The Modification of Instinctive Behavior

DO YOU HAVE A LIGHT?

For two days, Greg has resisted his urge to smoke. Having attempted to quit on more occasions than he can count, he's determined not to let his extreme nervousness and irritability keep him from succeeding this time. His family tries to distract his thoughts from cigarettes, but these attempts work only temporarily. Anticipating tonight's televised championship boxing match helped him for a while, but even this cannot prevent his recurrent, intense impulses to smoke. Greg began smoking cigarettes when he was 15. All his friends smoked, so it seemed like the natural thing to do. At first, he did not like to smoke; it made him cough and sometimes feel slightly nauseated. Greg smoked only with his friends to feel part of the group, and he pretended to inhale. However, as the unpleasant effects began to disappear, he learned to inhale and began to smoke more. By the age of 18, Greg smoked two to three packs of cigarettes each day. He never thought about stopping until he met Paula. A nonsmoker, she tried to convince him to quit. Finding himself unable to completely break his habit, he simply did not smoke while with Paula. After they married, Paula continued to plead with Greg to stop smoking. He has tried every now and then over the past 10 years to resist cigarettes, usually avoiding his habit for a day or two. This time has to be different. At age 35, Greg felt himself in perfect health, but a routine checkup with the family physician two days ago proved him wrong. Greg learned that his extremely high blood pressure makes him a prime candidate for a heart attack. The doctor told Greg that he must lower his blood pressure through special diet, medication, and not smoking. Continued smoking would undoubtedly interfere with the other treatments. The threat of a heart attack frightened Greg; he saw his father suffer the consequences of an attack several years ago. Determined now to quit, he only hopes he can endure his withdrawal symptoms.

Millions of people share Greg's intense desire to smoke, as well as his record of repeated attempts to stop. Their addiction, stemming from dependence on the effects of cigarettes, motivates their behavior. Evidence of this dependence includes the aversive withdrawal symptoms that many people experience when they attempt to stop smoking. When the symptoms are strong enough, the withdrawal state motivates them to resume smoking.

Cigarette smoking is just one example of addictive behavior. People become addicted to many drugs that exert quite different effects. For example, the painkilling effects of heroin contrast

sharply with the arousing effects of cocaine. Although the effects of drugs may differ, the cycle of drug effects, withdrawal symptoms, and the resumption of addictive behavior characterizes all addictive behaviors.

Addictive behavior is thought to reflect the combined influence of instinctive and experiential processes. In this chapter, we focus on the influence of instinct on addictive behavior, as well as on other behaviors. The role that experience plays in addictive behavior, as well as in other behaviors, is also addressed in this chapter and throughout the rest of the text.

This chapter discusses how experience alters instinctive behaviors. But first, the Lorenz-Tinbergen theory of instinctive behavior provides the background necessary to appreciate the way in which experience modifies instinctive behavior.

Konrad Zacharias Lorenz (1903–1989)

Lorenz (right) received a doctorate in medicine and a doctorate in zoological studies from the University of Vienna in Austria. He taught at the University of Vienna Institute of Anatomy for 5 years and the Department of Psychology at the University of Königsberg for 1 year before World War II. He also conducted research at the Max Planck Institute for Behavioral Physiology for 25 years after the war. His text, *Behind the Mirror, a Search for a Natural History of Human Knowledge,* was written while he was a prisoner of war in the Soviet Union. He was awarded the Nobel Prize in Medicine or Physiology in 1973 for his research on the instinctive basis of social behavior.

Nikolass "Niko" Tinbergen (1907–1988)

Tinbergen (left) received a doctorate in biology from the University of Leiden in the Netherlands. He taught at the University of Leiden where he began his classic research on the nature of instinctive behavior of stickleback fish. During World War II, he was imprisoned for 2 years in a Nazi camp for supporting Jewish faculty colleagues. After the war, he taught at the University of Leiden for 2 years before moving to the University of Oxford in England for 39 years. Richard Dawkins and Desmond Morris, two prominent biologists, were students of his at Oxford University. He was awarded the Nobel Prize in Medicine or Physiology in 1973 for his research on the instinctive basis of social behavior.

THE INSTINCTIVE BASIS OF BEHAVIOR

Greg smokes a cigarette when he wakes up in the morning. After about 30 minutes, he goes outside to smoke another cigarette because Paula does not allow him to smoke in the house. He does the same at work; after about 30 minutes or so, he goes outside to smoke. If he sees a coworker smoking, Greg often goes outside to smoke, even if less than 30 minutes has passed since his last cigarette. What causes Greg to smoke a cigarette about every 30 minutes? Why will seeing a coworker smoke a cigarette cause Greg to smoke even if less than 30 minutes has passed since his last cigarette? The instinctive theory of behavior proposed by Konrad Lorenz and Niko Tinbergen provides a reasonable explanation of Greg's behavior.

The Interaction of Energy and Environment

Lorenz and Tinbergen developed their instinctive theory from years observing animal behavior. To illustrate their theory, we present one of Lorenz and Tinbergen's classic observations, followed by their analysis of the systems controlling this observed behavior.

In 1938, Lorenz and Tinbergen reported their observations of the egg-rolling behavior of the greylag goose. This species builds a shallow nest on the ground to incubate its eggs. When an egg rolls to the side of the nest, the goose reacts by stretching toward the egg and bending its neck, bringing its bill toward its breast. This action causes the bill to nudge the egg to the center of the nest. If, during transit, the egg begins to veer to one side, the goose adjusts the position of its bill to reverse the direction of the egg. What causes the goose to react to the rolling egg? Lorenz's energy model addresses this question.

Energy Model

According to Lorenz (1950), **action-specific energy** constantly accumulates (see Figure 3.1). This accumulation of energy resembles

Figure 3.1 Diagram of Lorenz's energy system. The energy flows constantly from the tap T into the reservoir R. The cone valve V represents the releasing mechanism, which is open when the sign stimulus exerts pressure on the scale pan SP. The weight on the pan corresponds to the intensity of stimulation. The spring S represents inhibition from higher centers. Energy released from the reservoir R flows in the reservoirs of internal pressure that occur from the accumulation of action-specific energy and the external stimulation of the sign stimulus; both act to release the stored energy.
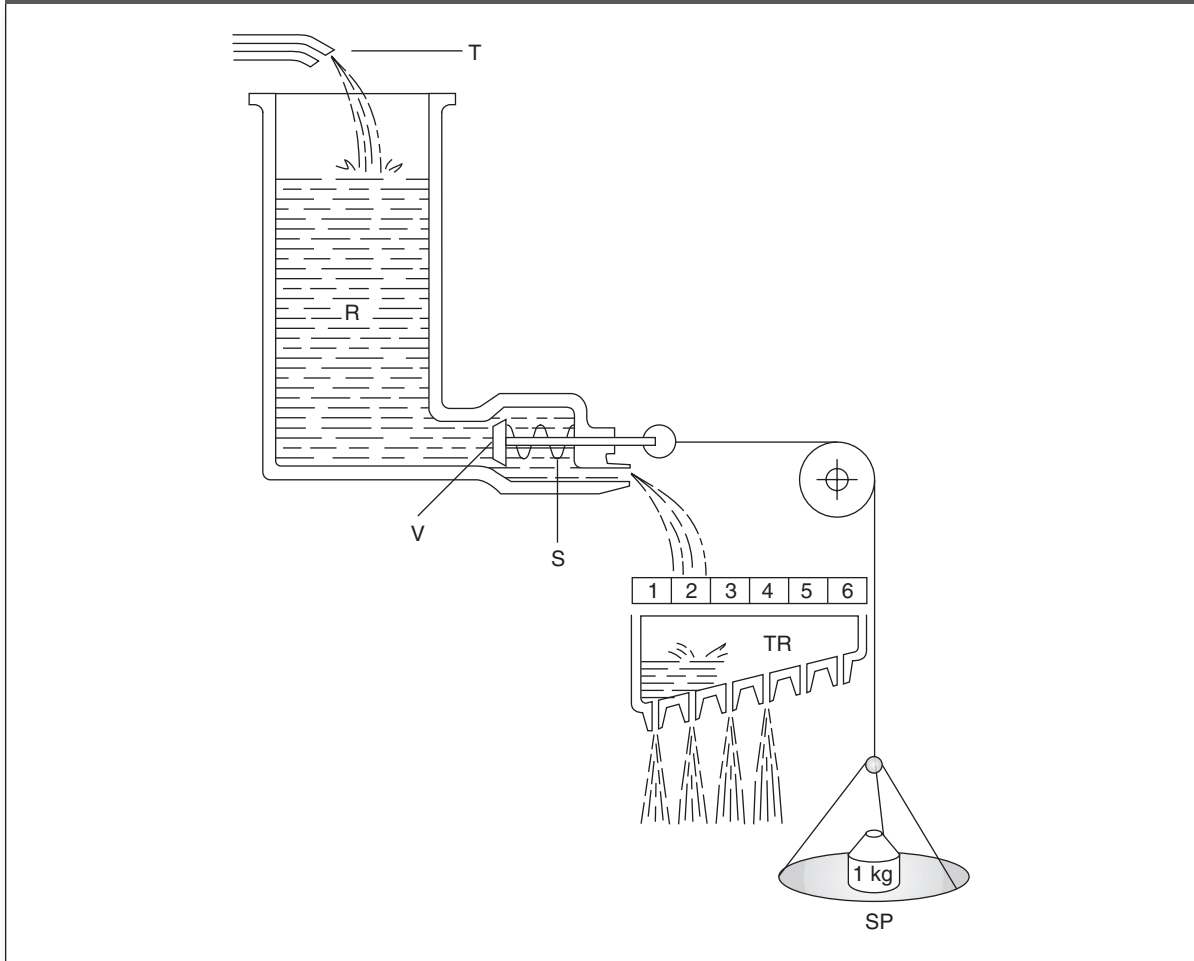
filling a reservoir with water; the more liquid in the reservoir, the greater the internal pressure for its release. In behavioral terms, the greater the pressure, the more motivated the animal is to behave in a specific way. The internal pressure (action-specific energy) motivates **appetitive behavior**, which enables the animal to approach and contact a specific and distinctive event called a **sign stimulus**. The presence of the sign stimulus releases the accumulated energy. In our goose example, the stretching movement and adjustment reaction are appetitive behaviors directed toward the rolling egg, which is the sign stimulus.

