major recovery of the freezing response, illustrating the stimulus specificity of habituation. The sound of the red-tailed hawk was reintroduced on Trials 12 through 16. The major finding was that exposure to the white noise caused a significant recovery of the freezing response to the predator call. This illustrates the phenomenon of dishabituation (Dissegna et al., 2018).

**FIGURE 3.4. Demonstration of Dishabituation**

Note. Disruption of running in 1-day-old chicks habituated in response to predator calls presented on trials 1 to 10. White noise, presented on Trial 11, caused a dishabituation effect when predator calls resumed on Trial 12. From “Short-Term Memory in Habituation and Dishabituation of Newborn Chicks’ Freezing Response,” by A. Dissegna, M. Turatto, and C. Chiandetti, 2018, *Journal of Experimental Psychology: Animal Learning and Cognition*, 44(4), p. 443 (<https://doi.org/10.1037/xan0000182>). Copyright by the American Psychological Association.

The phenomenon of dishabituation is useful in ruling out *sensory adaptation* as a cause of habituation. Sensory adaptation is a reduction in the functioning of a sensory receptor. If the decrease in responding to the predator call in Figure 3.4 had been due to sensory adaptation of the auditory system, presentation of the dishabituating white noise would not have produced recovery in freezing to the red-tailed hawk call. Dishabituation, along with the stimulus specificity of habituation, indicates that habituation reflects a central nervous system process rather than changes in peripheral sensory or motor mechanisms.

Unfortunately, the term *dishabituation* is used inconsistently in the research literature. In studies with human infants, the term dishabituation is used to refer to recovery of a habituated response that occurs when the habituated stimulus is changed and a novel stimulus is tested (e.g., Kavšek, 2013). In contrast, in research with other species and response systems, dishabituation is reserved for cases in which the introduction of a second stimulus produces recovery in responding to the original habituated stimulus. This latter usage was advocated by Thompson and Spencer (1966) in their seminal work that provided the foundations of contemporary research on habituation. The distinction between the stimulus specificity of habituation and dishabituation remains important in contemporary neuroscience (Rankin et al., 2009).

### Characteristics of Sensitization Effects

Sensitization effects are influenced by the same stimulus intensity and time factors that govern habituation phenomena. In general, greater sensitization effects (greater increases in responding) occur with more intense eliciting stimuli (Groves et al., 1969).

Like habituation, sensitization effects can be short-term or long-term (e.g., Davis, 1974). **Short-term sensitization** decays as a function of time without presentations of the stimulus. Unlike the decay of short-term habituation, which is called *spontaneous recovery*, the decay of short-term sensitization has no special name. It is not called spontaneous recovery, because responding declines (rather than increases) as sensitization dissipates. In contrast to short-term sensitization, **long-term sensitization** is evident even after appreciable periods without stimulation. As was the case with long-term habituation, long-term sensitization effects satisfy the durability criterion of learning, whereas short-term sensitization effects do not.

One important respect in which sensitization is different from habituation is that sensitization is not as specific to a particular stimulus. As we discussed earlier, habituation produced by repeated exposure to one stimulus will not be evident if the stimulus is altered substantially. In contrast, sensitization is not so stimulus-specific. For example, the startle response to a brief loud auditory stimulus can be sensitized by exposure to a fear-eliciting stimulus. Fear-potentiated startle has been well documented in studies with both laboratory animals (Davis et al., 2008) and human participants (Bradley et al., 2005). In a similar fashion, the experience of illness increases or sensitizes the flavor neophobia response, and once flavor neophobia has been sensitized, the participants show heightened finickiness to a variety of different taste stimuli (Domjan, 2018).

### THE DUAL-PROCESS THEORY OF HABITUATION AND SENSITIZATION

So far, we have described the behavioral phenomena of habituation and sensitization. We have not discussed what underlying processes or machinery might produce these behavioral effects. Here we consider a prominent theory of habituation and sensitization, the dual-process theory of Groves and Thompson (1970). Although the theory was proposed some time ago, it remains the major theoretical framework for thinking about habituation and sensitization (Thompson, 2009). The theory was based on neurophysiological studies, but it can also be described at the level of behavior analysis.

