CHAPTER 5

Substance Abuse: A Disorder of Learning

CHAPTER FIVE OVERVIEW

Drug addiction is not a passive, static process that randomly happens to some people. Instead, it is an active, dynamic, and always-changing process that drug users initiate. While they initiate the cycle drug users are not in complete, conscious control of their actions and reactions. Many of the behaviors important in maintaining drug addiction are learned. Furthermore, many of the learned behaviors responsible for the development of an addiction occur without the user's awareness. These learned, yet unconscious, processes play a profound role in maintaining the cycle of drug abuse.

The cycle of drug abuse begins with the administration of a drug. This naturally leads to rewarding effects, withdrawal, and recovery. Subconscious learning processes then facilitate drug-seeking behavior and subsequent administration of the drug.

As the cycle continues, drug use often escalates. Increases in drug use contribute to a variety of medical problems. Some of the problems are a direct result of the drug, such as high blood pressure, dehydration, and headaches. Other problems are indirectly related to drug use, such as cancer, pneumonia, or acquired immune deficiency syndrome (AIDS).

In this section, you will explore how learning directly influences the cycle of drug abuse. Specifically, you will learn how classical and operant conditioning effects drug use, euphoria, recovery, withdrawal, and drug-seeking behavior. Understanding the cycle of abuse and a user's place within the cycle is important for providing appropriate psychological or medical intervention.

Perceiving Drug Effects

Case Study: Nicole

Nicole's life philosophy is to "work hard and play harder." While she was in college, she would frequently schedule times to go out and party with her friends, but only after she finished all of her school work. Despite some significant, bad consequences (e.g., failing and having to repeat a class, passing out at a friend's party, and getting rushed to the hospital for alcohol poisoning), she was able to do well enough in college to get accepted into a reputable graduate program. Even graduate school was a little tumultuous for her, as her life philosophy often created difficult situations for her (e.g., working with a hangover, postponing work on important assignments, and missing classes). Nonetheless, after wrapping up her advanced degree in public relations, she landed her dream job working for a large corporate marketing firm. Much of her job required her to travel around the country and "wine and dine" with potential clients. Nicole figured she had landed the perfect job, one that encompassed her life philosophy. Her new boss warned her that, while their clients might drink too much and embarrass themselves, she was to keep her drinking under control. If she drank too much, she would discredit herself and make the company look bad. Furthermore, Nicole's boss pointed out that while most of their clients expected an all-out-party atmosphere on business trips, the expectations for the marketing firm was much less flexible. In fact, the definition of "acceptable behavior" was quite broad for clients but considerably restrained for members of the marketing firm. This was a very different situation compared to what Nicole had been expecting. Although Nicole was committed to doing a great job, she often found herself "partied-out" by the end of the night and unable to wrap up event-related activities—getting the clients home safe, paying the various vendors, and taking care of last minute changes in the schedule. She also had trouble getting to work on time the next day. Nicole made a conscious effort to pay more attention to her alcohol intake and tried to limit herself to just a couple of drinks. To do this, she tried counting the number of drinks she had per hour, monitored her bar tab, and tried to quit drinking earlier in the evening; however, most of the time her strategy just didn't work, as she got lost in the excitement and craziness of the evening and drank too much.

One evening, her boss suggested that she pay less attention to external factors and more attention to how the alcohol made her feel. Nicole's boss took her out to a more serene club and simply asked her at various points throughout the evening how intoxicated she felt. To Nicole's surprise, she knew almost exactly when she was beginning to feel the effects of the alcohol. To her surprise, she began feeling them after fewer drinks than she had anticipated. As she continued to sip on a drink, she was able to describe when she felt buzzed and, later, she was starting to feel a little too tipsy. Similarly, Nicole's boss could easily tell where he was at along the continuum of intoxication, especially since they were in a quiet, less distracting environment. Nicole's boss pointed out that it was much harder to detect the effects of alcohol in a chaotic environment. He also pointed out that when he was tired, especially nervous, or taking cold medication with sedative effects, it impacted his ability to internally reference his own level of intoxication. Nicole had never even considered that she could gauge her intoxication by using internal cues instead of external ones. She had never thought that how she felt prior to going out and drinking could impact her perceived level of intoxication. For future parties and events, Nicole decided to frequently pause and ask herself how she felt. The strategy of internally evaluating her intoxication helped her to control her drinking, and she started to do a much better job self-regulating her alcohol intake. She often found herself drinking a lot less than she had before.

Nicole learned that she could be somewhat aware of how alcohol was affecting her. This is true for other drugs as well. People can readily distinguish between a drug and non-drug state, even discriminating between various intensities and types of "highs" or intoxicated feelings. In fact, people can detect which drug they are intoxicated by with just a little bit of practice. For example, have you ever taken a cold or allergy medication like pseudoephedrine or an antihistamine? While both are used to treat sinus problems, people can easily tell which one they are taking by how they feel. The emphasis, here, is on the word "feel." After taking a drug, a person can perceive that drug's effect if it enters into the brain. This is especially true with abused drugs. Many drug dependent individuals have almost perfected the process of drug discrimination and can distinguish between different qualities of the same drug. They can show a preference for one dealer over another based on the quality of the drug they are buying. People learn to associate a drug with a particular effect or feeling in the same way people learn about things they encounter. The only difference between drugs and other things that people encounter is that drugs have the ability to interfere with the brain's ability to perceive the world. Even a little child can tell you whether or not something is sweet; better yet, a child can tell you if one drink is sweeter than another drink. Likewise, a child can readily adjust the volume on a pair of headphones to maintain intensity-desired volume. These are generally intuitive processes that are easy to master after just several learning trials. In summary, we are able to perceive a particular drug effect almost as readily as we can perceive other stimuli that elicit tastes, smells, sounds, sights, pain, and other experiences Detecting drugs is similar to detecting other things because the biological process of detecting drugs compared to other things is nearly identical. Suffice to say, drugs are readily detectable stimuli that follow the same conventional rules as other stimuli.

Case Study: Allen

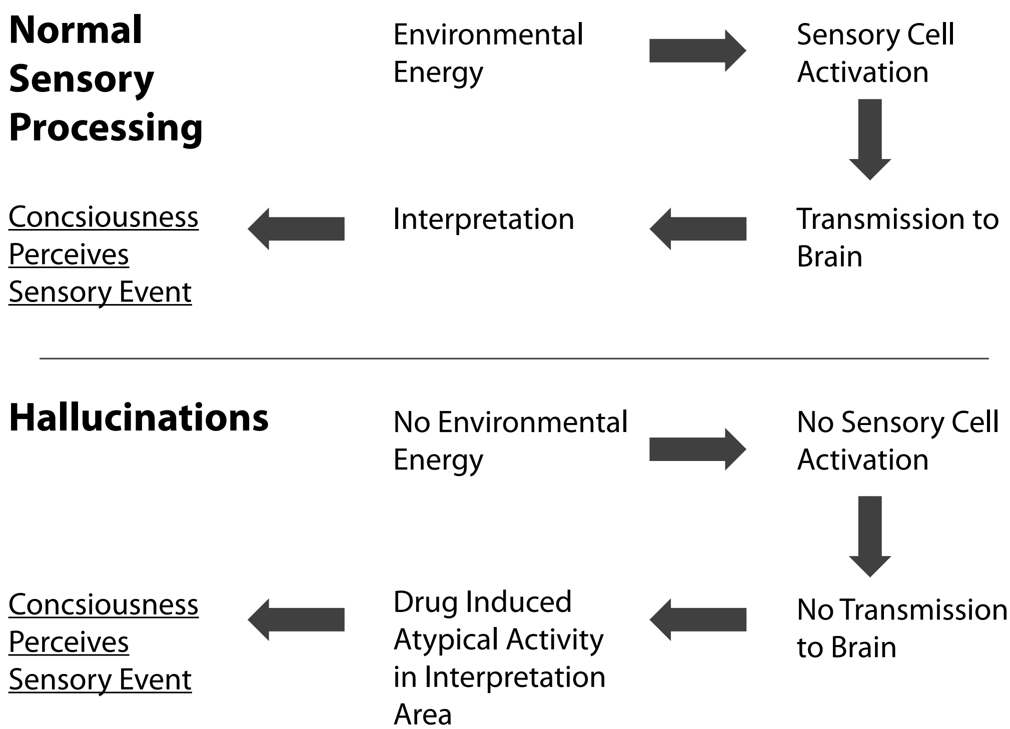
Allen, a college student, began using drugs when he was in high school. Currently, he primarily experiments with hallucinogens. Allen enjoys using the drugs and often describes the hallucinations and the altered states of consciousness that the drugs induce as pleasant and desirable. Occasionally, however, he experiences what he calls a "bad trip." He had one of those experiences recently.

After ingesting some LCD, Allen began experiencing hallucinations. While, at first, he enjoyed the altered state of perception, he began to see spiders all over his room. He became extremely anxious and eventually started screaming after he felt spiders crawling all over his arms and legs. His roommate found him and was able to calm him down after a few minutes.

After the effects of the drugs wore off, Allen's roommate asked him why he had been screaming about spiders. Allen explained that although he now knew it was only the effects of the drugs, everything had seemed so real at the time. He had felt all of their tiny, prickly legs crawling over his skin, and he had seen them swarming over the floors and walls of his room. They both found it fascinating and weird that the drug caused Allen's brain to see things that weren't real.

Hallucinations are something that society finds fascinating but often doesn't understand. Hallucinations are perceptual experiences that take place in the absence of an environmental stimulus—an imagined, yet perceptually real experience. People experiencing hallucinations are often depicted in TV shows. In many contemporary court cases, the media often gives significant coverage to individuals with mental illness who experience hallucinations, or at least claim to—like schizophrenics who hear voices instructing them to engage in terrible atrocities.

So how exactly do hallucinations work? Why are certain drugs capable of causing them? To understand this, you need to understand the basic layout of the human sensory systems. With this knowledge, it's easy to see how the sensory systems malfunction in the presence of drugs, creating hallucinations.



The human sensory system revolves around transduction. **Transduction** is the conversion of physical, environmental energy into an electrical impulse in the nervous system. All sensory information begins as physical energy in the environment. For example, sound is the physical vibration of molecules in the environment. The ear converts these vibrations into neuronal activity and, consequently, we perceive sound. In fact, much of the ear is designed to control vibrations so that very sensitive and delicate hair cells can facilitate this conversion of environmental energy.

Likewise, we have specific sensory cells that are designed to convert mechanical energy into neuronal activity, and we experience this as touch. When a friend pokes you with their finger, their finger physically squishes some of these sensory cells. These sensory cells generate action potentials when they are compressed, again converting the mechanical force of your friend's finger into neuronal activity. The brain organizes incoming sensory information topographically, meaning that it has an internal map of where these sensory events occur. This allows the brain to know exactly where your friend's finger is poking you, not just that you are being poked somewhere.

Incoming sensory information, originally collected by sensory cells, is then sent to different areas of the brain for interpretation. Information about touch is sent to the spinal cord and then sent to the brain, moving up through the brainstem, the thalamus, and finally arriving at the cortex for interpretation. In fact, all sensory information from the body, including information about temperature, pain, and body position, follows this same pattern, originating in the body, traveling up the spinal cord and through the brain until it reaches an interpretation area. Sensory information coming from the mouth, nose, ears, and eyes travels through special nerves in the head (called cranial nerves) to get to the brain and ultimately to an interpretation area. This is how we receive information about taste and smell as well as auditory and visual information.

So what do all of the senses have in common? Specific sensory cells detect environmental energy, convert it into neuronal activity, which then travels to the brain where it gets interpreted. In the simplest of terms, drugs produce hallucinations by affecting the "sensory interpretation" areas of the brain. That is to say, hallucinogens alter the functioning of these primary sensory interpretative areas (e.g., the same thing has been known to occur during certain types of neurosurgery when the surgeon stimulates a portion of the brain with a small electrode). Abnormal function in these "sensory interpretation areas" is then sent to the parts of the brain responsible for producing consciousness. Thus, it appears to our consciousness that a sensory event is occurring, even though there wasn't actually something in the environment (a sound, a light, etc) that the person ended up experiencing.

For example, the parietal lobe interprets touch information from the body, specifically in the somatosensory cortex. Thus, abnormal activity in the somatosensory cortex induced by drugs can create artificial sensations of touch. The occipital lobe interprets visual information, so abnormal activity there caused by drugs can create visual hallucinations. Auditory information is processed in the temporal lobe, so abnormal activity there can create auditory hallucinations. While Allen and his roommate were fascinated by the drug's ability to "magically" create images and sensations that were not real, remember that, as discussed previously, drugs can never create a new biological process—they can only alter processes that are already occurring. Hallucinations are a perfect example of this, as they are simply disruptions to the normal processing of sensory information.

