THE 3D BRAIN

Get inside your teen's head and learn how alcohol, marijuana, and prescription painkillers–three of the most commonly abused drugs by teens–affect the brain.

Cerebral Cortex

Function

As humans have evolved, the cerebral cortex is the most recent addition to the brain. Anatomically, the cortex is divided into four distinct areas (frontal, parietal, occipital, and temporal). Some areas are associated with specific jobs, such as processing information related to vision, hearing, touch, movement, and smell. Others are responsible for critical thinking, reasoning, and producing and understanding language.[1]

One of the most important regions of the cerebral cortex lies toward its front, and is called the prefrontal cortex. This is the brain region involved in judgment (making choices), among other things. The prefrontal cortex controls a person's ability to make decisions based on personal desires.[2,3]

Effects on the Brain

Alcohol

Heavy alcohol use can cause structural abnormalities in the cerebral cortex, such as a smaller or shrunken brain region compared to non-drinkers. This effect increases with the amount of alcohol consumed.[4, 5] Alcohol consumption also causes a decrease in blood flow to the frontal lobe.[6] The user's senses will be dulled, which can cause blurred vision, decreased hearing, and impaired smelling and tasting.[7] The person may also experience a decrease in language, thinking, and reasoning skills. Fifteen percent of heavy and prolonged drinkers have seizures from alcohol withdrawal, which may be related to the brain's shrinkage in this area.[8] The prefrontal cortex can be particularly affected in teens who drink heavily over long periods of time. Prolonged and excessive alcohol use during teen and younger years can result in a smaller prefrontal cortex and reduced brain white matter as young adults.[9] Recent research also shows that alcohol slows the communication between neurons in the prefrontal cortex, which plays a critical role in coordinating appropriate responses possibly leading to risky behaviors.[10, 11]

Marijuana

Delta-9-tetrahydrocannabinol (THC) is the main active chemical found in marijuana. It sticks to specific sites throughout the brain, called cannabinoid receptors. The cortex has a high concentration of cannabinoid receptors, especially in areas responsible for sensory perception (touch, sight, hearing, taste, and smell).[12] Marijuana activates cannabinoid receptors leading to altered sensory experiences that users feel while under the influence.[13] The person may experience heightened or dulled sensations (e.g., visual, auditory), or dramatic, and sometimes frightening, emotions. The user may also exhibit slowed reflexes.[14] Marijuana also affects the prefrontal cortex by changing the normal patterns of blood flow and impairing decision-making abilities.[15, 16] This can lead users to engage in risky behaviors they wouldn't ordinarily do.[17] Also, malfunctions in the prefrontal cortex are believed to contribute to schizophrenia. This could explain why some people who use marijuana may have increased risk of schizophrenia later in life.[18]

Cerebellum

Function

The cerebellum is a part of the brain involved in balance, posture, and coordination. The cerebellum coordinates the actions of the muscle. In this way, the cerebellum makes sure that the body moves smoothly and efficiently.[19]

Effects on the Brain

Alcohol

Extended, heavy drinking causes brain shrinkage in the cerebellum, as well as the brain white matter, the tissue through which messages are transmitted throughout the brain.[20, 21] Even in the short term, excessive alcohol use causes a lack of fine-motor skills and problems with balance and coordination, such as difficulty walking and picking up and handling objects. Some users may be unable to tell where they are. These experiences can be temporary, but can become permanent with extended alcohol use.[22]

Marijuana

The THC in marijuana interferes with the functioning of the cerebellum, resulting in impaired coordination, balance, and fine-motor skills and reaction time.[23,24] Athletic performance, for example, could suffer.

Brainstem

Function

The brainstem is the part of the brain that connects the brain and the spinal cord. It controls many basic functions, such as heart rate, breathing, eating, and sleeping. The brainstem does this by directing the spinal cord and the body to do what is needed to maintain these functions.[25] The brainstem is most affected by depressants such as alcohol and opiate painkillers.

Effects on the Brain

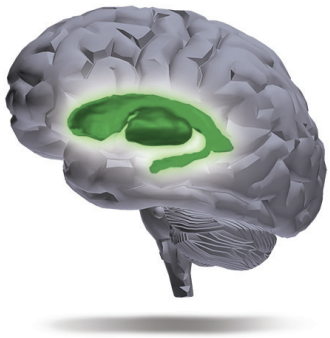
Alcohol

By disturbing the normal functions of the brainstem, alcohol slows breathing and heart rate and lowers body temperature. This can shut down the brainstem's functions and cause a coma.[26] Alcohol depresses other brainstem actions such as breathing and the gag reflex (which prevents choking). There is then the danger of choking on vomit because the brainstem no longer controls the gag reflex. This helps explain why it is also common for someone who drinks a lot of alcohol to vomit, since alcohol irritates the stomach. A person who drinks a lot of alcohol in a short period of time may end up vomiting and choking. Additionally, a person who drinks a large amount of alcohol may stop breathing. People who survive such an alcohol overdose may sustain permanent brain damage.[27]

Painkillers (opiates)

Within the brainstem and spinal cord, there are places on the surface of certain nerve cells that recognize opiates specifically (opiate receptors). When stimulated by opiates, these sites trigger responses in the brain and body.[28] Opiate painkillers act directly on the respiratory center in the brainstem where they cause a slowdown in activity, resulting in slowed breathing. Excessive amounts of these painkillers can cause the respiratory centers to shut down breathing altogether.[29,30] Opiates include prescription painkillers such as hydrocodone (Vicodin), oxycodone (OxyContin), propoxyphene (Darvon), hydromorphone (Dilaudid), and meperidine (Demerol). When used as directed by a physician, prescription opiates are generally safe and beneficial; however, they can cause addiction and even death when not taken as prescribed, even on the very first use.[31, 32] Opiates also include the illegal drug heroin, which has no medical use.