The goose does not exhibit the retrieving behavior until it has reached the egg. The retrieving behavior is an example of a **fixed action pattern**, an instinctive behavior that the presence of a

specific environmental cue, the sign stimulus, triggers. An internal block exists for each fixed action pattern, preventing the behavior from occurring until the appropriate time. The animal's appetitive behavior, motivated by the buildup of action-specific energy, allows the animal to come into contact with the appropriate releasing stimulus. According to Lorenz and Tinbergen (1938), the sign stimulus acts to remove the block by stimulating an internal **innate releasing mechanism (IRM)**. The IRM removes the block, thereby releasing the fixed action pattern. The sight of the egg stimulates the appropriate IRM, which triggers the retrieving response in the goose. After the goose has retrieved one egg and its energy reserve dissipates, the bird will allow another egg to remain at the side of the nest until sufficient action-specific energy has accumulated to motivate the bird to return the second egg to the middle of the nest.

In some situations, a chain of fixed action patterns occurs. In these cases, a block exists for each specific fixed action pattern in the sequence, and the appropriate releasing mechanism must be activated for each behavior. For example, a male Siamese fighting fish exhibits a ritualistic aggressive display when he sees another male or even when he sees a reflection of himself in a mirror. However, no actual aggressive behavior occurs until one male intrudes on the other's territory. The second fixed action pattern is blocked until the two males come into close proximity. If neither fish retreats after the ritualistic display, the fish approach each other (an appetitive act), and fighting behavior is released.

Environmental Release

In some cases, the sign stimulus for a particular fixed action pattern is a simple environmental stimulus. For example, Tinbergen (1951) observed that the red belly of the male stickleback is the sign stimulus that releases fighting behavior between two male sticklebacks. An experimental dummy stickleback, which resembles the stickleback only in color, releases aggressive behavior in a real male stickleback, supporting this conclusion.

The releasing sign stimulus can be quite complex for other fixed action patterns; for example, consider the sexual pursuit of the male grayling butterfly (Tinbergen, 1951). Tinbergen found that a male grayling would pursue a female flying past. Although the color and shape of a model grayling did not influence the male's flight behavior, the darkness of the female, the distance from the male, and the pattern of movement that simulated the male's forward and backward flight all influenced pursuit. Tinbergen noticed that an increased value in another component could compensate for the absence of one female characteristic. For instance, one model passing by at a certain distance from the male did not elicit a flight reaction. However, a darker model at the same distance did elicit pursuit.

The likelihood of eliciting a fixed action pattern depends upon both the accumulated level of action-specific energy and the intensity of the sign stimulus. Research (Lorenz, 1950; Tinbergen, 1951) indicates that the greater the level of accumulated energy, the weaker the sign stimulus that can release a particular fixed action pattern. For example, Baerends, Brouwer, and Waterbolk (1955) examined the relationship between a male guppy's readiness to respond and the size of the female. They found that a large female model released courtship behavior even in a male that was typically unresponsive.

Lorenz (1950) envisioned an IRM as a gate blocking the release of stored energy. The gate opens either by pulling from external stimulation or by pushing from within. As the internal pressure increases, the amount of external pull needed to open the gate and release the behavior decreases. And because the amount of accumulated energy increases during the time since the last fixed action pattern, the reliance on a sign stimulus to activate the IRM and release the fixed action pattern decreases.

Another view, proposed by Tinbergen (1951), suggested that sensitivity to the sign stimulus changes as a function of time passed since the occurrence of the specific behavior. According to Tinbergen, the sensitivity of the innate releasing mechanism to the sign stimulus increases when no recent fixed action pattern occurs.

How would the Lorenz-Tinbergen model explain Greg's addiction to cigarettes? According to the Lorenz-Tinbergen model, after Greg smokes a cigarette, action-specific energy builds up until Greg encounters an effective sign stimulus (cigarette). The appetitive behavior of going outside puts Greg into contact with a cigarette, which releases the stored action-specific energy and elicits the instinctive smoking behavior. In Greg's case, after about 30 minutes, enough action-specific energy accumulates for the cigarette to motivate the appetitive behavior of going outside to smoke.

Hierarchical System

Lorenz proposed that action-specific energy exists for each fixed action pattern. It is now clear, however, that the internal motivation for functionally equivalent behaviors depends on a common source. Tinbergen (1951) suggested that a central instinctive system (e.g., the reproductive instinct of stickleback fish) controls the occurrence of a number of potential behaviors (see Figure 3.2).

Energy accumulates in a specific brain center for each major instinct, and numerous systems can contribute energy for each instinct. Internal impulses can develop from the release of energy from a higher center following the occurrence of a fixed action pattern, from energy buildup at the level on which the animal is presently operating, or from both. Hormones or other internal stimuli as well as external forces can also generate energy. All of these factors influence the level of accumulated energy and the likelihood of additional behavior.

Once an effective sign stimulus releases energy, this energy flows to lower centers. The next fixed action pattern (or patterns) occurring in the chain depends on prevailing environmental

Figure 3.2   Reproductive instinct of the male stickleback fish. The diagram shows the fixed action patterns that can be released by the appropriate sign stimuli at each level of the hierarchy.
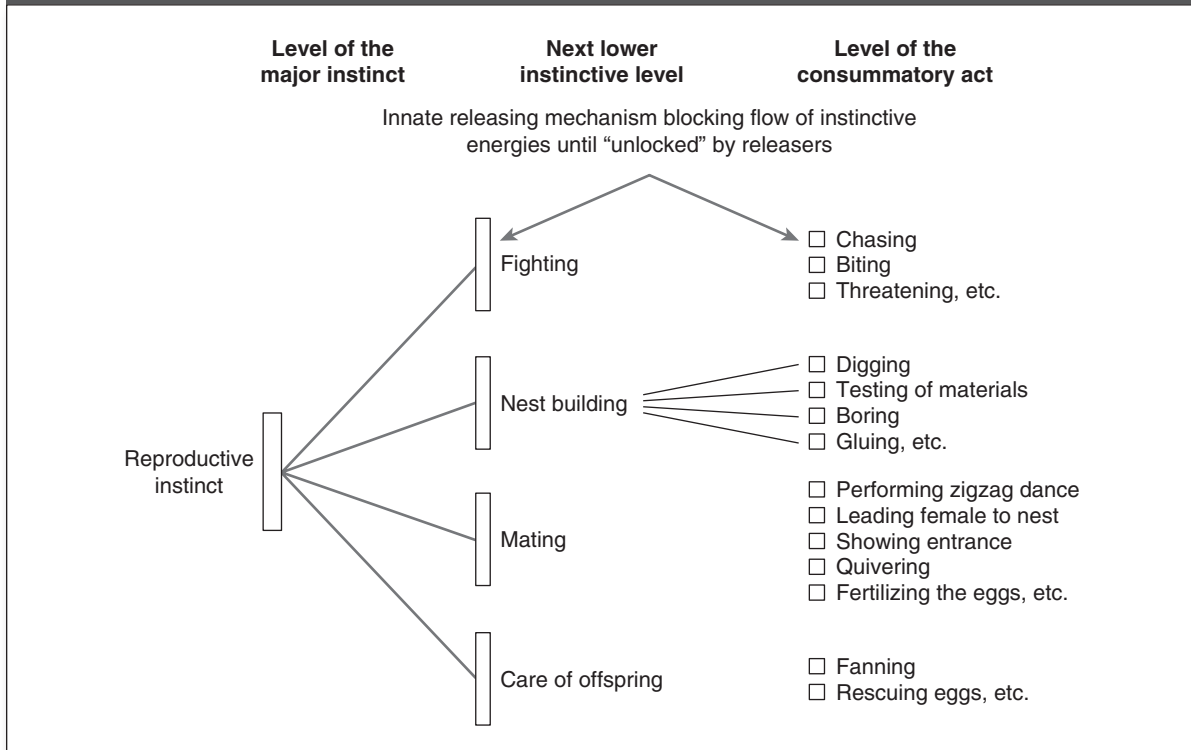
conditions. Several fixed action patterns might be released, but the sign stimulus determines the specific fixed action pattern that occurs.

Let's consider the reproductive instinct of the male stickleback fish to illustrate Tinbergen's (1951) hierarchical system (refer again to Figure 3.2). The reproductive instinct will be activated when a mature male is placed in an aquarium, if sufficient space exists. The stimulation of the reproductive instinct causes the male to establish a territory and releases energy to lower brain systems that control specific instinctive behaviors. The presence of specific environmental events determines which of the lower center's IRMs will be activated and, therefore, which specific fixed action pattern (or patterns) will occur. Thus, the male stickleback will defend his territory and use threadlike weeds to build a nest, but the nest-building instinct is not activated if there are no weeds in the territory. Similarly, the mating and care-of-offspring instincts also depend on the presence of appropriate releasing stimuli. If a female swollen with eggs approaches the male's territory, the male displays a ritualistic courtship pattern, first exhibiting a zigzag dance, then leading the female to his nest. The male's quivering behavior causes the female to lay her eggs in his nest, and the male fertilizes them. The presence of the eggs then activates the care-of-offspring instinct and motivates the male to fan the eggs, enabling them to hatch. Thus, the presence of appropriate sign stimuli determines which of the behaviors that the reproductive instinct controls will actually occur.

Von Holst and Von St. Paul in 1962 found support for Tinbergen's hierarchical theory in their study of the manner in which chickens go to sleep. A chicken exhibits a ritualistic behavior pattern before sleeping, standing on one leg and putting its head under one wing. Von Holst and Von St. Paul discovered that electrical stimulation of one brain site elicited the whole behavioral sequence; however, stimulation of other locations elicited only specific behavioral components, such as the presleeping ritual. These results suggest that different brain systems mediate the central instinctive motive and the specific fixed action patterns that this motive controls.