Introduction to Sensations and Perceptions

Much of one's conscious experience involves sensory imagery, which is defined as thinking about a particular sensory and/or perceptual event. Examples of sensory imagery include thinking about your childhood home, remembering the smell of freshly baked pepperoni pizza, and recalling what it is like to be drunk or high. For the most part, our thoughts and memories require at least some form of sensory imagery, be it visual, auditory, or otherwise. In addition to providing the basis of consciousness, sensory systems provide important information that is used to control movement and maintain arousal. Furthermore, sensory experiences provide the most fundamental connection between learning and memory.

The vast majority of information we acquire throughout our lives begins as environmental energy. Our ability to detect environmental energy, however, is very limited compared to all the different types and sheer quantity of environmental energy we could potentially detect. We can see only a narrow range of light frequencies, we can hear only certain frequencies of sound, and we can't taste or smell every chemical in existence. Whether or not energy is detectable, based on the type of energy and its intensity, is the defining feature of a stimulus. In order for something to be called a stimulus, it must have the capacity to interact with and stimulate specialized cells in the human body. These specialized cells form the basis of what most people refer to as "sensations," and these sensory experiences ultimately produce our perception of the world. Drugs are unique compared to other sensory systems because they directly interact with the brain to produce a perception while conventional sensory stimuli activate specialized cells in the body, which then send signals to the brain. In fact, much of consciousness depends upon the relationship between sensations and perceptions, even in the absence of sensory input. Although sensory systems offer some of the most tangible evidence of brain function to a layperson, it can still be difficult to understand how sensory energy is transformed into meaningful perceptual experiences and, subsequently, into thoughts.

In order to function in an ever-changing world, we need to detect and understand what is happening in our environment. Scientists have argued that humans have an internal representation of the external world that is coded in patterns of neural activity. While the internal patterns are diverse and composed of energy that is very different from the external world, the internal patterns do maintain some type of an equivalence or quantitative relationship with the external world they represent These neural patterns of activity within the brain occur regardless of what is happening in the environment, and they are what most people refer to as memory, thought, consciousness, or the mind.. Although this information seems technical and complicated, Protagoras, a Greek philosopher in 450 BC stated, "Man is nothing but a bundle of sensations," capturing the same idea.

Sensations refer to specific, immediate, and directly qualitative experiences or attributes of an object that are produced by simple, isolated physical stimuli. Examples of sensations are "warm," "smooth," "red," and "bright." We often describe our own bodies and other objects in these terms. Interestingly, drug users describe their experiences in the same way. Just as heat produces a feeling or perception of warmth, a drug produces similar feelings and perceptions. Furthermore, sensations are **spatiotemporally universal**, meaning that sensations occur in a similar, but not identical, fashion in all people across time. If this were not the case, it would be very difficult for humans to have shared experiences. When we say something like, "Try this candy, it tastes sweet," we assume that other people experience the candy the same way we did. When someone says, "Man, I was so drunk last night," other people who have been drunk know what that feels like.

Another important characteristic of sensations is that they always travel in an ascending fashion. In other words, they always travel from a particular sensory receptor to the specific area in the brain that adds value and meaning to that stimulus. Sensations are always produced by a stimulus. To be precise, a stimulus is defined as a measurable and predictable pattern of physical energy that is able to interact with a person and produce definable changes in the condition of the person. Again, drugs fit this definition of a stimulus. Drugs are chemicals that interact and change the function of specific cells in the body. **Potential stimuli** are detectable physical energies that have not yet been detected by the body. Therefore, if the physical energy from the environment does not cause a change in the organism, it cannot be considered a stimulus. For example, certain animals can detect ultraviolet light while humans can't, so ultraviolet light could be a potential stimulus for those animals, even though it could never be for humans. For a stimulus to hold value, we must be aware of it, and the brain is the only organ that can produce awareness. Consequently, as previously noted, a drug must be able to enter the brain in order for it to serve as a stimulus. This explains why we can detect alcohol and other drugs of abuse, while we can't detect other drugs, like antibiotics. Drugs of abuse enter into the brain, while the antibiotics don't.

A **perception** is a subjective, sensory experience that has been given meaning by the brain through the integration of past experiences and judgment. In other words, a sensation becomes a perception once that stimulus has been given meaning. A perception is a sensory experience that has been integrated into a person's consciousness. Since perceptions involve an individual's personal experience, they are unique and often modifiable. This helps to explain why people love different types of food. Factors such as expectation, experience, and fatigue can alter perceptions but rarely affect sensations. For example, while you might be too tired to listen to someone, you are never too tired to hear that person. As most sensations arise from outside the brain or central nervous system (CNS), all perceptions take place inside the brain. While sensations are produced by a particular sensory cell's activation, we see, hear, feel, taste and smell with our central nervous system. Effectively, this means that each person's brain develops individualistic, culturally bound "sensory lenses" of which the person is usually unaware. Acquiring these "sensory lenses" is a unique, developmental process that shapes the way new information is perceived. In turn, that new information alters our "sensory lenses," which perpetuates the cycle.

In Summary

Important characteristics of sensations:

1. They are spatiotemporally universal.
2. They always ascend from a receptor to the brain.
3. They are evoked by a stimulus.
4. They modulate or change.

Important characteristics of perceptions:

1. They organize and integrate sensory attributes.
2. They are unique and modifiable.
3. Perceptions take place in the brain.
4. They are part of a developmental process.

The Common Pathway of the Sensory Systems: From Receptor to Awareness

Despite their diversity, all sensory systems and sensory subsystems extract the same basic information from stimuli, including modality, intensity, duration, and location. The only aspect that separates drugs from conventional stimuli is that drugs directly impact the brain, so they don't provide information about location. For example, when a person's arm is touched, receptors in that person's arm send signals to that person's brain. Consequently, that person knows exactly where the touch originated because the receptors encode information about their location. Since drugs activate receptors in the brain, they don't provide information about location. On the other hand, drugs do produce very different experiences, similar to modality. Additionally, people can take different doses of a drug, a property similar to intensity. Finally, drugs have varied affects across time, so they essentially incorporate an element of duration. Furthermore, drug events are transformed from environmental energy to awareness through biochemical and neural processes that are very similar to the processes that convert conventional stimuli. Once the energy is converted from environmental energy to biochemical energy, it is carried along certain pathways to a number of brain structures. Each sensory system has a peripheral area of maximal sensitivity and an area of the brain dedicated solely to processing that information. Collectively, the sensory systems work in a very similar fashion, conveying, distributing, and examining information in common ways. In general, most of the sensory systems include the following features, moving through them in the same order, which is noted below:

- Environmental energy
- Detection of environmental energy
- Activation of sensory receptors
- Transduction of energy
- Neural encoding
- Neural pathways
- Central integration
- Perception

The study of sensory systems and their corresponding perceptual attributes has always been a multidisciplinary field of study. Our knowledge of sensory systems, including our understanding of the perception of drug effects, includes contributions from a variety of fields like physics, computer science, chemistry, anatomy, physiology, genetics, medicine, and psychology. This multidisciplinary effort has tremendously furthered our understanding of sensory systems. However, despite significant findings explaining how sensory information is collected and sent to the brain, scientists continue to be perplexed, wondering how that information creates our consciousness. For example, scientists know a lot about how the eye collects and convert light energy into neural impulses. For the most part, they also understand how and where that information is sent within the brain. Yet, scientists know almost nothing about how people can perceive a stimulus, adding meaning to vision and recognizing it as one object versus another. The same is true with drugs and their effects. Scientists possess very detailed information about which receptors are activated by different drugs and even know which areas of the brain seem to be most sensitive to various drugs. Unfortunately, we still don't know how the activation of specific brain receptors produces euphoria, hallucinations, paranoia, or tolerance.

Sensory receptors are sensitive to a specific form of **physical energy** like light, sound, pressure, or movement. Despite their apparent diversity, sensory receptors can be broadly classified into three categories: exteroceptors, interoceptors, and proprioceptors. **Exteroceptors** (extero-: external) respond to environmental energy or stimuli that are occurring from the outside of one's body. They respond to light, sound, touch, and chemical agents. **Proprioceptors** (proprio-: position) are sensory receptors that are activated by muscular movement or passive displacement of body parts. These are often found in muscles and joints. While our conscious awareness of internal and external changes only includes information obtained from exteroceptors and proprioceptors, there is still another category of receptors that are essential for survival. The last group of receptors is called **interoceptors** (intero-: internal), and they respond to inhaled and ingested materials. They also respond to changes in chemical surroundings, mechanical pressure, and shearing force or pressure change (i.e., stretching). Interoceptors trigger the release of insulin after we eat and increase respiration during periods of increased oxygen demand. In the case of abused drugs, interoceptors produce euphoria, arousal, or relaxation. Abused drugs and chemicals activate interoceptors, and since they do, we often refer to the perceptible effects of drugs as interoceptive effects and/or experiences.

Another way to categorize sensory receptors is based on the type of energy that they maximally respond too, and this categorization includes the following types of receptors: photoreceptors, mechanoreceptors, chemoreceptors, thermoreceptors, and nociceptors. **Photoreceptors** are sensitive to radiant, electro-magnetic energy (light). **Mechanoreceptors** sense the deformation and motion of solids, liquids and gases. Mechanical forces are those that tend to deform or accelerate objects possessing mass. **Chemoreceptors** detect chemicals, although as previously mentioned, not every chemical is detectable. For a chemical to be detectable, it usually must be water soluble, lipid soluble, and made of organic material (i.e., in most cases). Abused drugs and abused chemicals also fit into this definition. **Thermoreceptors** are sensitive to changes in temperature. Finally, **nociceptors** respond to painful stimuli or stimuli that are capable of causing tissue damage. All sensory receptors fall into one of these five types of receptors. While it is helpful to consider each of the senses separately, our perceptions depend largely on multisensory inputs and are the combination or culmination of a number of senses (e.g., flavor is the combination of taste, smell, and texture).

Transduction is the process by which environmental energy is transformed by sensory receptors into different sensations or sensory modalities. Other names for transduction are **receptor potential** and **generator potential**. All sensory receptors have the ability to take information from the world around us and convert it into neural codes. These codes are able to generate neural activity, which our brain can interpret. Another important characteristic of sensory cells is that they are often spontaneously active. In other words, they demonstrate some baseline level of activity, even in the absence of stimulation. This is extremely important because it allows for differential activation. In other words, stimuli can serve to increase or decrease a sensory cell's firing rate. Hence, receptor activation is bi-directional, causing either stimulation or inhibition. This bi-directional process increases the accuracy at which we discriminate between two similar stimuli. Another way of stating this is our sensory systems are particularly skillful in detecting contrasts and changes in the environment, but they are particularly poor at detecting constant stimulus energy. Lastly, when stimulus energy is transduced by the sensory receptor into neural energy, specific features of the stimulus, such as intensity and duration, are represented in the resultant pattern of action potentials. Again, the process of transduction is readily apparent with abused drugs. Drugs, once carried into the brain, directly activate specific receptors like conventional sensory systems, but do so on the surface of neurons instead of throughout the body (i.e., within the synapse). The activation of receptors in the brain changes the rate at which neurons fire and, if enough neurons are affected, there are changes across an entire neural system. Drugs, like sensory cells, simply increase or decrease the firing rate of a given neuron, which ultimately give rise to drug-related perceptions.

Neural encoding is the process by which sensory receptors produce patterns of neural energy that the brain is capable of interpreting. There is a distinct neural code for each of the four sensory attributes. Neural codes may be the product of activity in a single neuron or many neurons (i.e., across space/location), or they may be related to the activity of neurons across time. Neural codes that are based on time are called **temporal codes**, while neural codes that are distributed across space (e.g., location) are referred to as **spatial codes**. For example, the sensation elicited by a painful stimulus may increase in intensity because a single nociceptor (i.e., pain receptor) fires more frequently or because additional nociceptors are activated. Hence, one sensory cell may increase its firing rate 100 times per second or 100 sensory cells may increase their firing rate by only 10 per second at the same time. Both of these changes would intensify the sensation of pain. Generally, because they are dispersed throughout the brain, drugs activate many receptors as opposed to strongly affecting a small number of receptors, thus generating spatial codes. In summary, the neural encoding process for abused drugs encompasses the activation of many receptors across a well-defined period of time, producing a unique perceptual experience.