The dual-process theory postulates the existence of two underlying processes, a habituation process and a sensitization process. Unfortunately, the processes have the same names as the behavioral phenomena we described earlier. However, habituation and sensitization processes are distinct from habituation and sensitization phenomena or effects. Habituation and sensitization *phenomena* are performance effects; they are the observable changes in behavior

that we can easily observe and measure. In contrast, habituation and sensitization *processes* refer to the underlying neurobiological mechanisms that are responsible for the observed behavioral changes.

### The S–R System and the State System

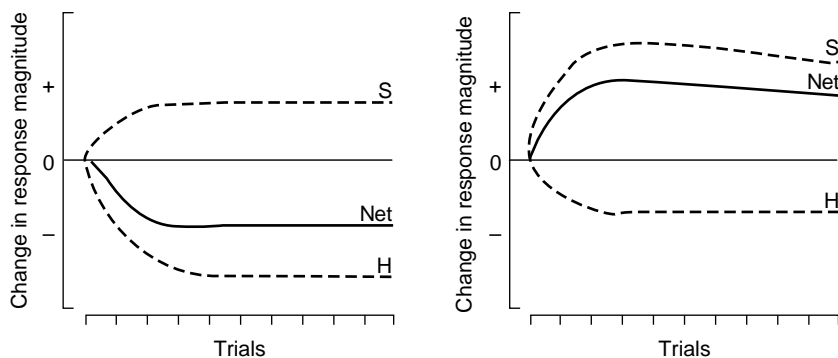
According to the dual-process theory, habituation and sensitization processes operate in different parts of the nervous system. One of these is called the S–R (stimulus–response) system; the other is called the state system. The **S–R system** is the shortest path in the nervous system between an eliciting stimulus and the resulting elicited response. The S–R system corresponds to Descartes’s reflex arc. It is the minimal physiological machinery involved in a reflex. Typically, the S–R system consists of three neurons: the **sensory** (or **afferent**) **neuron**, an **interneuron**, and an **efferent** (or **motor**) **neuron** (see Figure 2.1). The eliciting stimulus activates the afferent neuron. The afferent neuron in turn activates the interneuron, which then activates the efferent neuron. The efferent neuron forms a synapse with the muscles involved in making the elicited response and triggers the behavioral response.

The **state system** consists of all neural processes that are not an integral part of the S–R system but influence the responsivity of the S–R system. Spinal reflexes, for example, consist of an afferent neuron that synapses with an interneuron in the spinal cord, and an efferent neuron that extends from the spinal cord to the relevant muscle. This is the S–R system of a spinal reflex. However, the spinal cord also contains neural pathways that ascend to the brain and ones that descend from the brain. These ascending and descending fibers serve to modulate spinal reflexes and make up the state system for spinal reflexes.

After one understands the distinction between the S–R system and the state system, the rest of the dual-process theory is fairly simple. As we noted earlier, the dual-process theory presumes the existence of separate habituation and sensitization processes. A critical aspect of the theory concerns where these processes are located. The habituation process is assumed to take place in the S–R system, whereas the sensitization process is assumed to take place in the state system.

Habituation and sensitization processes are not directly evident in the behavior of the organism. Rather, observable behavior reflects the net or additive effect of these processes. Habituation and sensitization processes serve as opponent mechanisms that modulate reflex responsivity. Whenever the habituation process is stronger than the sensitization process, the net effect is a decline in behavioral output. This is illustrated in the left panel of Figure 3.5. The opposite occurs if the sensitization process is stronger than the habituation process. In that event, the net effect of the two processes is an increase in behavioral output. This is illustrated in the right panel of Figure 3.5.

After being activated, both the habituation process and the sensitization process are assumed to decay with time. This temporal decay assumption explains short-term habituation and short-term sensitization effects.

**FIGURE 3.5. Mechanisms of the Dual-Process Theory of Habituation and Sensitization**

*Note.* The dashed lines indicate the strength of the habituation (H) and sensitization (S) processes across trials. The solid lines indicate the net (or combined) effects of these two processes. In the left panel, the habituation process becomes stronger than the sensitization process, which leads to a progressive decrement in responding. In the right panel, the sensitization process becomes stronger than the habituation process, which leads to a progressive increment in responding.

### Implications of the Dual-Process Theory

Like Descartes's reflex arc, the S–R system is the minimal or most primitive mechanism of elicited behavior. Therefore, the S–R system is activated every time an eliciting stimulus is presented. Because the habituation process operates in the S–R system, each activation of the S–R system also results in some buildup of the habituation process. This makes habituation a universal feature of elicited behavior. Whenever an eliciting stimulus is presented, the habituation process is activated to some extent.