Conflicting Motives

An often-observed phenomenon occurs when two incompatible sign stimuli are experienced. The response is different from the fixed action patterns typically released by either sign stimuli acting alone. According to Tinbergen (1951), when a human or nonhuman animal experiences conflict due to the presence of two antagonistic sign stimuli, energy overflows into another motivational instinct system and releases a behavior from this other system. The process of activating a third instinct system, different from the two involved in the conflict, is called **displacement**.

Naturalistic settings are ideal for observing displacement behaviors. Tinbergen and Van Iersel (1947) reported that the stickleback, when between its own territory and the territory of another stickleback, often displays nest-building behavior. This out-of-context nest building is presumably due to the fish's conflict between attacking the neighbor's territory and escaping into its own. A person who whistles nervously before a date may be exhibiting displaced activity resulting from the conflict between anticipation of the date and fear of acting inappropriately.

The Importance of Experience

You might have the impression that an instinctive response is inflexible or that the releasing sign stimulus cannot be altered. Although this view is often accurate, in some circumstances, experience can modify instinctive systems. Lorenz (1950) suggested that the instinctive processes of many animals are programmed to change as the result of experience.

According to Lorenz (1950), a conditioning experience can alter instinctive behavior, the releasing mechanism for instinctive behavior, or both. Only the consummatory response at the end of the behavior chain, according to Lorenz, is resistant to modification. Conditioning can

alter the effectiveness of existing appetitive behavior or change the sensitivity of the releasing mechanism to the sign stimulus. Depending on the nature of the conditioning experience, this change can be either increased or decreased sensitivity. In addition, conditioning can establish new behaviors or new releasing stimuli. All of these modifications increase the organism's ability to adapt to the environment.

Lorenz's (1950) observations of the jackdaw's nest building illustrate his view of the importance of learning in adaptation. He discovered that the jackdaw does not instinctively know the best type of twigs to use as nesting material. This bird displays an instinctive nest-building response—stuffing twigs into a foundation—but must try different twigs until it finds one that lodges firmly and does not break. Once it has discovered a suitable type of twig, the bird selects only that type. According to Lorenz, the twig gained the ability to release instinctive behavior as the result of the bird's success.

Returning again to Greg's addiction to cigarettes, according to the Lorenz-Tinbergen model, a number of stimuli (e.g., end of a meal, party) released cigarette smoking behavior and a number of behaviors (e.g., buying a pack of cigarettes, asking a friend for a cigarette) became appetitive behaviors as a result of Greg's experiences.

Evaluation of Lorenz-Tinbergen Model

It is important to distinguish the general aspects of the Lorenz-Tinbergen instinctive approach from the specific aspects of their hypothetical energy system. Our understanding of the factors that govern a wide range of behaviors has benefited from the instinctive approach. Further, the hypothetical energy system is an excellent way to conceptualize the processes motivating instinctive behavior. Environmental stimuli do release instinctive behaviors, and the likelihood of environmental release depends upon both the time since the last occurrence of the behavior and the intensity of the releaser. Animals do approach environmental releasers, and the animal's motivation level influences the approach's intensity. However, recent physiological research has raised questions concerning certain aspects of Lorenz and Tinbergen's theory. Although scientists (Friesen, 1989; Willows & Hoyle, 1969) have identified brain systems responsible for the release of both appetitive behavior and fixed action patterns, no physiological system operates according to the structure of the energy model. Energy does not appear to accumulate in any identified brain systems, nor does it appear to flow from one system to another. Brain structures do communicate and interact, but not in accordance with Lorenz and Tinbergen's energy model. Let's examine one study that illustrates this interaction.

Willows and Hoyle (1969) examined the brain structures controlling the innate escape response of the sea slug, elicited by contact with a predatory starfish. Contact with the starfish releases a chemical from the starfish's tentacles that receptors on the sea slug's body detect. The sea slug's chemical sensory receptors then send a message through the sea slug's nervous system that elicits alternating contractions of the muscles on the sea slug's back and underside.

Willows and Hoyle (1969) traced the neural circuit from the sensory receptors to the muscles (see Figure 3.3). The neural message is first sent to Area 1 in the slug's brain. Activity in Area 1 causes the muscles in the sea slug's back to contract and inhibits brain Area 2, which controls the muscles on the slug's underside. Willows and Hoyle found that activity in brain Area 1 lasted for a set time. When activity in brain Area 1 stopped, the inhibition of brain Area 2 was removed, thereby allowing activity in brain Area 3 to stimulate brain Area 2. (Activity in brain Area 3 began when the message reached the brain, but Area 3 could not stimulate brain Area 2 until the inhibition from brain Area 1 ended.) Activity in brain Area 2 causes the sea slug's underside to contract and inhibits brain Area 1. The neural activity in brain Area 2 continues for a set time and then stops, removing the inhibition on brain Area 1. The removal of this inhibition allows brain

Figure 3.3   A schematic representation of the neural network controlling the sea slug's escape behavior.
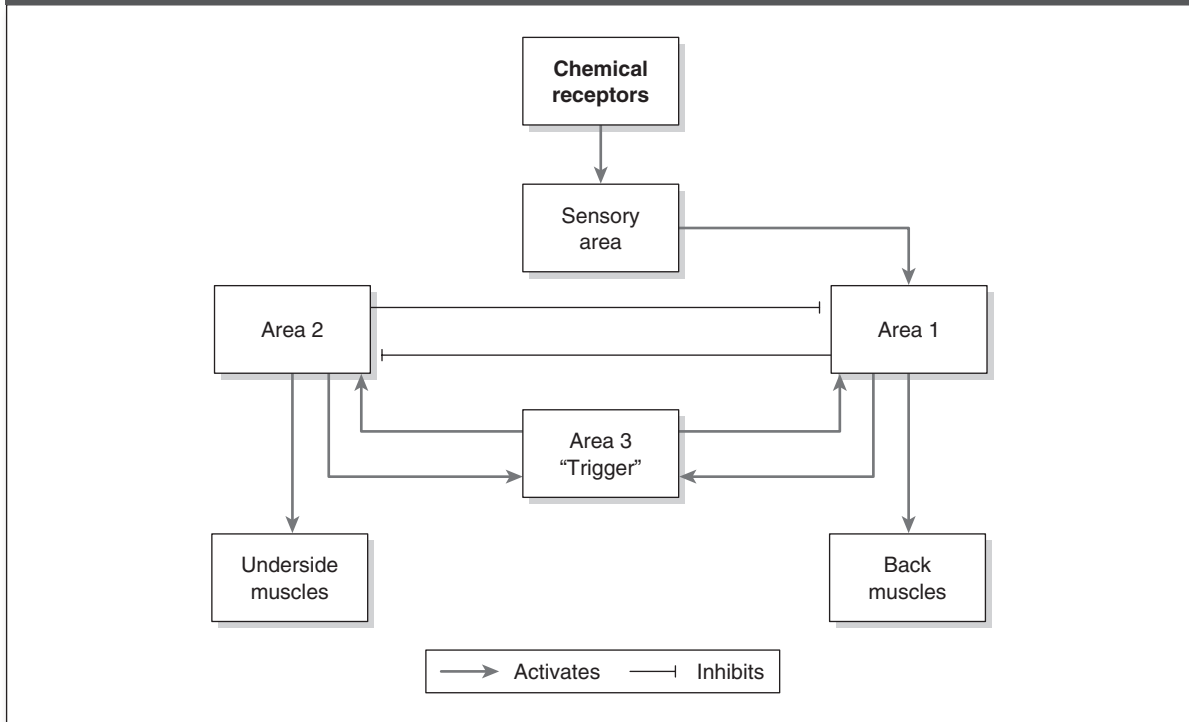
Area 3 to stimulate brain Area 1. Activity in brain Areas 1 and 2 will continue to cycle, resulting in alternating contractions of the sea slug's back and underside muscles. What is the function of the alternating contractions? This innate sequence of muscle responses can propel the slug to safety away from the predatory starfish.

Lorenz (1950) believed that conditioning enhanced a species' adaptation to its environment and that the ability to learn is programmed into each species' genetic structure. However, Lorenz did not detail the mechanism responsible for translating learning into behavior. In addition, neither Lorenz nor Tinbergen investigated the factors determining the effectiveness of conditioning.

BEFORE YOU GO ON

- Are any aspects of Greg's smoking explainable as instinctive?

- How might experience interact with these instinctive aspects of Greg's smoking?

SECTION REVIEW

- Lorenz and Tinbergen proposed that a specific internal tension (or action-specific energy) exists for each major instinct.

- The accumulation of internal action-specific energy motivates appetitive behavior, which continues until a specific environmental cue, called a sign stimulus, is encountered.

- This sign stimulus can activate an innate releasing mechanism (IRM), which releases the stored energy and activates the appropriate fixed action pattern.

- According to Lorenz and Tinbergen, the instinctive system is not inflexible; experience can sometimes alter the releasing stimuli, the instinctive behavior, or both.

- In some cases, the modification involves altering the effectiveness of the existing instinctive actions, while at other times, new releasing stimuli, new behaviors, or both enable the organism to adapt.

We next examine the changes in instinctive behavior that occur with experience. In later chapters, we discuss how new releasing stimuli or new behaviors are acquired as a result of experience.

HABITUATION AND SENSITIZATION

Students who have to give speeches in a class show different reactions to this experience. Some students become less nervous with experience; for others, the anxiety increases rather than declines with experience. Why do some students experience less distress after several speeches, while others find the experience more distressing? The phenomena of habituation and sensitization provide one reason.