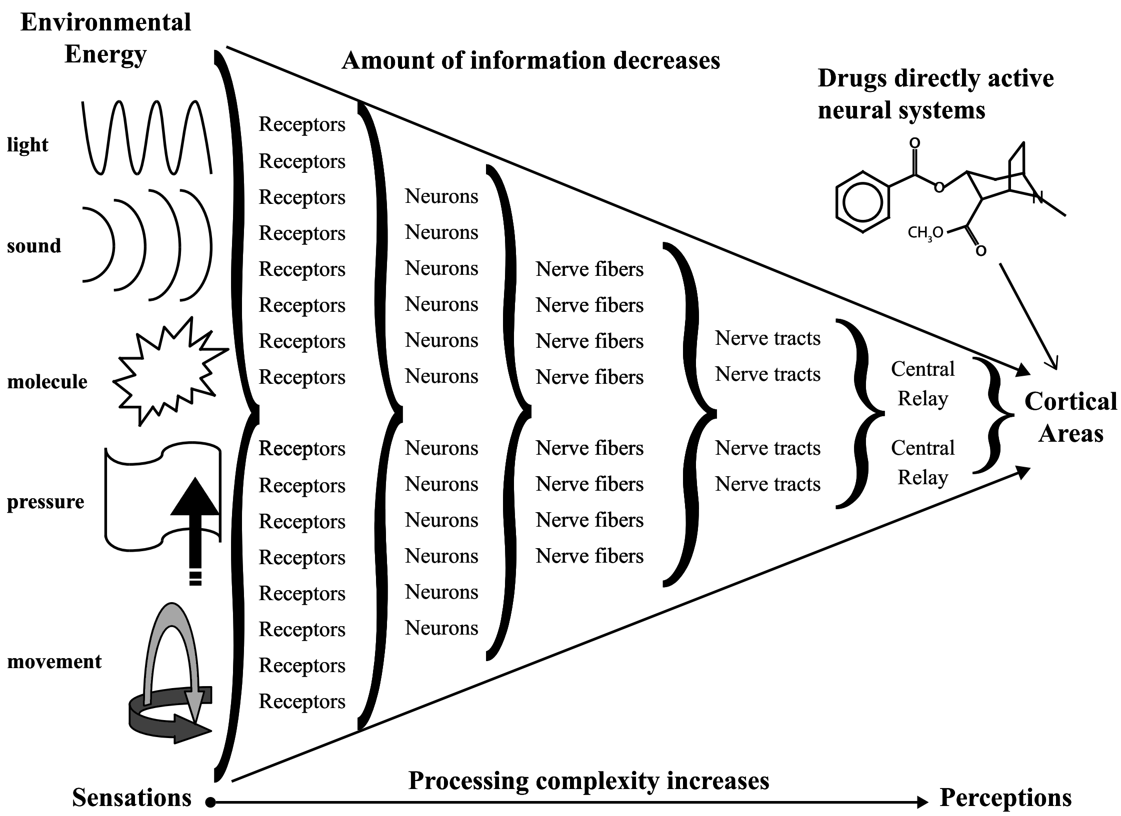
Again, sensory systems, through the activation of various receptors, are able to mediate four attributes of a stimulus that are quantitatively related to perception. These attributes are modality, intensity, duration and location.

Modality: Different forms of energy are transformed by the nervous system into different sensations or sensory modalities. Everyone generally recognizes five major sensory modalities: vision, hearing, taste, touch, and smell. However, there are actually more. Furthermore, each modality has submodalities (i.e., taste: sweet, sour, bitter or salty). Every sensory nerve fiber is activated by certain stimuli and normally serves one modality, although under unusual circumstances a blending of effects can be observed. For example, a punch to the eye can produce a bright flash of light even when no light enters the eye. Finally, each modality has a target (terminal) cortical area that maximally responds to only one sense modality. Historically, drugs have also been classified into "modalities" like stimulants, depressants, opioids, and hallucinogens, based on which receptors they activate. Again, like conventional sensory systems, drug-related modalities can be further subdivided, as there are numerous drugs in each of the classic "modalities" that produce differing but overlapping effects. Cocaine, amphetamine, and methylphenidate are all stimulants, but they produce slightly different effects. Just like people can readily discriminate across different modalities like taste, smell, and touch, so too can people discriminate across different modalities of drugs.

Intensity: Intensity, or the amount of a sensation, depends on the strength of the stimulus. At the receptor level, stimulus intensity is influenced by two factors. The first relates to the total number of receptors activated (spatial encoding), while the second relates to the output generated by a single receptor or a group of receptors (temporal coding). The lowest stimulus intensity a person can consciously detect is defined as the sensory threshold. Interestingly, sensory thresholds are not stable across time, nor are they similar across different people. Psychological factors like practice, fatigue, and the environmental context of stimuli can influence sensory thresholds. Again, drugs directly model this pattern. Drugs directly activate receptors, so the number and the strength of receptors activated directly relates to the perceived intensity of that particular drug effect. With drugs, this is called a dose-response curve.

Duration: The duration of a sensation is defined by the relationship between the stimulus intensity and the perceived intensity. Essentially, if a stimulus persists for a sustained period of time, its intensity decreases over time. This phenomenon is known as adaptation. For example, if a person decides to go swimming and jumps into a swimming pool, the water may feel cold at first. However, this sensation tends to fade over time. The one place this sensation will not fade, however, is the area of skin that is interfacing with both the water and the air. This emphasizes another perceptual phenomenon—perception is greatest at the regions of greatest contrast. Sensory systems are able to detect change the best, not constant stimulation. Drug effects have well-defined actions across time, and they are based on the speed of absorption (i.e., route of administration) and the rate of metabolism (i.e., half-life). Just as repeated or prolonged exposure to a conventional stimulus produces adaptation, a similar process occurs with drugs. It is referred to as tolerance.

Location: There are two important measurements of a person's ability to detect spatial aspects of a sensory experience: (1) the ability to locate the source/site of stimulation, and (2) the ability to distinguish between two closely spaced stimuli. Since drugs directly activate the brain, there's no way information about location could be encoded. The user is not concerned with the stimulus' location anyway, except perhaps concerning the route of administration, which does have a definitive location.



Organization of Sensory Pathways

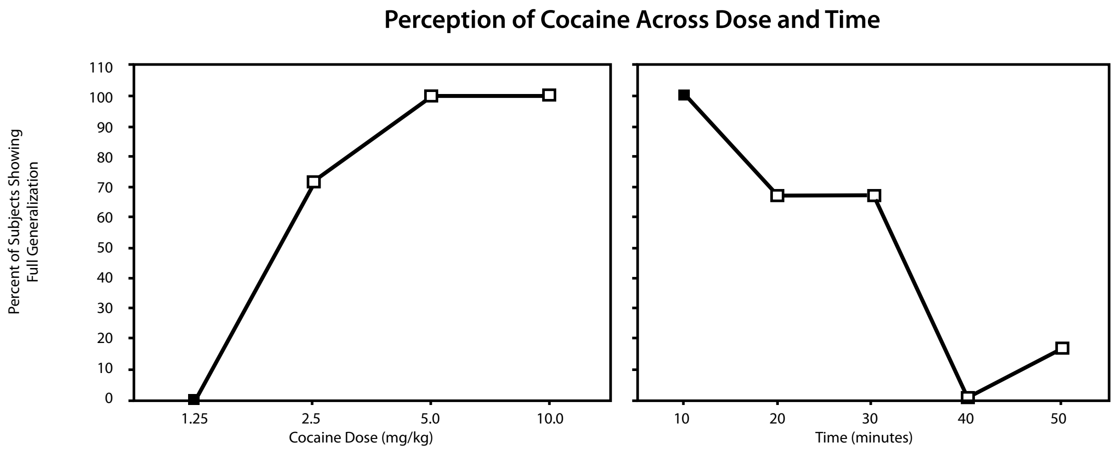
The neural pathways sensory information travels from sensory receptors to the brain and is divided across multiple neurons and pathways. Information goes through a series of relays in a particular order on its way to the cortex. Each sensory system requires three to four neurons, connected in succession, to move information from the receptors to the cortex. This type of neural organization is advantageous for a number of reasons. First, early on in the relay, some kind of motor response can be elicited before a person is even consciously aware of it. For example, the spinal cord has numerous reflex circuits that, when activated by a painful stimulus, result in a reflexive limb withdrawal response. A second advantage is that further along in the sequence, the brain stem signals to multiple muscle groups, usually orienting a person to a particular stimulus. Again, this happens prior to conscious awareness. Third, because multiple sensory modalities and their related cortical structures are often involved in any given sensory experience or motor response, the brain needs a central relay structure to distribute information to a variety of cortical sites. This complex organization allows the body to protect itself from dangerous or potentially harmful stimuli. Since drugs directly impact the brain, they bypass the general, protective features present in the sensory systems. Once the drug is in the brain, it won't leave until it is metabolized, which could take hours or even days. Generally, more complex responses require more complex neural circuits. Complex circuits are located further along the pathways and higher into the brain. They evoke increasingly complex patterns of neural activity. Unlike conventional sensory systems, overstimulation from drugs can directly interfere with the perception of their effects. For example, after a moderate dose of alcohol, the alcohol itself can interfere with a person's ability to determine his or level of intoxication. So, while drugs serve as perceptible stimuli through activation of a variety of interoceptors, activation of these same interoceptors can simultaneously interfere with the perception of drug effects. Unlike the activity in conventional sensory systems, this can produce a host of side effects.

Measuring the Perceptual Effects of Abused Drugs

Psychophysics is the area of study that examines the relationship between changes in the characteristics of various stimuli (i.e., physical dimension) and changes in the attributes or magnitude of the subjective experiences (i.e., psychological dimension). Psychophysics describes a lawful relationship between the physical and psychological dimensions. As noted in our case study, Nicole was readily able to perceive how much alcohol she had ingested as her body interpreted the interoceptive effects of the drug. Since drugs are similar to other stimuli, they can be studied the same way. In recent years, scientists have applied methods typically used to assess conventional sensory systems to assessing the effects of drugs. The greatest focus of this research has been on drugs and chemicals of abuse. People abuse drugs because of their interoceptive effects, and people quickly learn how drugs, acting as stimuli, produce desirable effects—a very clear cause and effect relationship. This type of learning is no different than the learning that takes place when a person eats something particularly delicious and is capable of understanding that a certain food produces a particular, desired effect. This type of learning is consciously mediated and is easy to quantify for both conventional stimuli and other drugs.

Absolute threshold is the minimal amount of environmental energy needed to achieve a detectable response. In other words, absolute threshold describes the smallest detectable intensity of a stimulus. This implies that there is a precise point on the intensity dimension where a stimulus becomes perceptible. Essentially, a stimulus is either perceptible, or it isn't. Consequently, from a strictly physical or physiological standpoint, there should theoretically be a precise and predictable intensity that will trigger the awareness of a stimulus. However, this is not the case. In reality, a number of psychological variables can interfere or enhance a person's ability to detect stimuli. Therefore, in some situations, people can detect stimuli across a range of intensities, but not others. Our sensory systems tend to work the same across time, and the nature of the stimulus doesn't change (i.e., the physics of sound waves don't change over time and the mechanics of our sensory system also change little across time). So, the variation in a person's ability to detect a stimulus has psychological routes. Tests assessing a person's sensory systems produce a consistent pattern, regardless of the sensory system being tested. These tests result in a typical sigmoid curve, where performance is highly predictable at very low and very high intensities (i.e., doses) but highly variable in between. Human sensory systems always show the most variability across the middle of the intensity spectrum.

The graph below demonstrates how even mice can detect the interoceptive stimulus properties of cocaine across a dose-response curve (left). It also shows how a mouse's ability to detect a cocaine stimulus decreases over time (right). In this testing paradigm, often called a drug discrimination experiment, mice quickly learned to detect a cocaine stimulus vs. a non-cocaine stimulus. Like the detection of all other stimuli, the detection of cocaine depends on both the dose of the drug and time. As shown in the left graph, none of the subjects recognized they had been exposed to cocaine when the dose was low; however, as the dose increased, over half of the mice could detect cocaine in their system. At higher doses, all of the subjects were able to confirm that they had received cocaine. The mice were trained to press one lever if they received a cocaine injection or a different lever if they received a non-cocaine, placebo injection. Therefore, if mice can learn this skill, so too can people as people learn it faster, often after just one trial, and quickly become very proficient at it. It generally takes only one use of alcohol, marijuana, or another drug to learn the drug's specific time dependent stimulus properties. That is, perception of drug effects occurs in just one trial.