The universality of the habituation process does not mean that a decrement in responding will always be observed. Whether a habituation effect is evident will depend on whether the habituation process is counteracted by activation of the sensitization process. Another important factor is the interval between successive presentations of the eliciting stimulus. If this interval is long enough, habituation created by the first stimulus presentation will have a chance to decay before the stimulus is repeated, and a decrement in responding will not occur. On the other hand, if the interval between stimulus presentations is too short to permit decay of the habituation process, a decrement in responding will be evident.

In contrast to the habituation process, the sensitization process is not always involved when an eliciting stimulus is presented. Sensitization occurs in the state system. The state system modulates responsivity of the S–R system, but it is not essential for the occurrence of elicited behavior. Elicited behavior can occur through the S–R system alone. Therefore, sensitization is not a universal property of elicited behavior.

When is the sensitization process activated? An informal way to think about this is that sensitization represents arousal. Sensitization or arousal occurs if the

organism encounters a stimulus that is particularly intense or significant. You can become aroused by a loud, unexpected noise or by someone telling you that a close friend was seriously hurt in an accident. The state system and the sensitization process are activated by intense or significant stimuli.

The sensitization process can be activated by the same stimulus that elicits the reflex response of interest. This is the case if an intense or significant stimulus is used as the eliciting stimulus. The right panel of Figure 3.5 illustrates such a situation. In that example, the eliciting stimulus produced a substantial degree of sensitization, with the result that the net behavioral effect was an increase in responding.

The sensitization process can be also activated by some event other than the eliciting stimulus. If someone taps you on the shoulder while you are watching a scary movie, you are likely to show an exaggerated startle response. In this example, the scary movie activates the state system. The tap on the shoulder engages the S–R system and produces a startle response. Because the startle is triggered when you are already aroused by the scary movie, you react more forcefully to the tap on the shoulder. Because the state system is separate from the S–R system, the state system can be activated by stimuli that are not registered in the S–R system of the response that is being measured. This is a critical feature of the dual-process theory and another respect in which sensitization is different from habituation.

The dual-process theory has been remarkably successful in characterizing short-term habituation and short-term sensitization effects. However, the theory was not designed to explain long-term habituation and long-term sensitization. Explanations of long-term habituation and sensitization typically include mechanisms of associative learning (e.g., Wagner, 1976, 1981), a topic we turn to in Chapters 4 through 6.

## SUMMARY

Reflexive or elicited behavior is commonly considered to be an automatic and invariant consequence of the eliciting stimulus. Contrary to this notion, however, repeated presentations of an eliciting stimulus may result in a monotonic decline in responding (a habituation effect), an increase in responding (a sensitization effect) followed by a decline, or a sustained increase in responding. Thus, far from being invariant, elicited behavior is remarkably sensitive to different forms of prior experience. The magnitude of habituation and sensitization effects depends on the intensity and frequency of the eliciting stimulus. Responding elicited by one stimulus can also be altered by the prior presentation of a different event (as in the phenomenon of dishabituation).

Many of the findings concerning habituation and sensitization are consistent with the dual-process theory, which holds that the processes that produce decreased responding occur in the S–R system, whereas the processes that produce sensitization occur in the state system. The S–R system is activated every time an eliciting stimulus is presented, making habituation a universal property of elicited behavior. Sensitization, by contrast, occurs only when the

organism encounters a stimulus that is sufficiently intense or significant to activate the state system. Through their additive effects, the processes of habituation and sensitization serve to modulate the vigor of elicited behavior.

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## TECHNICAL TERMS

habituation effect, page 31  
 sensitization effect, page 32  
 orienting response, page 32  
 startle response, page 33  
 spontaneous recovery, page 37  
 flavor neophobia, page 37  
 short-term habituation, page 37  
 long-term habituation, page 37  
 dishabituation, page 38  
 short-term sensitization, page 40  
 long-term sensitization, page 40  
 S–R system, page 41  
 sensory neuron, page 41  
 afferent neuron, page 41  
 interneuron, page 41  
 efferent neuron, page 41  
 motor neuron, page 41  
 state system, page 41

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