With **habituation**, responsiveness to a specific stimulus declines with repeated experiences with that stimulus (R. F. Thompson, 2009). In our example, the lessened anxiety some students feel after several experiences giving a speech may be due to habituation. **Sensitization** refers to an increased reaction to environmental events. The greater nervousness other students feel after several instances of giving a speech may be due to sensitization. It is also possible that classical conditioning leads to the increased or decreased reactions to giving a speech; for example, a change in nervousness may be the result of negative or positive aspects of giving the speech. We look at classical conditioning in Chapter 4. There are many real-world examples of habituation and sensitization; we examine these phenomena next.

Suppose an animal is given a new food. Most animals would only eat a little of this novel food, an avoidance referred to as **ingestional neophobia**. This neophobic response has considerable adaptive significance. Many foods in the natural environment contain poisons. If the animal eats too much of a poisoned food, it will die. To determine whether the food can be safely consumed, the animal eats only a small quantity of the food on the first exposure. After repeated experiences with a food, the neophobic response habituates and the animal consumes greater amounts.

Michael Domjan's 1976 study documents the habituation of ingestional neophobia. Rats received either a 2% saccharin and water solution or just water. Figure 3.4 shows that the rats drank very little saccharin solution when first exposed to this novel flavor. However, intake of saccharin increased with each subsequent experience. Eventually, the animals drank as much as rats given only plain water. These results indicate that the habituation of the neophobic response led to the increasing consumption of saccharin.

Animals also can show an increased neophobic response. Suppose that an animal is sick. Under this illness condition, the animal will exhibit an increased ingestional neophobia (Domjan, 1977). The sensitization process causes the greater neophobic response.

The properties of a reward also have been found to change with experience. It has generally been assumed that this decreased effectiveness of a reward is due to satiation; that is, the animal is no longer motivated to obtain the reward. Or, increased deprivation can cause a reward to be more effective; that is, the animal is more motivated to obtain the reward. Thus, homeostasis (satiation or deprivation) has been assumed to be the mechanism responsible for either the

Figure 3.4   Animals show a reluctance to consume novel foods, but repeated exposure to a food will lead to habituation of neophobia. Animals in group S were given access each day to a 2% saccharin solution for 30 minutes, followed by 30 minutes of tap water. Over a 20-day period, the intake of saccharin in group S increased, while their consumption of tap water declined. The animals in group W received only 30 minutes of tap water each day, and their intake of water remained steady.
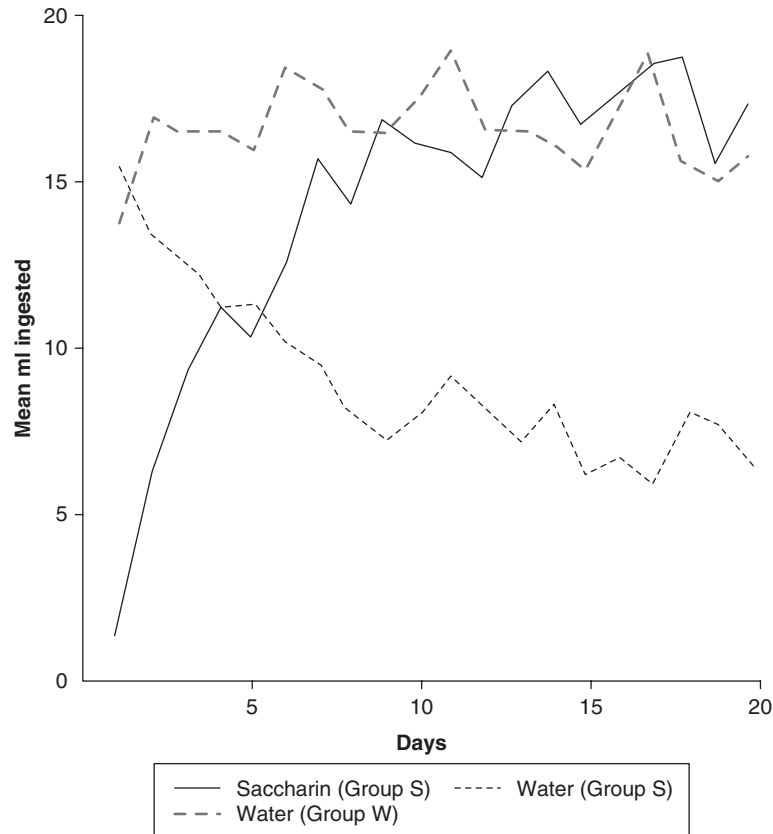
decreased or increased effectiveness of a reward. However, considerable evidence suggests that habituation can lead a reward to lose its effectiveness (McSweeney & Murphy, 2009). Similarly, sensitization can cause an increase in reward effectiveness. According to McSweeney and Murphy, habituation and sensitization explains many observations about changes in reward effectiveness that cannot be explained by homeostasis. For example, Blass and Hall (1976) observed that animals often drink before there is a physiological need and stop drinking before any physiological needs are met. McSweeney and Murphy suggest that sensitization can cause a reward to be effective in the absence of a physiological need and habituation can cause a reward to lose its effectives before the need is met. Additional evidence that habituation and sensitization can modify the effectiveness of a reward is presented in the next section.

Characteristics of Habituation and Sensitization

Habituation or sensitization doe not always occur with repeated experience (see R. F. Thompson, 2009; R. F. Thompson & Spencer, 1966). A number of variables affect the occurrence of habituation or sensitization.

First, stimulus intensity determines the rate of habituation and sensitization. With habituation, the weaker the stimulus, the more rapid habituation occurs to that stimulus. In fact, habituation to very intense stimuli may not occur. The opposite is true with sensitization; that is, a more intense stimulus produces stronger sensitization than does a weaker one.

Second, habituation increases with more frequent stimulus presentations, although the amount of habituation becomes progressively smaller over the course of habituation. Similarly, greater sensitization occurs when a strong stimulus is experienced more frequently.

Third, habituation to a stimulus appears to depend upon the specific characteristics of the stimulus. A change in any characteristic of the stimulus results in an absence of habituation. For example, many birds become alarmed when seeing a hawklike object flying overhead (Tinbergen, 1951). Any novel object flying overhead can elicit this alarm reaction and will habituate when the stimulus is repeatedly experienced. However, the reaction will return if any quality of the object is altered. For example, in one study, Schleidt (1961) reported habituation of the alarm reaction in young turkeys when either a circular or rectangular silhouette flew overhead. However, if the shape of stimulus changed, habituation ceased, and the alarm reaction returned.

What is the significance of these observations? There appears to be no specific sign stimulus eliciting alarm in young turkeys. In the natural environment, the birds habituate their alarm reaction to members of their species. When a hawk approaches (or the shape changes), the turkeys experience a new shape, and their alarm reaction is elicited.

By contrast, a change in the properties of the stimulus typically does not affect sensitization. For example, illness elicits enhanced neophobia even if the characteristics of the sensitizing stimulus (illness) change.

Finally, both habituation and sensitization can be relatively transient phenomena. When a delay intervenes between stimulus presentations, habituation weakens. In some instances, habituation is lost if several seconds or minutes intervene between stimuli. Yet, at other times, delay does not lead to a loss of habituation. This long-term habituation does not appear to reflect a change in an innate response to a stimulus. Instead, it seems to represent a more complex type of learning. We look at the long-term habituation of responding to a stimulus in Chapter 5.

Time also affects sensitization. Sensitization is lost shortly after the sensitizing event ends. For example, M. Davis (1974) noted that sensitization of the startle response to a tone was absent 10 to 15 minutes after a loud noise terminated. Unlike the long-term habituation effect, sensitization is always a temporary effect. This observation suggests that sensitization is due to a nonspecific increased responsiveness produced by the sensitizing stimulus.

We learned in the last section that habituation may lead to a decreased reward effectiveness and sensitization may lead to an increased reward effectiveness. Support for this view comes from research showing that the characteristics of habituation and sensitization described previously also affect the influence of a rewarding stimulus on behavior (Raynor & Epstein, 2001; McSweeney & Murphy, 2009). For example, the intensity of responding does not decline when a variety of rewards are used (Ernst & Epstein, 2002). In the Ernst and Epstein study, human subjects participated in a computer game for food reward (either three pieces of turkey sandwiches or three different sandwiches that were the same caloric value as the three turkey sandwiches). Ernst and Epstein reported that decreases in responding within a session were steeper for those subjects given the same food than the different food. According to McSweeney & Murphy, satiation should still occur when different rewards are used, whereas

habituation of reward effectiveness should be reduced when a variety of rewards are used. The fact that variety of rewards results in the continued effectiveness of reward supports the view that habituation plays an important role in the reduced effectiveness of reward over time on motivated behavior. It also has been observed that once an animal stops eating food, giving the animal a nibble of the food restores eating, presumably due to that nibble producing sensitization of reward effectiveness.

I have frequently observed people overeat at a restaurant with a buffet or view the desert tray and order a desert after having eaten a large meal. Decreased habituation likely causes the first example, due to the presence of a variety of reward, and sensitization provided by the desert tray likely causes the second example.

The Nature of Habituation and Sensitization

Dual Process Theory

Why do animals show a decreased (habituated) or increased (sensitized) reaction to environmental events? Groves and Thompson (1970) suggested that habituation reflects a decreased responsiveness of innate reflexes; that is, a stimulus becomes less able to elicit a response resulting from repeated exposure to that stimulus. By contrast, sensitization reflects an increased readiness to react to all stimuli. This increased reactivity operates on the animal's central nervous system. According to Groves and Thompson, drugs that stimulate the central nervous system increase an animal's overall readiness to respond, while depressive drugs suppress reactivity. Emotional distress can also affect responsiveness: Anxiety increases reactivity; depression decreases responsiveness.

Research on the startle response (M. Davis, 1974) supports Groves and Thompson's (1970) view. When animals are exposed to an unexpected stimulus, they show a sudden jump reaction due to tensing muscles. A variety of stimuli, such as a brief tone or light, elicits the startle response. As an example, imagine your reaction when you are working on a project and someone talks to you unexpectedly. In all likelihood, you would exhibit the startle reaction to the unexpected sound.