Limbic System



Function

The limbic system contains the brain's reward circuit, which allows humans to feel pleasure from doing things that they like. It also plays an important role in memory formation and learning. The limbic system consists of many structures, all of which can be affected by drugs of abuse. However, initially, one of the most important effects of drugs of abuse (rewarding or pleasurable effects) occurs in a limbic region called the ventral striatum (or nucleus accumbens). These effects are major contributors to the addiction process. The effects on the hippocampus are also very important. This structure is important for processing and storing new information and experiences. When it doesn't function right, remembering becomes difficult and learning is impaired.[33, 34]

Finally, drug effects in the hypothalamus can also lead to serious health problems since this area of the limbic system regulates housekeeping activities, such as blood pressure and heart rate, thirst, appetite, sleep, metabolism, breathing, temperature control, and hormones that are essential to healthy growth, development, and puberty.[35, 36]

Effects on the Brain

Alcohol

Heavy drinking can reduce the size of the hippocampus. It also damages the brain white matter, the tissue through which messages are transmitted throughout the brain. Unlike adults, teens are still forming connections between nerve cells that play a role in memory, and alcohol can disrupt the normal development of these connections.[37] Alcohol use can also affect the healthy function of the hypothalamus, resulting in low testosterone and altered levels of additional reproductive hormones that are important for all normal body functions, including growth, development, metabolism, and reproduction later in life.[38] Low hormone levels are also associated with weak bones, decreased muscle mass, anemia, and immunological deficits. Each of these conditions can cause significant health problems.[39]

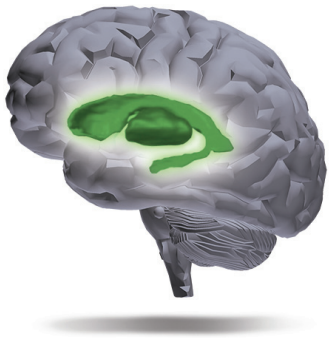
Marijuana

Exposure to THC activates the nucleus accumbens, causing the "high" associated with marijuana use, and disrupts the function of the hippocampus[40,41] making it hard to learn and remember new information.[42,43] Someone who smokes marijuana every day is probably performing at a reduced intellectual level most or all of the time.[44] The THC in marijuana also interacts with receptors in the hypothalamus. This affects certain "housekeeping functions" such as regulating thirst, appetite, and body temperature.[45] As a result, users may experience increased appetite or thirst ("munchies" or "cotton mouth"), and insomnia (not being able to sleep).[46,47]

Painkillers (opiates)

The limbic system is also rich in opiate receptors. This explains why opioid drugs can induce euphoria, because they indirectly activate the same brain regions that allow us to feel pleasure. This feeling is often intensified by those who abuse opioids by administering the drug via routes other than those recommended. For example, OxyContin is often snorted or injected to enhance its pleasurable effects, while at the same time increasing the risk for serious medical consequences, such as overdose and addiction. When used as directed by a physician, prescription opiates are safe and beneficial, and the risk for addiction is low. Non-medical use can lead to the effects described above.[48]

Limbic System (Continued)



The Limbic System and Addiction Examined [49]

The oldest part of the brain

Evolutionarily speaking, the limbic system is a very old part of the brain. It sits deep inside the brain and, even though its operation is largely unconscious, it has a profound effect on our experiences. The limbic system generates our most basic reactions, like emotions, pleasure, habits, appetites, and urges. When working properly, the functions of the limbic system help humans survive. For example, we are rewarded with a strong sense of pleasure after we eat a large meal. Because food is crucial to human survival, this sense of pleasure from eating encouraged primitive humans to consume food and ensured their survival.

Different parts for different functions

The limbic system is a complex network of structures that includes, among others, the nucleus accumbens (or ventral striatum), thalamus, hypothalamus, pituitary gland, hippocampus, and the amygdala. These structures have specialized, highly coordinated functions. For example, the nucleus accumbens is activated by stimuli associated with reward or pleasure, but also by unpleasant, novel, unexpected or intense stimuli. The thalamus acts as a relay station that conveys sensory information to and from different brain areas for processing. Beneath the thalamus lies the hypothalamus, which works together with yet another structure, the pituitary gland, to ensure that the internal conditions in the body (e.g., temperature, hormones, salt concentration, etc.) stay well balanced. The hippocampus plays a key role in storing information in the form of memories. In front of the hippocampus lies the amygdala which is in charge of registering fear and mounting emotional responses.

The link to addiction

The limbic system contains the brain's reward circuit, which allows us to feel pleasure when we eat chocolate, listen to music, or go surfing. It also helps build up memories of what it was that made us feel good, and motivates us to repeat those behaviors. As you can imagine, this can be the basis of addiction, because drugs of abuse—like cocaine, marijuana, alcohol, nicotine, and opiates—also affect the reward circuit, particularly the nucleus accumbens, and drugs may do so more intensely and for longer periods of time. This is how drugs of abuse can end up "hijacking" the entire brain's reward system. When this happens the person feels the compulsive need for more drugs just to feel normal, and a lack of satisfaction from previously pleasurable activities—the hallmarks of addiction. This can happen with drugs and alcohol but can happen with far more common items like food.

Resources

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