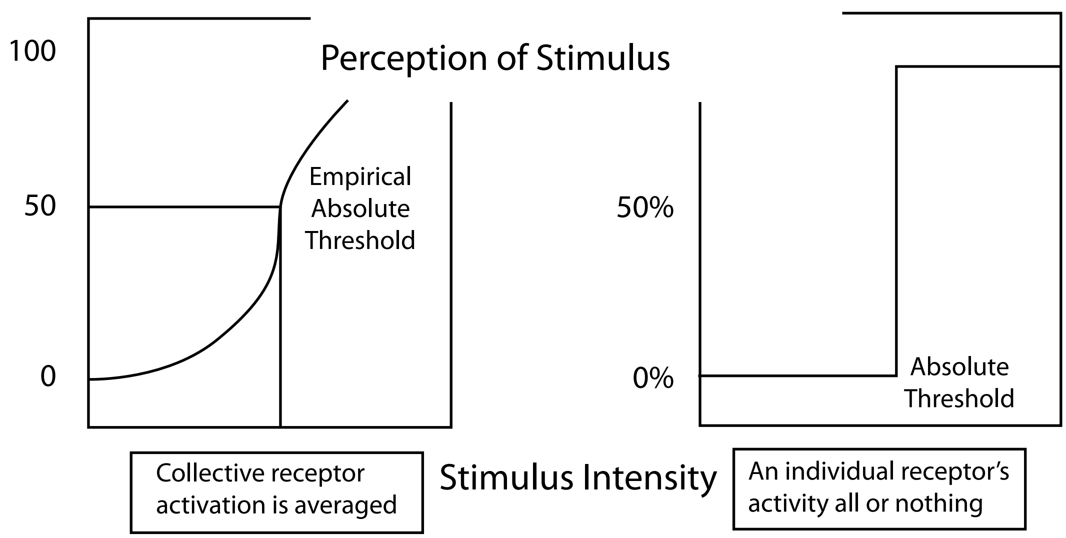


So, how come we can detect a stimulus on some occasions and not others? What are the specific psychological factors that affect our ability to detect stimuli? This variation in performance is actually seen in a lot of other assessments. For instance, how come professional basketball players can make 9 out of 10 free throws in a quiet practice but are lucky to make 6 out of 10 during a game? The answer is that the physical conditions necessary to perform well aren't always present. With sensory systems, variations are a product of the brain rather than muscle groups. In order to understand why we do well in some situations and not others, we need to consider the psychological variables that affect our performance. A number of psychological or non-sensory factors affect a person's performance when detecting a stimulus, and this is especially true regarding the body's ability to detect drugs. The top, most influential psychological factors include the following:

1. Motivation
2. Attention
3. Experience
4. Fatigue
5. Expectation
6. Drugs (or other drugs)

Whenever a stimulus is particularly weak (i.e., hard to detect), psychological variables are more influential than the sensory variables themselves. Imagine going to a highly anticipated party. Arriving a little late, you notice most everyone is already drunk. The music is blasting, and the party seems pretty chaotic. After a couple of drinks, you would be likely to join the momentum of the party. However, what if your drink didn't contain any alcohol or, alternatively, just contained a low dose of alcohol? Do you think you would be able to tell? Probably, like Nicole in the case study, the many factors influencing you at the party would be tremendously distracting, interfering with your ability to tell how intoxicated you were. The other factors would probably override the effects of alcohol until you had consumed a very large amount of it. Of course, by then you would be very drunk, and this factor would interfere with your ability to tell how drunk you were. This helps to explain why many people commit to drinking responsibly but get overwhelmed by situational factors at exciting events. Often, they end up realizing how intoxicated they are only after it is too late. Do you think someone would lose control of their drinking while sitting at home alone, drinking and watching television? Probably, they would not. Thus, factors like motivation, attention, and expectation play an enormous role in our decision making process. They often overshadow the actual stimulus, even familiar stimuli. Experience also plays a significant role and helps to explain why people over the age of 25 tend to get "wasted" less often than younger drinkers. Experience often comes with a greater ability to detect a stimulus, like alcohol, regardless of the situation. Older drinkers tend to pay more attention to interoceptive cues, using them to limit alcohol consumption. So, why is this important? It is important to understand that when people consume drugs, they are doing so to achieve a specific, predictable outcome; however, the situation and psychological variables are always changing, and these variables often impact how much of a drug a person consumes.

Data from absolute threshold experiments is typically plotted as a graph. A **psychometric function** is a graph describing the absolute threshold of a stimulus. Stimulus intensity is plotted on the X-axis (horizontal) and the percentage of detections is plotted on the Y-axis (vertical). Usually, about five to ten different intensities of the stimulus are used, progressing from nearly undetectable stimuli to ones that are easily detected. An accurate curve should form an S-shape or sigmoid curve. Data from the individual sensory cell, or receptor, is plotted on the right.



People may be unsure of whether or not they experienced a stimulus across a wide range of intensities or doses. Psychological factors are most influential during those doses. This is important because, on a conscious level, people self-administer drugs precisely because they want to experience a specific, perceptual state. Drug users run into significant problems when they do not pay attention to the dose of the drug and its resultant perceptual state because they end up administering too much. Remember, it's easier to detect a drug at higher doses. At a high enough dose of alcohol, regardless of the distractions in the environment, 100% of the users will recognize alcohol's effects; however, negative consequences occur at higher doses of most drugs, so the person may already be experiencing problems because of their intoxication.

In summary, abused drugs are very similar to conventional stimuli. Drug users learn the relationship between drugs and their effects. They actively seek the predictable, perceptual states produced by drugs.

Understanding Unconscious Learning

Simply put, **conditioning** is a type of learning based on the formation of new associations between a stimulus and a response. This type of learning is important in drug use because drug users quickly learn that certain stimuli (e.g., syringes, bongs, drug dealers, specific smells, and even certain locations) can come to predict the likely onset of drug effects. So, while the perceptual effects of the drug are readily apparent, as noted previously, the conditioning (or learning) surrounding those effects is not so obvious. These conditioned effects play a critical role in the initiation and maintenance of substance abuse behaviors.

Additionally, it is important to note that many of these associations are not the result of our will or conscious decision-making. If something occurs consciously, it happens within our realm of cognitive awareness. Therefore, the terms **subconscious** and **unconscious** describe events or processes of which we are not directly aware. Although we do not notice the occurrence of such events, they do shape our behavior. It is our general lack of awareness that makes this type of learning so powerful.

Music as a Stepping-Stone

To understand unconscious learning, consider how expectations play an important role in our everyday life. In fact, most of our behaviors are governed by unconscious expectations. For example, behaviors like driving, throwing or kicking a ball, and even reading may have taken considerable practice to be learned. Once they are learned, however, little if any conscious attention is required to carry out these behaviors. After these behaviors are well established, conscious thinking can actually interfere with the process. Listening to music is also an excellent example of a behavior that is dependent on expectations. What exactly makes a song "good?" Why do you like certain types of music and not others? Why does music have the power to tap into our emotions?

While those are fairly broad and deep questions, part of the general answer is that listening to music depends on expectations. For the purpose of this discussion, the term "expectation" refers to the subconscious patterns of stimuli the brain anticipates. Music is usually composed of fairly common musical patterns, most of which are repetitive. Many people, regardless of musical ability, can determine whether or not a given note fits in a song. Even people who can't sing in-tune can recognize when others sing off-pitch.

Throughout the course of your life, you've actually been exposed to thousands of songs and thousands of musical patterns. Despite the fact that there are thousands of artists writing countless compositions, many songs bear striking similarities, most notably in the progression of chords. The majority of popular songs that receive radio airplay are built from variations of a small, select group of progressions. Even if you've never heard a song before, the songwriter has written the song in such a way that the order of the chords makes sense. Often, we can tell what the first note of the chorus will sound like before we hear it for the first time.

It's also easy to tell when the chorus is about to begin. The drums get louder, the vocalist might raise his or her voice and hold out a note, and then, for a split second – the music stops. Right on time, the chorus starts, the instruments play just a little bit louder, and any tension that was building resolves. Even though we never realize it, a part of our brain "wants" the chorus to be a little bit louder. We "want" that abrasive note to resolve into the "proper" note. Expectations, even subconscious ones, naturally lead to tension as we await their fulfillment. It is amazing that we never really consider any of these musical elements when we're listening to a song, but in the end, we do know whether we like the song or not.

The greatest songwriters and composers have a thorough understanding of these expectations and manipulate them to alter our emotions. If it is difficult to accept that many of these expectations occur subconsciously, consider that there are many talented musicians who have never had any formal training. It's really amazing when someone picks up an instrument for the first time and can produce a melody that is pleasing. While professional composers often have more technical ways of dissecting chord progressions and discussing tension and suspense, the result of their workmanship is simply either that their music captivates their audience, or it does not.

Therefore, music demonstrates that the brain recognizes subconscious patterns. Based on preceding stimuli, the brain makes predictions about what stimuli are about to occur next. The brain works in a very similar fashion when it comes to anticipating abused drugs.

Why would the brain try to subconsciously predict drug use? The answer lies in the fact that the human body works very hard to maintain **homeostasis** (i.e., biological normalcy). Consider the temperature at which the human body operates best—98.6°F. If exposed to excessive heat, the human body responds by sweating, a process that aims to cool the body and thus return it to its original state of 98.6°F. If exposed to cold, the body will shiver, activating muscles to generate heat. Maintaining homeostasis is essential to survival. Many drugs alter other processes that are essential to survival, particularly heart rate and breathing. Drugs like cocaine can increase heart rate and blood pressure to lethal levels. Similarly, drugs like alcohol and heroin can depress heart rate and breathing enough to cause death. The body actively works to counteract these processes just as it does when it tries to maintain temperature. If a drug causes a decrease in heart rate, the brain will respond by sending signals to increase heart rate. Conversely, the brain responds to drugs that increase heart rate by sending signals to decrease heart rate. Learning processes allow the brain to take protection to the next level. In order to better protect the human body from harm, the brain tries to prepare the body for incoming drugs. Thus, it is important for the brain to learn subconscious patterns in the environment that can predict drug intake. After experiencing cocaine several times, the brain learns to decrease heart rate and blood pressure before cocaine ever makes it into the bloodstream. Thus, the environment and the stimuli contained in it serve an important role in activating learned processes that help to prepare the body for the administration of a particular drug.

Learning to Be an Addict

Case Study: Edward

Edward, a 16-year-old homeless boy, was addicted to heroin. He had little financial resources. Despite feelings of shame and guilt, he stole from people in order to purchase heroin. He engaged in only three activities: getting "high," recovering from the high, and buying more drugs to get high again.

Despite a strong desire to quit, Edward felt compelled to use heroin or similar-acting drugs, such as painkillers, when heroin was unavailable. Specific people, like drug dealers, the places where he bought and used heroin, and drug paraphernalia, all made him crave for heroin. At the same time, these drug-associated stimuli seemed to create physical symptoms of withdrawal such as dysphoria, nausea, headache, agitation, and insomnia. Sometimes, the feelings were overwhelming and resulted in uncontrollable drug-seeking behavior and subsequent drug use, reinforcing the vicious cycle.

Edward and several of his drug-using "friends" always used heroin together in the same abandoned house. One day, however, the police surrounded the house. Edward and his friends managed to escape. Later that night, Edward injected heroin in a nearby but unfamiliar location. Despite taking his usual dose, Edward died from an overdose.

The scenario in this case study is not altogether uncommon for heroin addicts. Although initially, they use and abuse a drug for the euphoria it produces, operant and classical conditioning tend to contribute greatly to the continued use of a drug, despite the desire to quit.

Operant conditioning is a form of learning that is based on the "law of effect." The law of effect states that in the presence of particular stimuli, behaviors that result in a positive experience tend to get remembered or repeated, while behaviors that result in a negative experience tend to be forgotten or avoided. This happened to Edward. Whenever he saw the place where he obtained heroin or met drug dealers, his brain remembered the "high" he would get after taking heroin and wanted to do it again.

Self-administration of an abused drug provides one of the clearest examples of the law of effect. Abused drugs produce immediately pleasurable experiences that users rapidly associate with stimuli in the environment. In the future, these stimuli trigger conditioned, or learned, responses tend to motivate the users toward repeated drug use. This form of learning is remarkable because users direct their own behavior but are unaware of the direct connection between environmental stimuli and learned responses (Tapert et. al., 2003).

After a drug is administered, it produces predictable and widespread changes in a person's biological systems. These changes, depending on the drug, often manifest themselves immediately as euphoria and alterations in the heart rate, blood pressure, metabolism, and gastrointestinal functions. These biological changes associate or pair with stimuli in the environment, which become conditioned. Repeated pairings of environmental stimuli and the particular drug effects cause previously neutral stimuli to take on powerful, predictive qualities. The more rapidly the drug works, the more rapidly the associations are formed—learning is highly affected by the time between drug administration and the onset of effects. The process by which neural stimuli are conditioned to a particular drug's effects is referred to as classical conditioning, also known as Pavlovian conditioning (Merkle, 1999).

Classical conditioning has five important components: the **unconditioned stimulus,** the **unconditioned response,** the **neutral stimulus,** the **conditioned stimulus,** and the **conditioned response**. Pavlov was famous for his experiments in which he trained a dog to salivate in response to the sound of a bell. Drug-related conditioning follows the exact same principles. In Edward's case, heroin was the unconditioned stimulus that produced immediate reflexive changes, or an unconditioned response, in his biological systems—euphoria and decreased heart rate, blood pressure, and respiration. The relationship between the drug and the response it produced was unlearned—Edward did not require any training to experience the effects of the drug. The neutral stimuli consistently present in the environment included drug dealers, the places where he purchased or injected heroin, and drug paraphernalia. These neutral stimuli, during the presentation of the unconditioned stimulus and the unconditioned response, served to predict the onset of drug effects. Over time, these neutral stimuli became conditioned stimuli, and their presence evoked biological reactions called conditioned responses.