Repeated presentations of unexpected stimuli can lead to either a decreased or increased intensity of the startle reaction. M. Davis (1974) investigated habituation and sensitization of the startle reaction in rats. A brief 90-millisecond, 110-decibel (db) tone was presented to two groups of rats. For one group of rats, the unexpected tone was presented against a relatively quiet 60-db noise background. Davis noted that repeated presentation of the tone under this condition produced a decreased startle response (see Figure 3.5). The other group of rats experienced the unexpected tone against a louder 80-db noise background. In contrast to the habituation observed with the quiet background, repeated experiences with the tone against the louder background intensified the startle reaction (refer also to Figure 3.5).

Why does the startle response habituate with a quiet background but sensitize with a loud background? A loud background is arousing and should lead to enhanced reactivity. This greater reactivity should lead to a greater startle reaction (sensitization). In contrast, in a quiet background, arousal of the central nervous system would be minimal. This should reduce the ability of the unexpected stimulus to elicit the startle reaction (habituation).

John Garcia and his associates (Garcia, 1989; Garcia, Brett, & Rusiniak, 1989) suggested that changes in animals' innate reactions to environmental events have considerable adaptiveness. For example, the reduced neophobia to safe foods allows the animal to consume nutritionally valuable foods. We discuss the modification of innate feeding responses further when we look at biological influences on learning in Chapter 9.

Figure 3.5   The magnitude of the startle response to the tone declined over trials with the 60-db background noise (habituation) but increased when an 80-db background noise was used (sensitization).
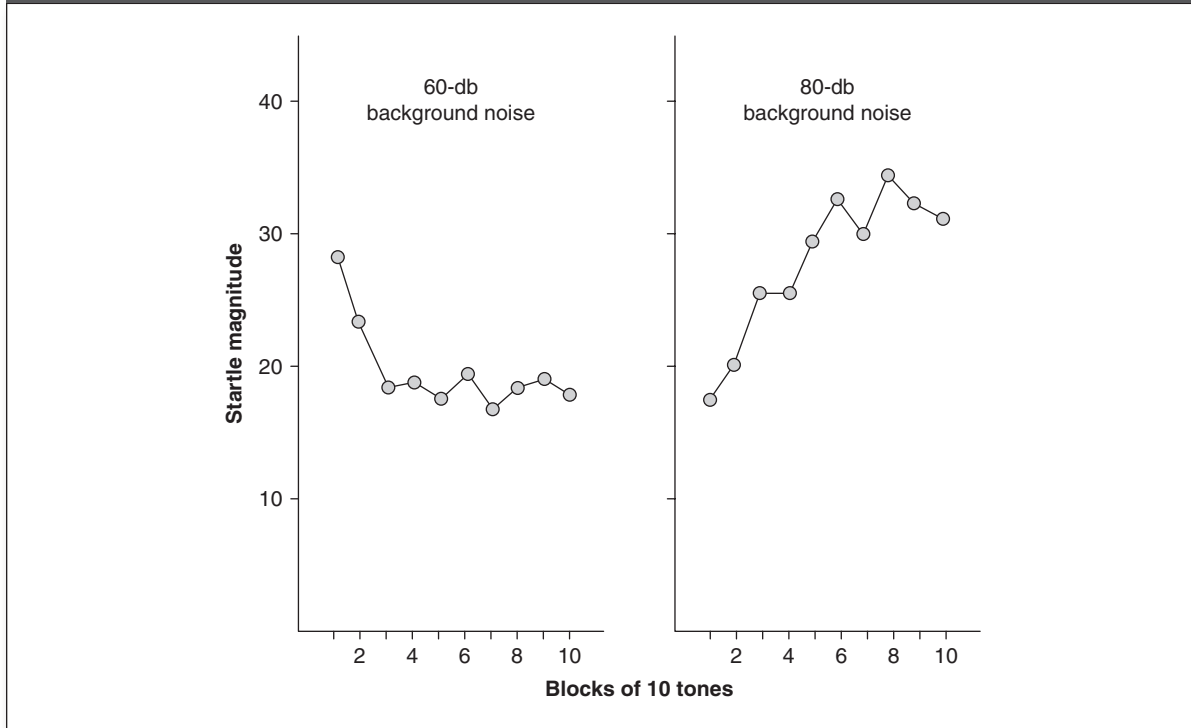

Evolutionary Theory

Edward Eisenstein and his associates (Eisenstein & Eisenstein, 2006; Eisenstein, Eisenstein, & Smith, 2001) suggested that the survival of an animal depends upon its ability to recognize biologically significant stimuli. According to these researchers, an animal needs to set sensory thresholds to maximize its probability of detecting potentially significant external events. If sensory thresholds are too sensitive, the animal will be flooded by irrelevant events and not notice the important ones. By contrast, if sensory thresholds are too insensitive, the animal also will not detect important external events. Obviously, the challenge for the animal is to set sensory thresholds at a level to maximize the detection of environmental events.

Eisenstein and Eisenstein (2006) proposed that the habituation and sensitization processes evolved as nonassociative forms of learning in order to modify sensory thresholds so that only significant external events will be detected. They interpret habituation as a process that filters out external stimuli of little relevance by raising the sensory threshold to those stimuli. By contrast, sensitization decreases sensory thresholds to potentially relevant external events. In Eisenstein and Eisenstein's view, habituation and sensitization are homeostatic processes that optimize an animal's likelihood of detecting significant external events.

Support for their evolutionary view comes from research showing that the same stimulus can produce both habituation and sensitization depending upon an animal's initial level of response to that stimulus. Eisenstein and colleagues (2001) reported that some human subjects (high

responders) react (galvanic skin response, GSR) intensely to a particular stimulus (shock), while other humans (low responders) will respond very little to the same stimulus. They report that the GSR response decreased over trials to a shock stimulus in high responders. By contrast, low responders show an increased GSR response to the shock stimulus over trials. In other words, they found that low responders' sensitization occurred to the same shock stimulus that produced habituation in the high responders.

Eisenstein and Eisenstein (2006) suggested that the initial responsiveness to a new stimulus is a function of an animal's sensory threshold just prior to that event's occurrence. According to Eisenstein and Eisenstein, high responders initially receive more sensory input than do low responders. As a result, high responders progressively decrease their responsiveness to a nonthreatening stimulus (habituation). Low responders initially receive less sensory input than do high responders. As a result, low responders steadily increase their sensory threshold and show an increased response to the next stimulus occurrence (sensitization). Eisenstein and Eisenstein assumed that the level of responsiveness achieved in both low responders and high responders balances between being too sensitive to an unimportant stimulus (and possibly missing other significant stimuli) and being too insensitive and missing a change in the relevance of the present stimulus. In other words, Eisenstein and Eisenstein posited that habituation and sensitization represents an animal's way to achieve an appropriate threshold level to events in its environment.
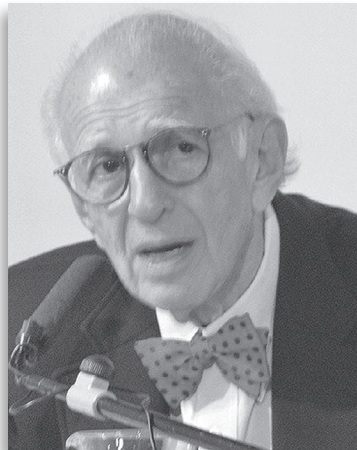
Eric Richard Kandel (1929–   )

Kandel received his doctorate in medicine from New York University. In 1939, at age 10, he and his brother Ludwig, age 14, fled Austria and the Nazi invasion to join their uncle in the United States. After receiving his MD degree, he taught at Harvard University and the New York University Medical School for 11 years before going to the Columbia University College of Physicians and Surgeons to become the founding director of the Center for Neurobiology and Behavior, where he has been for the last 36 years. After completing his residency in psychiatry in 1962, he went to Paris to learn, from Ladislav Tauc, about the marine mollusc *Aplysia californica*. He has spent almost a half a century studying the physiological basis of learning and memory in *Aplysia* and received the Nobel Prize in Physiology or Medicine in 2000 for that research.

Learning in the *Aplysia Californica*

Many scientists (Bailey, Kandel, & Si, 2004; M. A. Lynch, 2004) have proposed that permanent memory represents changes in neural responsiveness. This view, referred to as **cellular modification theory**, suggests that learning permanently alters the functioning of specific neural systems. This change can reflect either the enhanced functioning of existing neural circuits or the establishment of new neural connections. We briefly examine evidence in this chapter that neural circuits are modified as a result of habituation and sensitization. The view that conditioning reflects modification of neural circuitry is explored in Chapter 13.

Nobel Prize winner Eric Kandel and his associates (Antonov, Antonova, Kandel, & Hawkins, 2001; Bailey, Giustetto, Zhu, Chen, & Kandel, 2000; Kandel, 2000) have investigated changes in synaptic responsivity following learning in the sea snail *Aplysia californica* (see Figure 3.6). This simple, shell-less marine mollusk has three external organs—the gill, the mantle, and the siphon—that retract when either the mantle or the siphon is touched. This defensive withdrawal response either increases or decreases as a result of experience and is analogous to the withdrawal responses found in almost all higher animals.

