Science Education Collection

An Introduction to Reward and Addiction

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Abstract

Consequences play a major role in controlling our behavior. If the consequence is a reward, then it encourages the associated behavior. Rewards can come in many forms such as a pleasant feeling, money, or food. However, sometimes an individual engages in compulsive behavior despite of negative consequences, and this state is known as addiction. Administration of addictive substances is neurochemically rewarding, which ultimately causes a loss of control in limiting the intake. Scientists aim to better understand the mechanisms behind these concepts and subsequently develop new therapies for treating substance abuse disorders.

JoVE's introduction to reward and addiction explains the neuroanatomical components of the reward pathway. This is followed by some of the important questions asked by behavioral researchers such as how does our brain chemistry change in response to drug use. Prominent methods section reviews some of the tools being employed in the field, like self-administration protocols. Finally, the video discusses example experiments conducted in labs interested in investigating reward and addiction.

Transcript

Humans and animals frequently engage in behavior, which is motivated by reward. An example of such a behavior is increased intake, which is often repeated due to pleasurable feelings induced by the rewarding substance. There are two types of rewards: natural and artificial. Examples of natural rewards are food and social interactions, whereas artificial rewards can come from the use of drugs or alcohol.

Addiction is a state in which an organism engages in compulsive behavior despite being faced with negative consequences. This type of behavior is neurochemically rewarding, and ultimately causes a loss of control in limiting intake of an addictive substance. This video presents the neuroanatomy of the reward pathway, introduces key questions asked by reward and addiction researchers, describes some prominent methods, and discusses applications in this field.

Let's begin by learning a few key anatomical structures that are important for how the brain processes reward. This is your brain sliced in half. The colored areas are a part of the reward pathway, more specifically known as the mesolimbic dopamine system, which is the primary circuit that controls responses to rewards. When you first experience pleasure, your brain releases a neurotransmitter called dopamine.

Dopamine is primarily found in the ventral tegmental area, or VTA, in the midbrain. The VTA sends dopamine to many areas in the brain, such as: the amygdala, which regulates emotions; the nucleus accumbens, which controls motor functions; the hippocampus, where memories are formed; and the prefrontal cortex, an important area for decision-making and attention.

How do all these areas work together to make rewarding feelings? Think of eating a piece of cake. As soon as you take a bite, the VTA releases dopamine to all of these regions. Your amygdala tells you "This is delicious...this makes me very happy right now," and your hippocampus then remembers details about the experience, such as whose party it was where you had the cake.

Your prefrontal cortex helps focus your attention on the cake. When the nucleus accumbens, also known as the "pleasure center," is stimulated, it causes you to pick up your fork and take another bite. Your reward system is reactivated with each bite, causing these continued pleasurable feelings, which can cause addictive behavior if repeated too often.

Now that we've reviewed the anatomical pathway of reward, let's examine some of the fundamental questions asked by reward and addiction researchers today.

To begin, when drugs enter the body, what are the chemical and functional changes that happen as a result? Drugs like cocaine overstimulate the brain's reward system. Think of your brain as a large kitchen sink with water as dopamine molecules flowing through it. If you block the drain with a rubber stopper, the water will overflow and spill out of the sink. Cocaine acts like this rubber stopper in your brain. Dopamine naturally circulates in the brain. Cocaine molecules block the dopamine transporter and stop the natural reuptake of dopamine into the neurons. This causes a large excess of dopamine in the synapse. This "overflow" of dopamine causes feelings of pleasure and euphoria.

Another question posed by researchers in this field is: what causes relapse? Addiction has been characterized as the compulsion to seek out a substance to feel a sense of reward leading to intoxication or binge. When access to the substance is prevented, it causes unpleasant withdrawal symptoms, such as insomnia or anxiety, followed by a sense of craving which may lead to relapse. Relapse is very common in substance abuse, and researchers are interested in studying environmental influences that typically drive an individual to use the drug again.

A final question frequently proposed in this field is: what types of behaviors are associated with addiction? When a rat must decide which aperture contains the food pellet, it becomes harder to make any accurate decisions when under the influence of a drug. In addition, lack of attention and poor impulse control are commonly observed during addiction, and researchers are interested in studying the mechanisms behind these behavioral effects of addictive substances.

Now that you have a feel for some of the key questions asked by reward and addiction researchers, let's look at some of the prominent methods used to answer them. Self-administration studies are very common in this field, where a drug, such as cocaine, is administered by the animal through a cannula attached to its brain. The use of light cues and levers signal the availability of the drug, and allow the animal to control drug intake depending on how often it presses the lever.

Another method frequently used to study reward and motivational behavior is called "conditioned place preference." This method typically has three stages, which begins with habituation, where the rat is placed in a two-chamber cage for about 20 minutes. The rat learns how to associate the light and lever with drug or reward delivery. In the conditioning stage, the center panel is blocked so the rat is confined to one side of the cage in which it can repeatedly press the lever to receive either a drug or saline. Finally, during the place preference stage, the rat can now move freely into both compartments. The scientist must now compare the amount of time the animal spends in each compartment. Typically the animal will spend more time in the compartment with the drug.

Finally, a widely used method of studying reward behavior is through operant conditioning. This type of conditioning attempts to associate a behavior with a positive or negative consequence. For example, when a rat presses a blue button he receives a food pellet as a reward, but when he presses the red button he receives a mild electric shock as a punishment.

Now that you're familiar with some common research approaches, let's look at some applications of reward and addiction research.

Self-administration of ethanol into an animal via microdialysis is a precise approach to better understand pharmacological effects of drugs and alcohol. You begin by implanting a cannula into a rat's brain, and attach a tether. As the rat self-administers the ethanol solution, the microdialysis set-up allows for easy extractions of cerebral spinal fluid for precise measurements of drug concentrations in the brain at different time points.

Unfortunately, it's very common for an addict to relapse back into drug use. Researchers can study the neurobiology of relapse through a laboratory model called foot-shock reinstatement. This type of study involves training an animal to perform an operant response, or lever press, to obtain a drug like cocaine. Subsequently, this behavior is extinguished by no longer reinforcing the lever presses with the drug. Finally, the drug-seeking behavior is reinstated by exposing the animal to a stressful cue, such as an electric foot-shock.

Another application of reward and addiction research is operant behavioral testing using a two-alternative choice pitch discrimination task. This task can examine multiple cognitive brain functions, such as motivation, attention, and decision-making, by training an animal to associate a lever press with an auditory cue. With each lever press, the animal will receive a sugar pellet as a reward. This type of study can be used to investigate a wide variety of addictions and substance abuse.

You've just watched JoVE's introduction to reward and addiction. In this video, we've reviewed the reward pathway, some of the key questions asked by reward and addiction researchers, and common methods that are used in the field. Thanks for watching!