Conditioned stimuli multiply quickly as drug use increases in frequency and duration. Each injection, inhalation, or drink serves as a conditioning session. Self-administering a drug produces rewarding effects—operant conditioning. The biological changes produced by the drug get paired with stimuli in the environment—classical conditioning. Since a drug user might self-administer a drug several times a day, for many years, an enormous amount of conditioning can take place. The longer a drug is used, the greater the conditioning, and, therefore, the more resistant the user is to forgetting about the use of the drug or, really, unlearning the associations.

Extinction is a valuable process in the treatment of drug addiction. **Extinction** is a naturally occurring process in which conditioned stimuli lose their meaning after they are repeatedly presented to a person without being paired with drugs. Extinction is also a type of psychological intervention that uses this naturally occurring process to treat addiction. The goal of this intervention is to systematically decrease the impact of conditioned stimuli on urges, withdrawal symptoms, and relapse. This is done by repeatedly exposing an addict to stimuli associated with drug use in the absence of the drug. These cues over time lose their predictive value, since they no longer predict that drug effects are imminent. An example of this would be repeatedly showing a heroin addict a hypodermic syringe while the addict is in a safe place, such as a treatment facility. This would slowly diminish the conditioned response associated with these objects—like reflexive changes in heart rate, blood pressure, and craving. The addict would be better equipped to re-enter society when the physical and psychological signs of urges or withdrawal symptoms are significantly reduced.

Since a conditioned stimulus serves to predict subsequent drug effects, the body responds reflexively. Classical conditioning alters biological systems in an opposite direction of the impending drug effect. This is an adaptive response aimed at maintaining relatively normal levels of biological function (i.e., homeostasis). In classical conditioning, previously neutral stimuli eventually serve to warn the body of a predictable drug effect. For example, heroin produces euphoria while decreasing heart rate and blood pressure; therefore, conditioned stimuli produce dysphoria while increasing heart rate and blood pressure. As a result, after the drug is administered, biological functions are less disrupted than they would be without the conditioned stimuli.

What would happen if familiar stimuli were absent during drug administration? For example, what would happen if a person used drugs in an unfamiliar location? In Edward's case, the different location played a principal role in his overdose. The drug produced a greater effect on his body because his body did not have a chance to reflexively adapt to the impending drug effects. The absence of conditioned stimuli prevented his body from reflexively preparing itself for the effects of the drug. The euphoria he experienced was more pronounced; however, decreases in vital reflexes, such as the heart rate, blood pressure, and respiration, were also more pronounced. The adaptive responses produced by classical conditioning would have elevated these vital reflexes. Since this didn't happen, Edward's vital reflexes decreased drastically after he injected heroin. This difference was significant enough to result in an overdose and death.

It's important to remember that almost anything can serve as a conditioned stimulus. Drug users often show biological reactions to even the sight of a picture of a house associated with drug use. Drug dealers, other drug users, and drug paraphernalia are common conditioned stimuli. Therefore, even when a user decides to quit using drugs, familiar environmental stimuli trigger biological and psychological responses equivalent to withdrawal symptoms (O'Brien and Mclellan, 1996; O'Brien, 2001). Despite efforts to the contrary, this leads to self-administration of the drug, resulting in more classical conditioning. This further reinforces the cycle of drug abuse.

Case Study: Sherri

Sherri had been smoking cigarettes for many years. She often stated that she was "completely stressed out." She frequently complained of being "anxious about an upcoming phone call or meeting." During these periods of heightened stress, she took a "smoking break." After she smoked, she reported feeling much better and the stress "magically" disappeared. Sherri was likely going through nicotine withdrawal, which is associated with a variety of physical and psychological symptoms often mistaken for stress or anxiety. Since operant and classical conditioning occur below a person's conscious awareness, people are not aware that these types of conditioning, not stress or anxiety, drives the drug-using behavior. In Sherri's and countless other cases, the drug alleviates the symptoms produced by conditioning, reinforcing the cycle of drug abuse.

Withdrawal from abused drugs is also a drug-induced state, although delayed (Stolerman and Jarvis, 1995). This state is also subject to the principles of operant and classical conditioning. Drug users often blame their withdrawal state on some causal environmental factor, such as stress or anxiety, and credit the drug with alleviating or reducing the aversive feelings. Therefore, feelings such as stress and anxiety are conditioned to become synonymous with drug withdrawal. This makes matters worse because stress, anxiety, and other negative feelings frequently occur for everyone, for a variety of reasons that have nothing to do with drugs. Drug users, however, have already established in their minds an effective strategy for dealing with these feelings—taking more drugs.

The cycle of drug abuse is difficult to stop because most drug users are not aware of the direct relationships between environmental stimuli, reward, and conditioned biological responses. They are, however, fully aware of the adverse experiences that result from these forms of learning or conditioning. Replacement drugs, such as the nicotine patch for cigarettes and methadone for heroin, are thought to work by reducing craving and withdrawal. They were also designed to reduce the impact of conditioned stimuli on biological and psychological systems. The long-term effectiveness of these replacement drugs, however, is still under debate.

Generalization and Discrimination

Case Study: Hernandez

Hernandez has developed an addiction to cocaine over the past year. He wants to quit, but struggles with the cravings. He walks home from work every evening and always passes his drug dealer who is parked along the street. His drug dealer drives a green car. Hernandez can always see the car off in the distance and, when he does, his cravings for the drug intensify severely. By the time he reaches his dealer, Hernandez is thoroughly craving cocaine and usually buys some. Recently, he began developing unexpected cravings at his sister's house. He often has dinner with her on her porch, overlooking her driveway. His sister also drives a green car, although a different make and model, which is clearly visible from where they eat. Frustrated, Hernandez stopped going to his sister's house for dinner. His sister doesn't know about his addiction, and Hernandez feared she would figure out what was bothering him. One evening, Hernandez walked home from work a different way in an effort to avoid his drug dealer. Much to his dismay, another dealer spotted him and tried sell him cocaine. Surprisingly, Hernandez managed to tell him "no" and avoided buying any drugs. He walked home in disbelief as the dealer drove away in a shiny, new silver pick-up truck. Hernandez still has a tough road ahead of him, but his recent victory has left him optimistic about staying sober for good.

Hernandez's story illustrates how our brain interprets stimuli in relation to previously made associations. In other words, the brain decides whether new stimuli are important or not by comparing them to similar things. In some cases, the brain will give meaning to stimuli that have never been associated with drug use. This happens because the new stimulus is similar to a previously conditioned stimulus and the brain interprets it to have the same meaning. This process is called stimulus **generalization,** and it occurs anytime a stimulus is given new meaning because that stimulus is similar to another meaningful stimulus. When Hernandez was at his sister's house, her green car was similar to his drug dealer's car. Through the process of generalization, his brain interpreted this car to signify that drug reward was available and imminent. This caused unexpected cravings and withdrawal symptoms.

Of course, the process of generalization does not always occur with every new stimulus a person encounters. Sometimes the brain will recognize the new stimulus as separate or distinct from other meaningful stimuli and will attach no meaning to it. This process is called stimulus **discrimination**. When Hernandez met with the second drug dealer, one he was unfamiliar with, he had an easier time controlling his urges. His usual dealer's car served as strong indicator for drug use, but since he walked home a different route, Hernandez was exposed to a different stimulus. The second dealer's pick-up truck wasn't similar enough to a green Honda Accord and didn't intensify his cravings. Additionally, the fact that Hernandez was talking to a different drug dealer was significant, and his brain discriminated between the two different dealers. In fact, everything he saw on his way home from work was different. As a result, his cravings were weaker, and he was able to overcome them.

Focus on Operant Conditioning

Case Study: Jake

Jake is a middle school student who enjoys playing soccer with his friends. Jake recently tried out for a travel league soccer team. Despite being a decent player, many of the other players who were trying out had been playing together for years. Jake was intimidated by the fact that almost all of the other players were friends, so he didn't play as well as he normally did. Since he played poorly, Jake didn't make the team. While no one ever made fun of him, Jake was embarrassed by the experience. After school one day, his friends told him how to get high using markers, modeling glue, and paint thinner—all stuff he had at his house. Jake wasn't interested at first, but he eventually decided to try it. He had been in a bad mood all week because he didn't make the team, and he was ready to do something fun for a change. Jake sniffed the markers and liked how he felt afterwards. The "high" from the markers served as an excellent distraction from his bad mood. Jake didn't realize it, but his negative feelings about getting cut from the soccer team had faded away. Jake began using markers, modeling glue, and paint thinner on a regular basis to get high after school. Every time he did it, the experience was so pleasurable that he couldn't wait to do it again. He especially liked to get high whenever he had a bad day because getting high helped him forget about his problems.

Positive reinforcement occurs when a behavior allows a person to experience something that is pleasurable. In turn, this increases the probability that the person will engage in that behavior in the future. In Jake's case, the euphoria he felt after using markers or other chemicals to get high was pleasurable. Since Jake liked it, he became more inclined to act in the same way in the future. This allowed him to get the same rewarding effects over and over again. In short, Jake's behavior, using markers and chemicals to get high, was strengthened by the pleasurable consequences of that action. Jake was able to get something he wanted by using drugs, and so he was more likely to use drugs in the future. The reinforcing properties of abused drugs and chemicals can lead to powerful operant conditioning, making drug-seeking behavior difficult to control—especially when the time between the administration and the high is very short.

However, there was another reason Jake kept using drugs. Whenever he had negative feelings, "getting high" got rid of those negative emotions. In short, his behavior took away something that was undesirable. The learning that occurs in this type of situation is called negative reinforcement. **Negative reinforcement** occurs whenever a behavior gets rid of something undesirable, and the person becomes more likely to engage in that behavior in the future, so the experience is positive because a bad thing is taken away. Another example of this is how pain medication can lead to abuse in older adults. The majority of older adults do not want to use pain medication to get high. If they develop an addiction to a painkiller, it is usually because they were trying to get rid of their pain, often from some sort of chronic injury. Pain, depression, and anxiety are all undesirable experiences, and people will often use drugs to remove them from their consciousness.

Remember that although people are sometimes aware of the implications of operant conditioning, the learning is often subconscious (i.e., taking place whether they realize it or not). For example, drinkers may claim they drink because they "have a better time" when they do. In reality, they might drink because they have subconsciously learned that drinking alleviates their social anxiety, and they "have a better time" as a result. Nevertheless, there are also conscious elements to operant conditioning. The original choice to use pain medication to alleviate back pain is both logical and conscious. Drug administration is also a voluntary action. However, repeated use becomes more than just a conscious choice. The environment heavily influences these actions. Recall that in operant conditioning, behaviors are preceded by stimuli that signal a consequence is available. The connections between these stimuli and the urge to behave in certain ways are always subconscious. Thus, suffice to say, operant conditioning is a process that always has subconscious and sometimes conscious, elements to it. Drug administration is a complex behavior governed by many factors, most of which occur outside of our conscious awareness.

Punishment

Case Study: Michael

Michael is a student in high school. His friends have been experimenting with alcohol, and he decided to go to a party with them. At the party, Michael got drunk after drinking too much "hard lemonade." He had no idea how much he was supposed to drink in order to get drunk. His friends told him that he should probably stop, but he wanted to impress the girls at the party and kept drinking. After a little while, he vomited and felt terrible for several hours. To make matters worse, Michael's parents found out about the party. They were furious with him and took away his car keys. He was "grounded" for a month and wasn't allowed to spend time with his friends. His parents also took away his allowance. Even though Michael had a negative experience, he was determined to keep experimenting with alcohol. Desperate to redeem himself, Michael headed to a party soon after his punishment was over. However, while he was at the party, he only had a couple of drinks. This time, he only drank beer and absolutely avoided "hard lemonade." After excessively drinking "hard lemonade," Michael never wanted to drink it again. Michael's behavior left him feeling terrible, and as a result, his future behavior changed.

The type of learning that occurs in this type of situation is called positive punishment. **Positive punishment** occurs whenever a person obtains something undesirable as a result of their actions. The person could experience something unpleasant internally like Michael did, but external consequences like a disapproving look or a slap on the wrist are also possible. With drugs, undesirable consequences are often due to the direct effects of the drug. Vomiting, hangovers, and terrifying hallucinations could all alter someone's future behavior regarding that drug.

Michael's behavior changed because he stopped drinking "hard lemonade." In fact, the probability of Michael drinking any alcoholic drink decreased, showing that his experience with "hard lemonade" generalized to other stimuli.

However, Michael's parents punished him differently. They did not give him something that he didn't want, like extra chores, but rather took away things that he wanted to keep. They did this to change his behavior. The type of learning that occurs in this type of situation is called negative punishment. **Negative punishment** occurs whenever someone's behavior causes him or her to lose something they want. Michael's parents took away his car keys, his allowance, and even a large portion of his freedom. Michael would rather have kept all of those things, and he became less likely to drink in order to maintain possession of them.

Understanding the two types of punishment can be particularly confusing for students because "positive punishment" is somewhat of an oxymoron. It is hard to conceptualize punishment as being "positive" because we often use "positive and negative" as synonyms for "pleasant and unpleasant." After all, punishment is always unpleasant. However, like the two types of reinforcement, "positive" indicates that the person is receiving something while "negative" indicates that something is being taken away. In essence, these terms describe how a person is being punished or reinforced.