Repeatedly presenting a weak tactile stimulus to *Aplysia* decreases the strength of its withdrawal reaction (see Figure 3.7 on page 52), which satisfies our definition of habituation. Further, habituation of *Aplysia*'s defensive reaction is stimulus specific; that

Figure 3.6   In this shell-less marine mollusk, touching either the siphon or the mantle elicits a defensive retraction of the three external organs—the gill, the mantle, and the siphon. (a) The external organs are relaxed and (b) withdrawn.
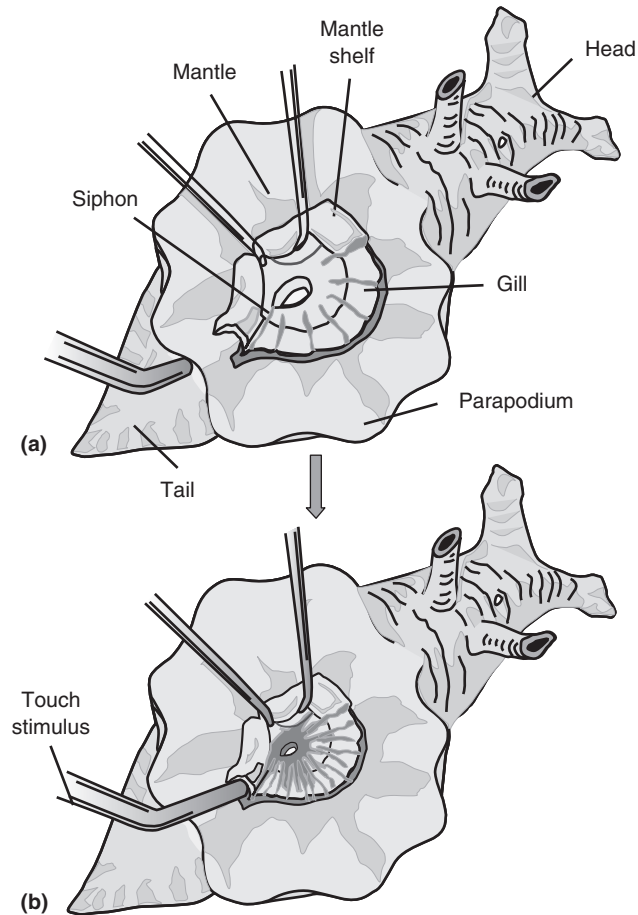
is, the decreased withdrawal response occurs only in response to a weak touch on a particular part of the animal's body. If the tail of *Aplysia* is electrically shocked before its siphon is touched, the result is an exaggerated defensive response because of sensitization—an increase in the innate reactivity to a stimulus following exposure to an intense stimulus. Unlike habituation, which occurs in response to a specific stimulus, the sensitizing effect is nonspecific. After exposure to an electric shock, any stimulus, even a weak one, will elicit a strong defensive response in *Aplysia.*

Habituation of the defensive response of *Aplysia* lowers the responsivity of the synapses between the sensory and motor neurons involved in the withdrawal response (see Figure 3.7; R. D. Hawkins, Kandel, & Siegelbaum, 1993). This decreased synaptic responsiveness reflects a decreased neurotransmitter release from the sensory neuron and decreased activity of the motor

Figure 3.7   (a) Repeated exposure to a weak tactile stimulus leads to a reduced withdrawal reaction (habituation), whereas either a rest period or another tactile stimulus reinstates the withdrawal reaction (dishabituation). (b) The neural circuit that mediates the habituation of the gill withdrawal response includes the sensory neuron, an inhibitory interneuron, and the motor neuron.
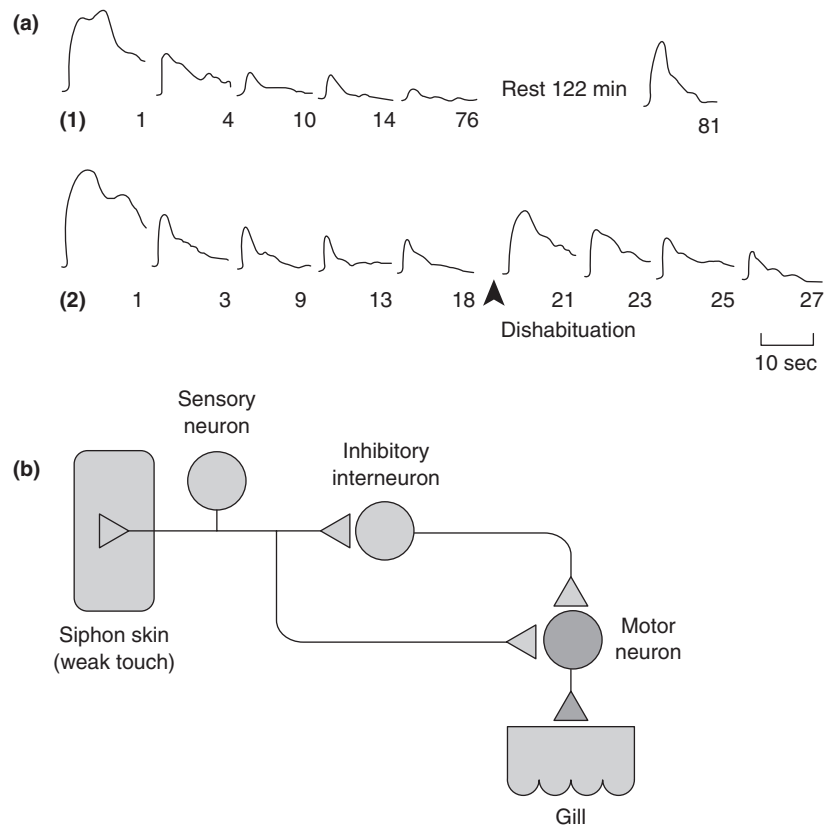
neuron. In other words, habituation results from a decrease in neurotransmitter release in the neural circuit that produces the withdrawal response in *Aplysia*.

By contrast, sensitization results from an increased responsiveness of the synapses between the sensory and motor neurons controlling the withdrawal reflex. The increased responsiveness reflects a greater neurotransmitter release from the sensory neuron and increased activity in the motor neuron.

Dishabituation

You are driving to school and thinking about going to the movies after class when suddenly a car turns into your lane. Startled by the car, you notice that you are going too fast and put your foot on the brake to slow down. Why did you notice your speed after, but not before, the car turned into your lane? The phenomenon of **dishabituation** is one likely reason.

The Dishabituation Process

Dishabituation refers to the recovery of a habituated response as a result of the presentation of a sensitizing stimulus (G. Hall & Channell, 1985; Wagner, 1981). G. Hall and Channell (1985) provided one study demonstrating dishabituation. In this study, rats habituated to a light stimulus in one context. A reduced orienting response (turning toward the light and rearing in front of it) demonstrated habituation. Hall and Channell then presented the light stimulus to the rats in a context where they had never experienced the light. The second context was either another familiar context or a novel environment. An orienting response to the light stimulus was observed in the novel context. In contrast, the orienting response was not observed in the familiar environment.

Why did exposure to the novel, but not the familiar, context lead to dishabituation? According to the Groves and Thompson dual-process theory (Groves & Thompson, 1970), the arousing effect of the sensitizing stimulus causes the habituated response to return. In the absence of a sensitizing stimulus, habituation remains. Exposure to a novel context is arousing, and this arousal caused the rats' orienting response to the light to return in the Hall and Channell (1985) study. In contrast, the orienting response did not return when the rats were exposed to a nonarousing, familiar environment. In our automobile example, the car turning into your lane aroused your central nervous system, which caused you to again notice the setting on the speedometer.

R. D. Hawkins, Cohen, and Kandel (2006) also have observed dishabituation of the withdrawal response in *Aplysia.* Hawkins, Cohen, and Kandel first touched the *Aplysia*'s siphon, which produced withdrawal of the *Aplysia*'s external organs. Repeated touch stimulations with a 5-minute intertrial interval produced reduced withdrawal response (habituation). After five touch stimulations, the *Aplysia*'s mantle shelf was shocked. Hawkins, Cohen, and Kandel reported that this shock produced an increased withdrawal response, or dishabituation (see Figure 3.7).

Dishabituation can also restore the effectiveness of a reward produced by habituation (McSweeney & Murphy, 2009). For example, Aoyama & McSweeney (2001) observed rats' wheel-running rates decrease over the course of a 30-minute training session. These researchers found that when a flashing light was introduced 20 minutes into a 30-minute session, the rate of running increased.

What process is responsible for dishabituation? We examine this question next.

The Nature of Dishabituation

Pavlov (1927) suggested that a reversal of habituation caused dishabituation. In Pavlov's view, the cause of dishabituation of the withdrawal response in *Aplysia* would be a return to the prehabituation level of neurotransmitter released from the sensory neuron to the motor neuron that controls the withdrawal response. By contrast, Grether (1938) proposed that dishabituation results from a process similar to sensitization that was superimposed on habituation. In terms of *Aplysia,* this "dual process" view would suggest that the cause of dishabituation is due to two processes: (1) a decreased neurotransmitter release as a result of habituation and (2) an increased neurotransmitter release produced as a result of a sensitization experience.

Which of the two views is correct? One way to test whether dishabituation is due to a process similar to sensitization that counteracts habituation is to determine whether the specific factors influence both dishabituation and sensitization in the same way. Most of the evidence suggests that sensitization and dishabituation are due to similar processes.

Marcus, Nolen, Rankin, and Carew (1988) found that weak tail stimulation produced maximal dishabituation of a siphon withdrawal response, whereas strong tail stimulation produced maximum sensitization. Further, they observed that a short delay (1.5 minutes) after the tail stimulation produced maximum dishabituation, whereas a longer delay (20 minutes) produced maximum sensitization. By contrast, T. E. Cohen, Kaplan, Kandel, and Hawkins (1997) did not find any differences in the gill withdrawal response produced by either a sensitizing or dishabituating stimulus;

that is, the same noxious stimulus could produce either sensitization or dishabituation with similar time courses.

R. D. Hawkins, Cohen, and Kandel (2006) analyzed the sensitization and dishabituation of the *Aplysia's* gill withdrawal response. They reported that sensitization and dishabituation can be dissociated, but only under very limited conditions. These researchers found that varying the intensity of a sensitizing shock stimulus or a dishabituation shock stimulus had different effects only when presented 2.5 minutes before a nontouch (water) stimulus to the *Aplysia's* gill. There was no effect of shock intensity when the sensitizing stimulus or dishabituation stimulus was presented 12.5 minutes before the nontouch stimulus or when either the sensitizing or the dishabituation stimulus were presented either 2.5 or 12.5 minutes before the gill was touched (touch stimulus). These results suggest that dishabituation generally is due to a process similar to sensitization. Only under very limited circumstances—a very short interval that is not conducive to sensitization—does dishabituation reflect a reversal of habituation. What process, then, could lead to a reversal of habituation? At this time, that mechanism remains unclear.

Our discussion suggests that habituation and sensitization represent independent, but also interdependent, processes. Habituation results in a stimulus that is no longer able to elicit a response, while an arousing stimulus can cause either a return to normal response in the case of dishabituation or a heightened response in the case of sensitization. This interdependence of habituation and sensitization has adaptive value. Habituation allows us to ignore unimportant or irrelevant stimuli, while sensitization reinstates the response in case those stimuli now have become important. While it is not essential that you know exactly how fast you are going while you are just driving down the road, a car turning in front of you makes noticing your speed important again. It might just prevent you from having an accident (or getting a speeding ticket).

BEFORE YOU GO ON

- Would habituation cause Greg to smoke less?

- Would sensitization cause Greg to smoke more?

SECTION REVIEW

- Habituation is a decreased response to a stimulus following repeated experiences with that stimulus; sensitization reflects an increased reaction to a stimulus.

- Groves and Thompson suggest that habituation results from the decreased ability of the stimulus to elicit the response (innate reflexes) that occurs by filtering out external stimuli of little present relevance through increased sensory threshold to those irrelevant stimuli.

- Sensitization represents an increased reactivity to all stimuli (central nervous system) that occurs by decreasing the sensory threshold to significant external events.

- Dishabituation is the recovery of a habituated response resulting from the presentation of a sensitizing stimulus, which is a process similar to sensitization that is superimposed on habituation triggers.

- Animals exposed to a novel food show ingestional neophobia, or avoidance of the food.

- With repeated experience, ingestional neophobia habituates and more food is consumed; when an animal is ill, it becomes sensitized and shows enhanced ingestional neophobia.

- Habituation can lead to decrease in reward effectiveness, while sensitization and dishabituation can increase reward effectiveness.

- Studies on *Aplysia* have demonstrated that habituation decreases neurotransmitter release from the sensory neuron to the motor neuron controlling the withdrawal response, whereas sensitization increases neurotransmitter release.

Experience can lead to either a more intense (sensitization) or less intense (habituation) reaction to environmental events. Our discussion has focused on the response produced during exposure to a situation. However, responses also occur following an experience. Solomon and Corbit (1974) examined this aspect of the innate reaction to events. We now turn our attention to their opponent-process theory.
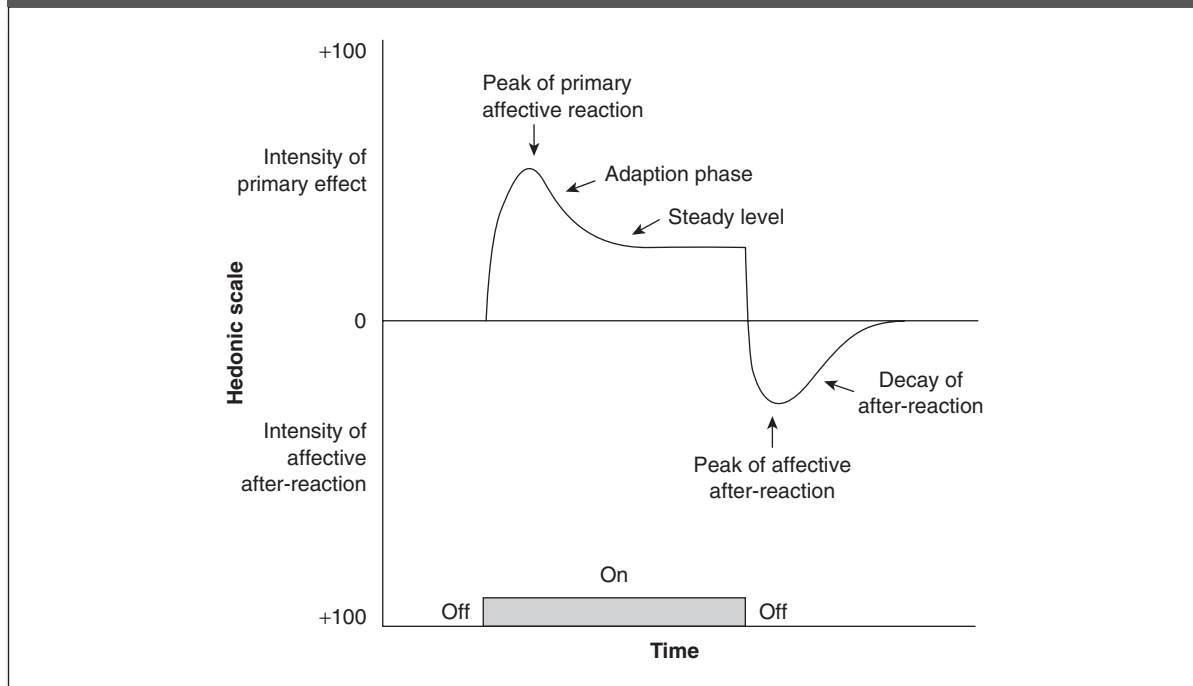
OPPONENT-PROCESS THEORY

Recall Greg's addiction to cigarettes, described in the chapter-opening vignette. Why does Greg crave cigarettes and find it so difficult to stop smoking? Opponent-process theory provides us with one answer to this question.

The Initial Reaction

Richard Solomon and John Corbit (1974) observed that all experiences (both biological and psychological) produce an initial affective reaction, the **A state** (see Figure 3.8), which can either be

Figure 3.8   Schematic diagram of the affective changes experienced during and after an environmental event during the first few exposures to that event. Notice the large initial A state reaction, the reduced A state over the course of the event, and the small opponent B state reaction that occurs after termination of the event.

pleasant or unpleasant. For example, drinking alcohol usually produces a pleasurable A state, while taking an exam often produces an unpleasant A state. According to **opponent-process theory**, the intensity of an experience influences the strength of the A state; that is, the more intense the event, the stronger the A state.

The A state arouses a second affective reaction, the **B state**. The B state is the opposite of the A state; if A state is positive, then the B state will be negative, and vice versa. Thus, the pleasurable A state aroused by drinking initiates an opposing, or opponent, aversive affective state. Similarly, the pain produced during the examination creates a pleasurable relief response. In Solomon and Corbit's (1974) view, our biological systems automatically initiate an opposite, or opponent, response to counter the initial effect of all events.

Several important aspects of the opponent process must be described in order to understand the system Figure 3.8 depicts. First, the B state is initially less intense than the A state. Second, the B state intensifies more slowly than the A state. Finally, after an event has terminated, the strength of the B state diminishes more slowly than the A state. As a result of the slower decline of the B state than the A state, the opponent affective response will only be experienced when the event ends.

Consider Greg's addiction to smoking to illustrate how these rules operate. Smoking a cigarette activates a positive A state—pleasure. Automatic arousal of the opponent B state—pain or withdrawal—causes his initial A state (pleasure) to diminish as he continues smoking the cigarette. When Greg stops smoking, the A state declines quickly, and he experiences the B state (pain or withdrawal).

## The Intensification of the Opponent B State

Solomon and Corbit (1974) discovered that repeated experience with a certain event often increases the strength of the opponent B state (see Figure 3.9), which in turn reduces the magnitude of the affective reaction experienced during the event. Thus, the strengthening of the opponent B state may well be responsible for the development of **tolerance**. Tolerance represents a decreased reactivity to an event with repeated experience. Furthermore, when the event ends, an intense opponent affective response is experienced. The strong opponent affect that is experienced in the absence of the event is called **withdrawal**.

Let's return to our example of Greg's cigarette smoking to illustrate this intensification of the B state process. Greg has smoked for many years, causing him to experience only mild pleasure from smoking. Yet, he feels intense prolonged pain or withdrawal when he stops smoking. Thus, the increased intensity of the B state not only produces reduced pleasure in smoking a cigarette, but it also increases withdrawal when the effects of smoking end.

Katcher, Solomon, Turner, LoLordo, Overmier, and Rescorla's (1969) study demonstrates this process. These experimenters observed physiological reactions in dogs during and after electric shock. After the termination of shock, physiological responses (e.g., heart rate) declined below preshock levels for several minutes before returning to baseline. After many presentations, the decline was greater and lasted longer. These observations show (1) a strong A state and a weak opponent B state during the first presentations of shock and (2) a diminished A state (tolerance) and an intensified B state (withdrawal) after many experiences.

The opponent process operates in many different situations (see Solomon & Corbit, 1974). Epstein's (1967) description of the emotional reactions of military parachutists is one real-world example of the opponent process. Epstein reported that during the first free fall, all the parachutists showed an intense aversive A state (terror). This A state diminished after they had landed, and they looked stunned for several minutes. Then, the parachutists began to talk enthusiastically with friends. This opponent B state (relief) lasted for about 10 minutes.