Positive Reinforcement	**Positive Punishment**
Increases the probability of a behavior's occurrence Involves giving the person a desired stimulus	Decreases the probability of a behavior's occurrence Involves giving the person an undesired stimulus
Negative Reinforcement	**Negative Punishment**
Increases the probability of a behavior's occurrence Involves the removal of an undesired stimulus	Decreases the probability of a behavior's occurrence Involves the removal of a desired stimulus

Schedules of Reinforcement

Case Study: Frank

Frank is a 17-year-old boy who was recently arrested for stealing a car. He has been arrested for theft several times before, but this is the first time he has ever been charged with grand theft. He will likely spend several years in prison for the offense. Frank never thought he would go to jail, and he knows that his drug problems are responsible for his lifestyle and current predicament. Frank's story began when he was just thirteen. He lived in an area of town where there were a lot of drug dealers. One afternoon as he was coming home from school, one of his neighbors offered him some cocaine. He just gave it to Frank for free and told him to come back and see him if he ever wanted more. Frank used the drug, liked it, and asked his neighbor for more the next day. His neighbor ended up giving him drugs every time he asked for them for about a week. After a while, his neighbor told him he couldn't afford to give him any more for free. Since Frank didn't have any money, he told Frank to go shoplifting. His neighbor told him he would take the shoplifted items in exchange for the drugs. Frank had never stolen anything before, so when he decided to do it, he felt terrible. His neighbor took the CDs Frank had stolen and gave him cocaine. Every time Frank brought his neighbor CDs, his neighbor gave him more drugs.

Several weeks later, his neighbor started becoming pickier. Sometimes he told Frank that the CDs he stole weren't worth very much money. By then, Frank was starting to realize that his neighbor wasn't just trying to be helpful, but he was actually a drug dealer who was trying to make money off of him. In order to get more drugs, he started stealing more often. Despite his best efforts, his dealer started giving him drugs less and less of the time. Eventually, Frank never knew when he was actually going to get the drugs. He just kept stealing and giving what he stole to his drug dealer.

Frank spent four years living that way. Hoping to get more drugs, he started stealing from other places. He broke into homes to steal television sets and stereo systems. On the day he was arrested, Frank's dealer had asked him to steal a car. Frank thought stealing a car would enable him to trade for lots of cocaine, so he tried to steal one without really considering the consequences. Frank told the judge he had wanted to stop stealing after his previous arrests, but he had never been able to because of his drug problems. Frank recalled how his dealer kept demanding more valuable products in exchange for drugs and admitted he was lost in his destructive lifestyle.

Frank's story is typical of many drug users. In order to understand why Frank's behavior continued to change for the worse, it's necessary to understand schedules of reinforcement. Schedules of reinforcement describe how a person is rewarded for engaging in a specific activity. The first type of reinforcement schedule is called a **continuous reinforcement schedule,** where a person is rewarded every time he or she engages in a behavior. Frank was operating under this type of schedule when he first started using drugs. All he had to do was ask his dealer for drugs, and every time he did, his dealer gave him some. The other main category of reinforcement schedules is an intermittent reinforcement schedule. **Intermittent reinforcement schedules** occur when a person is not rewarded every time they engage in a behavior. They reward a person only some of the times that a person engages in a behavior. Frank began operating under this type of schedule when his dealer started becoming pickier. He no longer got drugs from his dealer every time he stole CDs.

There are four types of intermittent reinforcement schedules. They can either be fixed and predictable or variable and unpredictable. In addition to predictability, schedules are also classified by whether they reward a subject based on the number of times they engage in a behavior or if they reward a person based on his or her first response after a period of time (Powell, Symbaluk, & Honey, 2009). Therefore, **fixed ratio schedules** reward an individual for engaging in a behavior a set number of times. An example of this would have been if Frank's dealer had said, "Every third time you steal for me, I will give you drugs." A **variable ratio schedule** rewards a person for a behavior an unpredictable number of times. This is the type of schedule reinforced Frank's stealing because he never knew how many times he would have to steal before he got drugs.

The third type of intermittent reinforcement schedule is called a fixed interval schedule. A fixed interval schedule rewards a person for engaging in a behavior after a certain amount of time has passed. Therefore, time is really the defining factor of an interval schedule, although the person must still engage in the behavior to be rewarded. If Frank had been operating under this type of reinforcement schedule, his dealer might have said, "I'll give you drugs once each day in exchange for some CDs." In this hypothetical scenario, it would have made no difference if Frank stole CDs multiple times each day. He would only be able to exchange them for drugs once each day. The amount of time that needs to pass before the reward is available is predictable and constant. Therefore, the last type of schedule is called a **variable interval schedule,** and it rewards a person for engaging in a behavior after an unpredictable amount of time has passed. An example of this would be if Frank always had money to buy drugs, but had to wait until his drug dealer received a shipment of the drugs, and they both never knew when that shipment would arrive.

All of these different schedules of reinforcement affect behavior differently. Variable ratio schedules often produce the highest rates of response because the person never knows when their reinforcement is coming. Additionally, the reward is dependent upon the number of times they engage in that behavior. This type of reinforcement schedule is often seen at casinos, as a gambler might always be "just one more try" away from winning it big. Variable schedules are also harder to extinguish because it is difficult for a person to tell whether or not the reward is still available. If his dealer had decided to stop giving Frank drugs entirely but did not tell him, Frank probably would have kept stealing and bringing him items for a long time. Even after many unsuccessful attempts to get drugs, Frank might continue to believe that drugs were available if he kept stealing. After all, he would have no way of knowing that his drug dealer had no intentions of giving him any more drugs since he never knew when he was getting drugs in the first place. The technical term for the unusually strong resistance to extinction caused by variable reinforcement schedules is called the **partial reinforcement extinction effect**.

Needless to say, many people use the highly reinforcing properties of drugs to manipulate other people. His drug dealer was exploiting Frank. Unfortunately, some women fall into lifestyles of prostitution because they are manipulated like Frank. Understanding the rewarding properties of drugs and the power of variable schedules of reinforcement allows us to understand why people become trapped in lifestyles that are clearly harmful and destructive. In fact, many people who use drugs operate under a variable ratio of reinforcement because they have to engage in various behaviors in order to access drugs

Another process relating to changes in behavior is called shaping. **Shaping** is a process that rewards a person for engaging in behaviors that come closer and closer to resembling a desired behavior. Shaping affected Frank's behavior. The drug dealer was trying to get him to steal increasingly valuable items. In other words, Frank's drug dealer was trying to shape his behavior. Frank was first rewarded for stealing anything. Next, he was only rewarded for stealing expensive electronics from people's houses. Finally, Frank was rewarded for stealing cars. During each step, the intensity of Frank's stealing increased until he was willing to steal cars in exchange for drugs. His dealer was clearly trying to make more and more money off of him by obtaining increasingly more valuable items. Understanding shaping also helps to explain why people gradually engage in destructive behaviors.

Focus on Classical Conditioning

Case Study: Jane

Jane is a 26-year-old woman who loves to read. She works as an English teacher and teaches a course in British literature, her favorite subject. One of the things Jane loves most about her job is she has summers off so she gets to spend long evenings reading on her porch with her husband. Jane recently began smoking. While it had never interested her before, her husband smokes, and after trying a few of his cigarettes, she continued smoking. She found it quite relaxing to smoke a cigarette or two while she was reading in the evening. After several weeks of smoking, she noticed that she began to feel an urge to smoke whenever she was reading. Jane did not want to smoke as much as her husband, so this concerned her.

However, Jane continued smoking on the porch while she was reading. Once school started again in the fall, her teaching load made her busier then she had been in the past. Unable to spend her evenings reading on the porch, she still found time to read regularly in the library during her lunch break, something she had never done before. Much to her surprise, she began craving a cigarette while she was reading in the library. However, no one was allowed to smoke on school property, so she simply kept reading.

One morning, Jane came into work early to print off a test for her class. She went to the library and sat down at a computer. She suddenly had the urge to smoke again. Jane never smoked early in the morning, nor did she ever smoke in the library or while working on a computer. Concerned and confused, she shook her head and muttered, "What is going on?"

Jane was able to relax, however, when she thought about her upcoming vacation plans. She and her husband were headed off to see her parents in a few weeks. She pictured her mother's living room, imagining the fireplace and the Christmas tree. It was there she had spent many warm and cozy evenings reading as a child, and she was looking forward to seeing the rest of her family for the holidays.

When she and her husband arrived at her mother's house, the rest of her family was already gathered in the living room. Everything was just as she had remembered it. There was a brightly lit Christmas tree, and the fireplace was crackling softly in the background. As she sat down in a big comfy chair, she started feeling like she needed a cigarette. Since she didn't want her mother to know that she had begun smoking, she sat there, and the calm feelings in her heart were replaced by a growing tension.

Drug use often leads to cravings that escalate beyond a person's control. Unlike her husband, Jane only wanted to smoke during summer evenings while she was reading. Since reading was her passion, however, it was integrated into her life in more ways than she realized. Once she began reading and smoking at the same time, her brain learned an important connection between the two activities. Afterwards, whenever she was reading, her body expected nicotine from the cigarettes. As her body prepared to receive nicotine, she developed the urge to smoke whenever she was reading on her porch, regardless of whether she had wanted to smoke prior to that. The connection that her brain made between reading and smoking became stronger, and she began to experience the urge to smoke when she read in other places and at other times during the day. Every time she read in the library, she wanted a cigarette. This is simply the process of classical conditioning as it has been discussed so far.

What was truly disturbing for Jane, however, was when she began experiencing the urge to smoke when she wasn't reading. The first time this happened, she was in the library, printing off a test for her class. Her brain had begun connecting the library to reading, since she was reading in the library every day. Since her brain had already connected reading and smoking, it then connected the library and smoking. The technical term for this process is **higher-order conditioning,** and when applied to substance use, it occurs when a stimulus produces a learned response, even though that stimulus has never been associated directly with the drug. The newest conditioned stimulus produces a learned response because it is associated with another conditioned stimulus, rather than the drug itself. Essentially, the brain uses other associations as a bridge to connect the new stimulus to the drug.

A similar process occurred regarding her mother's living room. That living room was already heavily associated with reading before Jane ever started smoking. Her brain then used reading as a bridge to connect the living room and nicotine through a process called **sensory preconditioning**. The difference between higher order conditioning and sensory preconditioning is that sensory preconditioning relies on connections that were already made, prior to the start of drug use, while higher ordering conditioning forms connections after the person starts using drugs.

As you can see, the complex associations that the human brain makes can quite rapidly connect drug use to a variety of people, places, and things from our past. These connections continue to multiply as the brain learns and forms new connections. While the connections from higher-order conditioning and sensory preconditioning are weaker than those caused by basic classical conditioning, it doesn't take long before a person can feel like everything in their life is associated with drug use. Perhaps this is especially true of smoking, because smokers often smoke multiple times each day in many different environments. Since every puff of smoke is a conditioning trial, smokers go through thousands and thousands of conditioning trials each year. If a person smokes eight cigarettes a day and takes ten puffs of smoke from each cigarette, that person experiences 29,200 conditioning trials in the course of one year. It's easy to imagine how everything in that person's life could become connected to smoking. Therefore, as the brain expands the connections through higher-order conditioning and sensory preconditioning, it isn't long before that person's life revolves around smoking. This is one of the reasons why smoking is so difficult to quit.

Temporal Conditioning

Case Study: Vanessa

Vanessa has been smoking a pack of cigarettes every day since she was nineteen. Four years later, she is working at a restaurant, waitressing. She likes her job and works from 9:00 a.m. to 5:00 p.m. on weekdays. She makes a decent salary, and her boss is flexible with her schedule. She likes her boss because he makes an effort to be accommodating with the employees.

Vanessa smokes in a fairly set routine. She has a cigarette every morning when she wakes up. She also has one on her way to work. Vanessa is allowed to have three smoking breaks during her eight-hour shift. She takes them every time at the same day. She also has a cigarette when she gets off work. She smokes the rest of her cigarettes throughout the evening.

One evening, as Vanessa was finishing up her shift, her boss asked her if she could work for another hour. Vanessa agreed, remembering how her boss had helped her in the past. However, as time went on, she started to get very irritated with him for asking her to stay late. After all, she had already worked hard all day, and it wasn't her fault that someone had called-in sick. When she finally left, she made a rude comment to her boss on the way out the door. She smoked two cigarettes on the way home, and by the time she got there, she regretted saying anything to her boss. Later that night, she called him to apologize, saying, "I just don't know what came over me."