Figure 3.9   Schematic diagram of the affective changes experienced during and after an environmental event after many presentations of that event. As a result of experiencing an event many times, there is a small A state response (tolerance) and a large and long B state reaction (withdrawal).
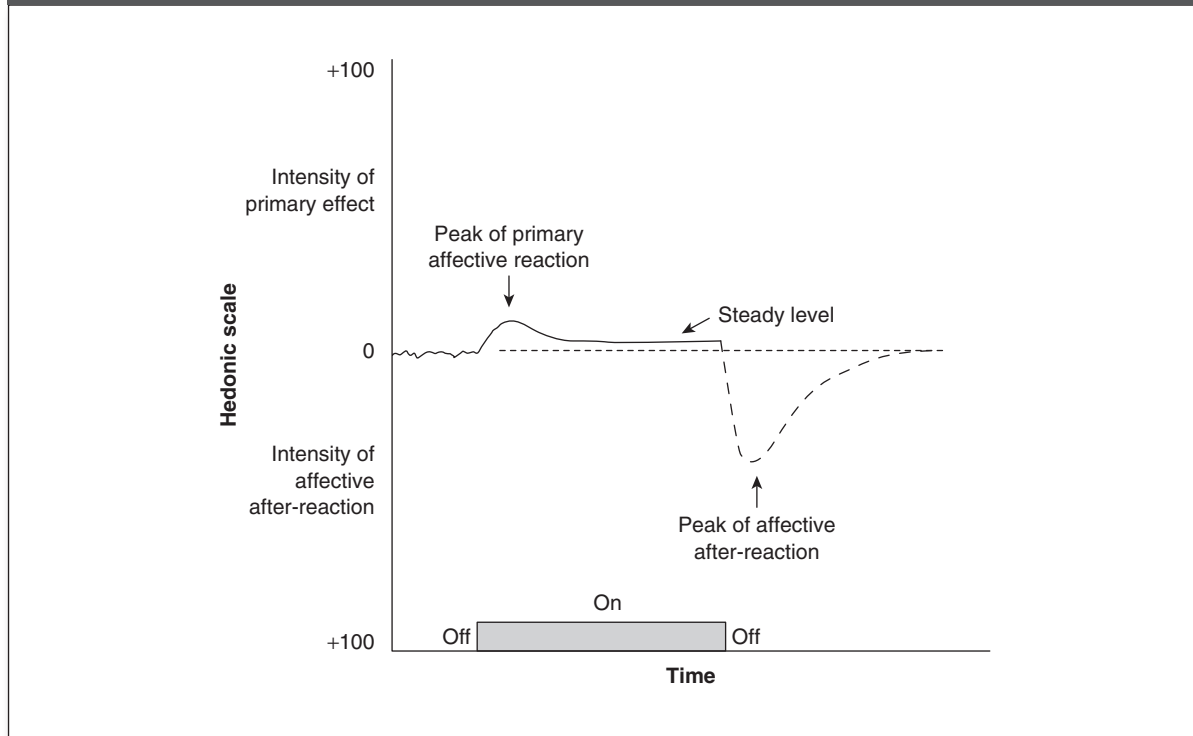
The affective response of experienced parachutists is quite different. During the free fall, experienced parachutists seemed tense, eager, or excited, reporting only a mildly aversive A state. Their opponent B state was exhilaration. Having landed safely, experienced parachutists showed (1) a high level of activity, (2) euphoria, and (3) intense social interaction. This opponent B state (exhilaration) decreased slowly, lasting for several hours.

People who consume cocaine report that the drug produces an initial and profound euphoria that is followed by an affective state described as anxiety, fatigue, agitation, and depression (Anthony, Tien, & Petronis, 1989; Resnick & Resnick, 1984). Ettenberg (2004) has reported a similar two-stage response to cocaine in rats. In his study, rats were placed in a distinctive environment either immediately after a cocaine injection, 5 minutes after a cocaine injection, or 15 minutes after a cocaine injection. Ettenberg reported that rats came to prefer the distinctive environment when placed there either immediately after or 5 minutes after the cocaine injection, presumably because the distinctive environment was associated with the positive effects (A state) of cocaine. By contrast, the rats avoided the distinctive environment when placed there 15 minutes after the cocaine injection, presumably because the distinctive environment became associated with the negative effects (B state) from cocaine use.

The Addictive Process

Opponent-process theory (Solomon, 1977, 1980) offers an explanation for the development of addiction. In Solomon's view, addictive behavior is a coping response to an aversive opponent B state. Addictive behavior is an example of behavior motivated to terminate (or prevent) the unpleasant withdrawal state.

Another way to terminate an aversive opponent B state is to experience an event that can produce a positive A state. Many individuals who chronically ingest cocaine also use alcohol (Anthony, Warner, & Kessler, 1994; Magura & Rosenblum, 2000). Cocaine users who also ingest alcohol report that the positive effects of cocaine are prolonged and the negative effects of cocaine withdrawal reduced (McCance-Katz et al., 1993; Perez-Reyes & Jeffcoat, 1992). Knackstedt, Samimi, and Ettenberg (2002) reported that rats placed in a distinctive environment 15 minutes after being administered cocaine and alcohol showed no avoidance of the distinctive environment, presumably because the positive effects of alcohol, which has a longer half-life than does cocaine, negated the negative effects of cocaine withdrawal. Rats placed in the distinctive environment 30 minutes after drug use show a weak avoidance of the distinctive place. Ettenberg suggested that the negative effects of alcohol produced the avoidance of the distinctive environment, but the avoidance was weak because the withdrawal (B state) from alcohol is weaker than that from cocaine.

Most people who drink alcohol do not become alcoholics. Similarly, people who consume other drugs do not always become drug addicts. Solomon (1980) suggests that for addiction to develop, people must recognize that abstinence causes withdrawal symptoms and that the resumption of the addictive behavior after abstinence eliminates or prevents aversive feelings. People who think that the discomfort they experience is caused by factors other than the absence of the drug are not motivated to resume taking the drug. Under these circumstances, addiction does not develop.

There is another reason why addiction may not occur following repeated exposure. The number of exposures to a substance or event alone does not determine the intensification of the B state. If sufficient time intervenes between experiences, the opponent state does not intensify. And without the aversive withdrawal B state, the motivation for addiction does not exist. In support of Solomon's view, Starr (1978) discovered that young ducklings showed no distress in the absence of their mother when a 5-minute interval lapsed between separations. In contrast, with a 1- or 2-minute interval, strong withdrawal symptoms occurred. The importance of the interval between experiences in strengthening the opponent state might explain why some people can take a drug infrequently and never experience intense withdrawal symptoms after its effect has ended.

Once an addiction is established, an addict is motivated to prevent or terminate withdrawal symptoms. One consequence of addiction is the sacrifice of potential reinforcers (e.g., friends or a job). Most addicts recognize the serious consequences of their addiction and try to stop their self-destructive behavior.

Why is it so difficult for addicts to change their behavior? The aversive withdrawal reaction is a nonspecific unpleasant affective state. Therefore, any event that arouses the aversive state will motivate the addictive behavior. Usually, alcoholics who attempt to stop drinking face multiple problems. The suppression of drinking while experiencing the B state is only part of the problem for the alcoholic. Many daily stressors, such as problems at work or home, can activate the aversive motivational state, which can motivate the habitual addictive behavior.

For example, suppose that an alcoholic's mother-in-law arrives and that her presence is a very aversive event. Under these conditions, the mother-in-law's presence will activate the aversive state, thus intensifying the pressure to drink. Solomon (1980) believes that all potential aversive events must be prevented for addicts to break their habits. Other reasons for why it is so difficult to eliminate addictive behavior are described in Chapter 4.

The Search for Pleasure

Most of us equate addictive behavior with situations in which people are motivated to terminate the aversive withdrawal state and reinstate a pleasant initial state. However, some people deliberately expose themselves to an aversive A state in order to experience the pleasant opponent B state (Solomon, 1977, 1980). The behavior of experienced parachutists is one example. Most people who anticipate parachuting from an aircraft never jump at all or quit after one jump. However, those who do jump and experience a strong reinforcing B state are often motivated to jump again. Epstein (1967) reported that some experienced jumpers become extremely depressed when bad weather cancels a jump. The reaction of these parachutists when denied the opportunity to jump resembles that of drug addicts who cannot obtain the desired drug. Other behaviors in which the positive opponent state may lead to addiction include running in marathons (Milvy, 1977) and jogging (Booth, as cited in Solomon, 1980).

R. L. Craig and Siegel (1980) discovered that introductory psychology students taking a test felt apprehensive and experienced a euphoric feeling when the test ended. However, it is unlikely that students' level of positive affect after taking a test is as strong as that of an experienced parachutist after jumping. Perhaps students are not tested often enough to develop a strong opponent reinforcing B state. You might suggest that your instructor test you more frequently to decrease your initial aversive apprehension and to intensify your positive affective relief when the test ends.

BEFORE YOU GO ON

- How would opponent-process theory explain Greg's addiction to smoking cigarettes?

- Does opponent-process theory make a prediction regarding how Greg might best quit smoking cigarettes?

SECTION REVIEW

- Solomon and Corbit suggested that all experiences produce an initial affective reaction (A state) that can either be pleasant or unpleasant.

- The A state arouses a second affective reaction, called the B state, which is the opposite of the A state; if the A state is positive, then the B state will be negative, and vice versa.

- The B state is initially less intense, develops more slowly, and declines more slowly than the A state.

- When an event is experienced often, the strength of the B state increases, which reduces the affective reaction (A state) experienced during the event.

- After the event ends, the increased B state leads to a strong opponent B state.

- The reduced A response to the event is called tolerance, and the intensified opponent B reaction in the absence of the event is called withdrawal.

- According to opponent-process theory, one form of addiction develops when people learn that withdrawal occurs after the event ends and that resuming the addictive behavior terminates the aversive opponent withdrawal state.

- A second form of addiction occurs when a person learns that an intense, pleasurable opponent state can be produced following exposure to an initial aversive state.

- Although early experience with the event was unpleasant, "the pleasure addict" now finds the initial affective response only mildly aversive and the opponent state very pleasurable. The anticipated pleasure motivates the addict to experience the aversive event.

CRITICAL THINKING QUESTIONS

1. Ming can usually pass a bakery without buying a donut, but sometimes she cannot resist the temptation. Using Lorenz and Tinbergen's energy model, explain Ming's behaviors.

2. Jamaal no longer notices the high pitch of his friend's voice. LaToya finds the friend's voice piercing. Explain how habituation and sensitization might be responsible for the different reactions of Jamaal and LaToya to their friend's voice.

3. Neal enjoys a few beers after work. He claims that it calms him after a hard day at the office. Using what you have learned about opponent-process theory, explain as much as you can about Neal's behavior. Focus on the conditions that cause Neal to drink, how we feel while drinking, and how he might feel in the morning.

KEY TERMS

action-specific energy	withdrawal
A state	appetitive behavior
cellular modification theory	B state
displacement	dishabituation
fixed action pattern (FAP)	habituation
ingestional neophobia	innate releasing mechanism (IRM)
opponent-process theory	sensitization
sign stimulus	tolerance