Many different stimuli can be paired with a drug exposure to create associations and conditioning. However, time itself can actually act as a stimulus. At first, Vanessa didn't mind staying late to help her boss. However, she was used to having a cigarette when she finished working her shift. Every day, at 5:00 p.m. when her shift ended, she smoked on the way home from work. This time of day, 5:00 p.m., was repeatedly paired with the effects of nicotine. When her boss asked her to stay late, she did not smoke at 5:00 p.m. and began going through withdrawal. This situation is not unusual as most coffee drinkers drink their largest dose in the morning and, if they miss their morning drink, they will usually experience a significant headache, even if they try drinking coffee later in the morning. This type of conditioning is called **temporal conditioning**. It occurs when time itself acts as the conditioned stimulus after being paired repeatedly with a drug exposure. Essentially, the body expects the same drug exposure at that specific time every day, and withdrawal occurs in the absence of a drug exposure at that time. Vanessa attributed the internal discomfort she was feeling to her boss when, in reality, her body was expecting nicotine and did not receive it.

The Role of Timing in Learning

Case Study: Bobby

Bobby is a 30-year-old who works at a retail store. His best friend started snorting cocaine and couldn't stop talking about how awesome it was. He constantly told Bobby he had to try it. So, after being worn down by his friend's constant "sales pitch," Bobby began using it when they hung out and partied together. Bobby's wife was furious when she found out he had started using cocaine, and they began fighting frequently. However, Bobby's boss was unaware of his drug use. Bobby was able to stay sober for work, and his coworkers never suspected he had developed a drug problem. Bobby also played on a recreational soccer team, a sport he loved and played since he was little kid. The cocaine use didn't seem to interfere with his ability to play soccer after work, as he never used cocaine unless he had free time, which was mainly on the weekends.

After several months, Bobby went to buy cocaine from his dealer. His dealer lied to him and told Bobby he didn't have any cocaine—all he had was crack. The dealer told him it was the same thing anyway, but that Bobby would just have to use it differently. Bobby was headed over to his best friend's house, so he decided he would give it a try and bought the different type of cocaine. Bobby and his friend couldn't believe how strong crack was compared to cocaine—and it was cheaper too. The rush of euphoria happened so much faster and was so much more powerful. Several hours later, Bobby and his friend went back to their dealer and bought more crack. After using it again, they got drunk and passed out at his friend's house. The next day, Bobby used crack again. Bobby was feeling terrible on Monday, so he told his boss he was sick with the flu. He promised himself he would sober up, but by the end of the day, he broke down and bought more crack cocaine. Within a week, he had a serious addiction problem, and his life was spinning out of control.

Bobby was unable to stay sober during the week, but his boss told him he couldn't miss anymore work. In response, Bobby started going to work high. It wasn't long until his boss realized what was happening. Bobby got fired and started to steal to support his drug habit. Bobby's wife tried to help him with his addiction, but he became violent and abusive when he couldn't obtain crack and went through withdrawal. Bobby began stealing more to support his drug habits, and he was arrested for shoplifting twice. Bobby stopped paying his bills and defaulted on the loan for his house. When the bank repossessed his house, his wife lost hope in Bobby and left him. Homeless, Bobby began sleeping on the street and continued to use illegal means to support his addiction. He no longer cared about anything other than crack.

The human brain is constantly learning through operant and classical conditioning as it makes associations beneath our conscious attention. However, not all associations are equally strong or have equal effects on our behavior. How does the brain know which associations are important, and for that matter, how does it know which associations are meaningless?

One important factor that the brain utilizes to determine the importance of an association is timing. In classical conditioning, the less time that occurs between the presentation of the unconditioned stimulus and the neutral stimulus, the stronger the association or learning that takes place. The same trend holds true in operant conditioning. The sooner the consequence occurs after the behavior occurs, the stronger the association. This plays a particularly important role in substance abuse and addiction.

Would anyone drink alcohol to get drunk if they experienced their intoxication twenty-four hours later? Of course they wouldn't. If alcohol's effects took twenty-four hours to take place, no one would use it; really, what would be the point? However, what if alcohol only took six hours to work? Surprisingly, alcohol can be absorbed through the skin. If an individual sat in a tub of alcohol for about six hours, they would get just as intoxicated as if they had drunk the alcohol. Of course, no one uses alcohol this way because you would need a lot more alcohol and a lot more time.

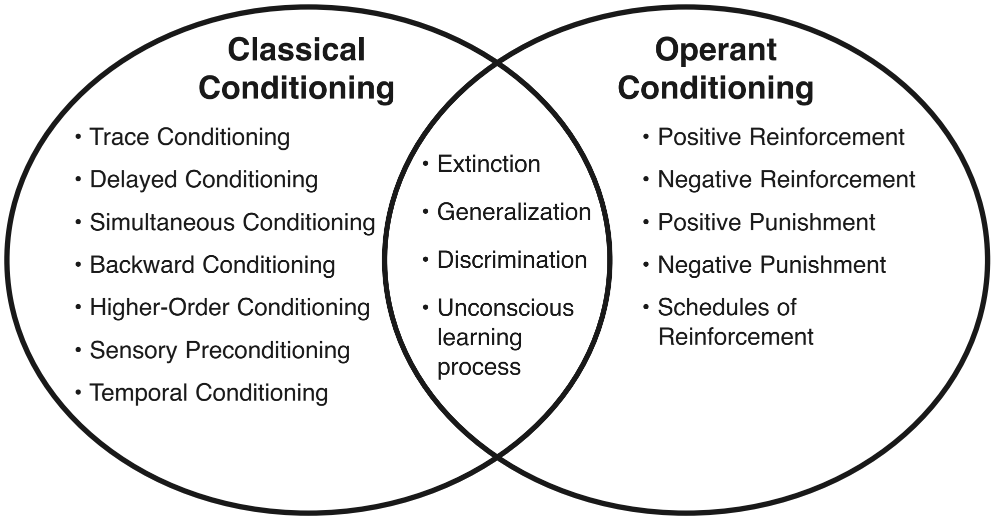
Drugs of abuse usually act incredibly fast. The faster they act after administration, the higher the abuse potential for that drug. In the 1980s, cocaine was quite popular in the United States. Some individuals snorted cocaine regularly for months or even years, but were not actually addicted to the drug in a broader sense. While frequent cocaine use probably impacted their relationships, occupations, and hobbies negatively, they were still able to have a life with all of those things in it. However, as crack cocaine became available, those same individuals stopped snorting cocaine and started inhaling it. After just a short period of use, they lost control of their lives and became addicted to the drug. Their relationships disintegrated, they lost their jobs, and they abandoned their hobbies in pursuit of crack cocaine.

Clearly, there was a difference in how the two forms of cocaine impacted the lives of individual users. However, functionally, cocaine affects cells in the brain the exact same way, regardless of whether it is snorted as cocaine or smoked as crack. When someone snorts cocaine, it takes about 3 to 5 minutes for the drug to take its full effect while inhaling cocaine produces an even more powerful effect in just 3 to 5 seconds. Therefore, the time delay between the administration of the drug and its effects is about 10 times shorter through inhalation. In fact, the timing difference between inhalation and snorting cocaine is particularly pronounced, more so then with other drugs, because cocaine constricts blood vessels. When it is snorted, the blood vessels in the nasal membrane constrict, which slows down the absorption of the drug. Similar differences in timing exist between snorting and injecting cocaine for the same reasons, and injection leads to a faster euphoria and higher rates of crippling addiction.

For inhalation and intravenous injection, the connection between the drug and the euphoria is "easier" for your brain to understand because the euphoria occurs right after the drug is administered. The brain uses time as an indicator for the importance of this relationship, and develops a powerful association between the drug and its effects. Later, whenever the brain recognizes that the drug is available, it also knows that euphoria is available. This creates the powerful drug cravings that lead to addiction.

The importance of timing is also evident in classical conditioning. How a stimulus precedes a drug exposure determines how well the brain learns the connection between that stimulus and the drug's effects.

Summary of Learning Processes



*This figure is a categorical summary of the different learning phenomena inherent to classical and operant conditioning.

Timing: Reward versus Punishment

Case Study: Jillian

Jillian wasn't a very popular student in high school. She did well in her classes, and other students made fun of her because she was smart. Jillian reacted by becoming withdrawn. She looked forward to college, hoping to create a new life for herself. When she finally graduated from high school, she was determined to have more friends. Her loneliness in high school had led to depression at times, and her counselor told her she needed to form healthy friendships. When she arrived at college, she liked her roommate and was able to get along well with her. They became best friends. Jillian's roommate taught her how to relax, have fun, and be more social.

At first, Jillian wasn't particularly interested in drinking, but her roommate frequently went out to parties. Despite being at a college with thousands of other unique and diverse students, Jillian began to believe that all students got drunk on the weekends. In fact, even during the week, many students came into class talking about how they had been drinking the night before. Jillian began drinking as a means of meeting new people. Much to her surprise, she fit in quite well. Alcohol relieved some of her social anxiety, and she was able to develop friendships as a result. Jillian selected this particular college because, out of all the offers she had received, it gave her the most financial aid. However, her scholarship had a strict minimum grade point average requirement. If she dropped below the threshold, she would still be able to attend school, but the funding she received would decrease dramatically.

Unfortunately, that's exactly what happened to Jillian. As she began drinking and hanging out with her friends more, she began spending less time reading and studying for exams. She was surprised when she received mediocre grades, but she blamed them on her professors instead of her study habits. When her funding got cut, her parents suggested that she transfer to a less expensive college. Jillian was content with her life (i.e., friends, hangouts, and partying), so she decided to take out student loans instead of transferring. During her senior year, she applied to several graduate schools, hoping to pursue a doctorate in English. However, she didn't get accepted because her grades were not good enough to be competitive. She began work immediately after graduation and worked for years to pay off her student loans. Once she became involved with her career, she never went back to school.

Jillian's experience with alcohol demonstrates how drug use can be simultaneously rewarding and punishing. She liked to drink because it helped her make new friends. Every time she went out drinking, she got exactly what she was looking for—a positive social experience. However, the cost of her drinking was also significant. She stopped doing as well in school, and she eventually lost her scholarship. She had to take out thousands of dollars in loans and got rejected from graduate schools.

As discussed in the preceding paragraphs, timing is critical to learning and plays an important role in addiction. Our brain struggles to learn the consequences of an action if there is a long delay between the action and the consequence. This often leads to poor decision making as people frequently have to choose between immediate and delayed rewards. Jillian often chose immediate rewards. She went drinking, which was immediately reinforcing. However, drinking was also punishing for her because she cared about her grades and getting into graduate school. She also had to pay thousands of dollars in student loans as a result of her drinking. Notice that all of these consequences came weeks and even years after her decision to drink. Her decision to drink was both reinforced and punished, but her brain learned that alcohol was a solution and not a problem.

The fact that our brain learns immediate consequences better than delayed consequences helps to explain much of human behavior. Some people develop the habit of procrastinating for this reason. It is immediately rewarding, but the long-term effects are detrimental. Crime often accompanies addiction, and people can spend years in prison as a result of their immediate need to satisfy their addiction. The human brain is so poor at recognizing the long-term consequences of drug use that people will often deny that it affects them negatively in any way. Almost all of our actions have both reinforcing and punishing aspects, but how we evaluate and interpret those consequences is crippled by our brain's tendency to favor immediate rewards over long-term ones, despite the fact that long-term consequences often overshadow immediate gains. This is almost always true with drug abuse.

Cycle of Drug Use and Addiction

Up until this point, the processes of operant and classical conditioning have mostly been discussed separately, for the sake of clarity. It's important to note, however, that both operant and classical conditioning happen simultaneously and work together, leading a drug user/abuser towards greater addiction. Every time a person self-administers a drug, operant conditioning associates the action of administering a drug with its rewarding properties, leading to positive reinforcement. Operant conditioning also incorporates the environment, using stimuli in the environment to serve as indicators. These indicators allow the brain to recognize when the rewarding properties of the drug are available to the user, producing an urge to respond by administering the drug. Operant conditioning leads to compulsive behavior because the cues in the environment indicate that a very powerful reward is available and that reward can be obtained by using the drug.

In classical conditioning, the environment also becomes associated with the effects of the drug. It teaches the brain to expect the drug in certain situations, and the brain responds by producing effects to counteract the imminent drug. The symptoms produced by classical conditioning are the same symptoms as those produced by withdrawal. Of course, the drug will counteract these effects and alleviate them, making the drug even more desirable. This strengthens compulsive drug seeking behavior.

Ironically, when a person alleviates these withdrawal-like symptoms caused by classical conditioning, further operant conditioning takes place. This time, operant conditioning teaches the brain that relief is available if the person responds to withdrawal symptoms through drug administration, leading to negative reinforcement. The processes begin to build upon one another, leaving the brain with a complex entanglement of associations that push the user towards compulsive drug use. This complex cycle is very difficult to break and usually leaves the user trapped in addiction.

Replacement Therapies

The objective of drug replacement therapies is to help manage the physical withdrawal symptoms associated with substance abuse by providing the drug user with a low, but constant, supply of the abused drug. An example of drug replacement therapy is the use of nicotine patches instead of cigarettes.

Strengths of Replacement Therapy	Weaknesses of Replacement Therapy
• Often, the administration route of replacement drugs is much safer than the original route, such as injections or smoking.	• If a person is unable to quit consuming the drug, then replacement therapies can result in drug overdose.
• The total amount of drug used is generally less than what would be used without the replacement drug.	• If the drug negatively impacts a person's health, then replacement therapy might further contribute to health problems.
• It may reduce withdrawal symptoms, such as irritability, dysphoria, and restlessness.	• Often, replacement therapies don't impact and eliminate the unconscious, learned processes that contribute to cravings and urges.

People often wonder why replacement therapies are not addicting. As discussed in Chapter 1, replacement therapies often utilize a different route of administration. Since they utilize routes of administration that are slower than the route used compulsively, the brain has more difficulty learning the association between the drug and its effects. The effects of the drugs are less detectable because the dosage is distributed across a longer period of time as well. This makes the concentration of drug in the bloodstream lower at any given point in time. Smoking leads to a giant peak in nicotine levels, while the nicotine patch results in a much lower overall effect. While this may be enough to block withdrawal symptoms, less noticeable effects are also harder for the brain to remember. Thus, the brain has difficulty establishing a connection between a replacement therapy and its effects because of the large latency and the dispersed dosage. Consequently, replacement therapies do not result in compulsive use.

It is important to remember that the environmental cues, given meaning by operant and classical conditioning, predict a rapidly acquired, high concentration of drug in the user's brain. When the brain recognizes these environmental cues are present, it rapidly prepares for the drug and produces biological changes opposite to the expected drug's effects. Replacement therapies do not offer a high enough concentration to compensate for this extreme change in a person's biological symptoms. Similarly, administering a replacement therapy in response to a craving won't help an individual because they take too long to act. These weaknesses severely limit the effectiveness of replacement therapies.

In response to these weaknesses, some newer replacement therapies for nicotine try to help users quit smoking without ending their addiction to nicotine. While this may at first seem pointless, some companies are beginning to sell small devices that administer a cigarette-sized dose of nicotine through inhalation. The advantage of this type of replacement therapy is it disconnects the user from all of the tremendous health risks of smoking tobacco, since the other chemicals in smoke, and not nicotine, cause most of the health hazards of cigarettes. Some of these devices, such as various electronic cigarettes, are designed to produce the exact same stimuli as an actual cigarette. They are shaped like cigarettes, produce fake smoke, and have glowing tips. In theory, generalization should occur, and these "fake" cigarettes should satisfy the user's cravings. Such a replacement strategy is obviously not possible for most drugs since the health problems produced by most other drugs are caused by the drugs themselves and not the chemicals with which they are combined.

SUMMARY

In this chapter, you learned about the sensory system and how drugs affect it. You learned that drugs act the exact same as other stimuli, like lights and sounds, but bypass much of the peripheral sensory systems and act directly on perceptual centers in the brain. It is for this reason that we can perceive the effects of a drug—both in type and intensity. Hallucinations are caused by the abnormal functioning of sensory systems, often by changing neural activity in the areas of the cortex responsible for interpreting sensory information.

Additionally, you learned about the powerful subconscious roots of addiction. Classical conditioning is a subconscious learning process by which previously neutral stimuli begin to predict imminent drug use. Classical conditioning allows the brain to detect regular patterns in the environment that always precede drug use. When the brain detects these stimuli, it reflexively alters biological processes to minimize the effects of the incoming drug. In other words, classical conditioning allows the body to predict imminent changes in homeostatic processes and preemptively compensate. Because classical conditioning is a subconscious process, it cannot be controlled. When users detect conditioned stimuli, they experience withdrawal-like symptoms. Drug users have already learned how to effectively eliminate these withdrawal-like symptoms—by administering the drug. As such, classical conditioning represents a serious barrier for addicts trying to quit. Classical conditioning also has important implications for overdoses. If the conditioned stimuli normally associated with drug use are absent prior to the administration of the drug, the body won't be as prepared for the drug as it normally is. This can result in an overdose when someone takes their normal dose of the drug.

Operant conditioning is another form of subconscious learning that contributes to addiction. In this form of learning, the brain forms connections between a stimulus, behaviors that occur in response to that stimulus, and the consequences of that behavior. In terms of addiction, this means the brain is forming associations between sensory information that signals drug use (ex. the sight of the drug), the act of administering the drug (ex. snorting it), and the effects of drugs (ex. euphoria). Operant conditioning explains how people are more likely to engage in behaviors that result in positive outcomes compared to behaviors that result in negative outcomes. Operant conditioning leads to drug cravings that are triggered by stimuli associated with drug use.

The strength of both the classical conditioning and operant conditioning that takes place with each drug administration depends on the intensity of the drug's effects. The strength of conditioning is also affected by the delay between the administration of the drug and the onset of the drug's effects. This explains the different levels of compulsive use seen for different routes of administration for the same drug. The importance of timing in learning is also particularly present in operant conditioning because drugs often produce many effects. Some of these are positive (ex. euphoria, reduction in anxiety) while others are negative (ex. hangover, legal problems). While the positive effects of drugs are immediate, the negative effects of a drug tend to be delayed. The operant conditioning linking drugs to desirable outcomes is often quite strong because those effects occur immediately after use. In contrast, there is little subconscious learning that takes place to steer the user away from drug use because the negative effects of drug use are delayed and not readily associated with the drugs. This helps to explain why a user might continue to use a drug despite the adverse consequences incurred over time.

Key Words

Sensations	Spatiotemporally Universal	Potential Stimuli
Perception	Sensory Receptors	Exteroceptors
Proprioceptors	Interoceptors	Photoreceptors
Mechanoreceptors	Chemoreceptors	Thermoreceptors
Nociceptors	Transduction	Receptor Potential
Generator Potential	Neural Encoding	Temporal Codes
Spatial Codes	Modality	Intensity
Duration	Location	Psychophysics
Absolute Threshold	Psychometric Function	Conditioning
Subconscious and Unconscious	Homeostasis	Unconditioned Stimulus
Unconditioned Response	Neutral Stimulus	Conditioned Stimulus
Extinction	Generalization	Discrimination
Positive Reinforcement	Negative Reinforcement	Positive Punishment
Negative Punishment	Continuous Reinforcement Schedule	Intermittent Reinforcement Schedule
Fixed Ratio Schedule	Variable Ratio Schedule	Variable Interval Schedule
Partial Reinforcement Extinction Effect	Shaping	Higher-Order Conditioning
Sensory Preconditioning	Temporal Conditioning	

Case Studies

Nicole	Edward	Sherri	Hernandez
Jake	Michael	Frank	Jane
Vanessa	Bobby	Jillian	Alan

Assessment

1. In classical conditioning, the drug serves as the __________, while drug related paraphernalia serve as the __________?
   A. Unconditioned response; conditioned response
   B. Conditioned response, unconditioned stimulus
   C. Unconditioned stimulus; conditioned stimuli
   D. Conditioned stimulus; conditioned response

2. The process by which the impact conditioned stimuli have on urges, withdrawal, and relapse is systematically reduced is called __________?
   A. Extinction
   B. The law of effect
   C. Withdrawal
   D. Tolerance

3. Classical and operant conditioning have a powerful impact on compulsive drug use and are often resistant to change for what reason?
   A. They occur below a drug user's conscious awareness.
   B. Biological interventions are the only way to treat problems related to conditioning.
   C. Medical treatments often negatively impact learning.
   D. Substance abuse interferes with learning.

4. Which type of operant conditioning reduces the likelihood of a behavior's future occurrence by the removal of a desirable stimulus?
   A. Positive reinforcement
   B. Negative reinforcement
   C. Negative punishment
   D. Positive punishment

5. Which of the following is a true weakness of replacement therapies?
   A. Replacement therapies can do nothing to stop the withdrawal symptoms directly related to tolerance during the first three weeks of abstinence from a substance.
   B. Replacement therapies use substantially higher doses of the drug in order to block symptoms.
   C. Replacement therapies often utilize a more dangerous route of administration.
   D. If a person is unable to quit using the drug, the replacement therapy can contribute to an overdose.

Ethical and Reflective Question

One of the biggest problems on college campuses today is drinking. Many administrators, faculty, and student groups have tried various campaigns to help curb high risk drinking but they have had little success. A new faculty member in psychology decided that perhaps working directly with those at risk for drinking would be more effective than campus wide prevention methods. His plan was to allow students, over 21, to drink alcohol and help train them to be more aware of alcohol's subjective effects. The faculty believed that if students could be trained to be more aware of alcohol-related effects, then they would drink less.

The administration had significant concerns about giving students alcohol. What are some of the pros and cons to developing a training program focused on monitoring the subjective effects of alcohol? Also, specifically discuss the ethical issues surrounding this new training program.

EVALUATION CRITERIA:

The students should have been able to do the following:

- Discuss how alcohol can produce subjective, perceptual effects that can be measured.
- Understand that drug perceptions are standard stimulus-response patterns.
- Demonstrate an understanding of the pharmacological principles behind the subjective effects of abused drugs.
- Describe to what degree this program would likely work or not.
- Discuss relevant ethical issues related to giving students alcohol and teaching them to gauge their level of intoxication.

Discussion Questions

Discussion Question 1:

Jack has had a problem with heroin for several years. Despite several meaningful attempts to quit, he has not been able to.

He recently placed himself in yet another intensive inpatient treatment program. The effort, however, seemed pointless because the result was another failed attempt at escaping the terrible cycle of heroin abuse that destroyed his life. He confessed that his biggest problem was and continues to be the cravings that seem to overtake him after he is back in his regular routine. He can't verbalize why it is so difficult to break the cycle, but he states that he would definitely like to break it.

Explain how factors related to learning such as classical and operant conditioning can impact his craving for heroin. In addition, discuss how craving is different from withdrawal.

Discuss several reasons why the intensive inpatient program failed. Take into account the fact that the entire treatment program occurred in an environment different from the real world, a world that people need to reenter. Do you think an intensive outpatient program might be more effective? Provide rationale for your answer.

Apparently, Jack's feelings of craving and withdrawal are quite debilitating. One possible option is methadone, a substitute drug with less abuse potential. Explain how such a drug works and discuss the benefits and problems associated with providing an addict yet another addictive drug to help with his existing drug addiction.

EVALUATION CRITERIA:

The students should have been able to do the following:

- Differentiate between craving and withdrawal and the causes of both.
- Demonstrate an understanding of the pharmacological principles used to manage drug withdrawal and minimize craving.
- Elaborate why the inpatient treatment failed.
- Provide a logical explanation for why an intensive outpatient treatment might or might not be more effective.

Discussion Question 2*:*

Drug addiction, among other things, is a learned behavior. People, places, and sensory events become associated with drug use and serve to activate cravings, urges, and withdrawal. One of the most difficult aspects of cessation (quitting) is dealing with cravings, urges, and withdrawal. Often, the substance abuse treatment occurs among people, doctors and nurses, and hospitals and/or treatment facilities that are very different from one's usual living environment and routine.

Still even after completing an intensive inpatient program, many people return to their usual routine and, despite not wanting to return to drug use, find themselves overwhelmed with the desire to use drugs again. Many feel unprepared for these feelings and don't report consuming drugs while in the hospital. Do you think it would be easier to quit drugs while in a hospital or in one's own home and community? Why do you think so? What, according to you, are the factors that activate the desire to use drugs? What suggestions do you have for people who are about to leave the hospital after a "successful" treatment program?

EVALUATION CRITERIA:

The students should have been able to do the following:

- Develop an appreciation for the complex and highly subjective aspects of conditioned drug reactions and their contribution to relapse.
- Describe several problems associated with drug cessation programs that occur outside of the users usual routine.
- Suggest several ideas for reducing feelings of cravings, urges, and withdrawal among drug abusers.

Application Question

Replacement Therapies—Are They Effective?

Drug replacement therapies were used for years to help substance abusers deal with heroin, nicotine, alcohol, and other drug addictions. Their long-term success, however, was unimpressive.

In a one- to two-page paper, discuss the theoretical underpinnings for this type of therapy; that is, how are these replacement drugs thought to work? What are the strengths and weaknesses of drug replacement therapies?

In your paper, you should include important drug-related terminology such as the following:
(1) Mechanism of action
(2) Half-life

(3) Route of administration
(4) Strength of effect

Using these terms, describe the optimal pharmacological profile for a replacement drug (short activating vs. fast acting, short effects vs. prolonged effects, limited strength vs. full strength, inhaled vs. swallowed). In addition, explain how learning—classical and operant conditioning—is thought to impact the effectiveness of replacement therapy.

EVALUATION CRITERIA:

The students should have been able to do the following:

- Explain and analyze the strengths and weaknesses of drug replacement therapies.
- Utilize appropriate pharmacologic terms to describe an ideal drug replacement therapy.
- Describe the relevance of classical and operant conditioning to craving and their response to a drug replacement therapy.