Amphetamine Addiction: A Neurological and Psychological Study

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Abstract – Drug addiction and substance abuse are a large global issue that have massive social and public health implications. In Australia, the most all-inclusive data (collected for 2004-05) states that drug addiction cost citizens approximately $55.2 Billion in increased costs to the healthcare system, losses in productivity and increase in crime rates. (Australian Institute of Health and Welfare, 2020). Approximately 3 million citizens use an illegal drug every year and more than 45% of Australians above the age of 14 have used illicit drugs in their lifetime (Health Direct, 2019). An in depth understanding the neurological and psychological processes of substance addiction is essential in forming effective rehabilitation approaches.

The Effects of Amphetamine Usage on the Dopamine Neurotransmitter System

The dopamine neurotransmitter system plays a large part in facilitating drug addiction. A neuron is the basic working unit of the brain; it is a cell that is specialised in transmitting electrical impulses to different parts of the brain. Neurotransmitters are molecules used by the central nervous system in order to transmit messages between neurons. Dopamine is an organic chemical that acts as a neurotransmitter that is involved in multiple neurological functions in the brain such as learning, emotion, motor control and reward. The reward system in the brain facilitates the release of dopamine when exposed to rewarding stimulus. The dopamine pathway most associated with reward is the mesolimbic dopamine pathway which originates in the Ventral Tegmental Area (VTA) (Pierce, 2006). The mesolimbic dopamine pathway connects the VTA, which has a high production rate of dopamine and the nucleus accumbens, a nucleus in the brain that facilitates reward (Izzo, 2001). Hence, when the brain is exposed to rewarding stimuli, neurons in the VTA are activated and they project to the nucleus accumbens via the mesolimbic dopamine pathway. This activation process leads to dopamine concentrations in the nucleus accumbens to increase and results in the brain being rewarded. A common element amongst all highly addictive substances is their potential to release dopamine directly or indirectly through a chain of complex processes in the brain. Studies have concluded that each drug has a primary neurotransmitter that it acts upon. Studies show that drugs such as Amphetamines act on the dopamine neurotransmitter system (Calipari, 2013). Whilst it has been found that the abusive reinforcing effects of almost all drugs is mostly due to the mesolimbic dopamine system being activated (Pierce, 2006), this essay will focus solely on the effects of Amphetamine usage. Amphetamines are psychoactive stimulants that are commonly used in the treatment of Attention deficit hyperactivity disorder (ADHD). Amphetamine is a dopamine agonist as it is of a similar shape to the dopamine neurotransmitter molecule (Izzo, 2001). Amphetamine increases the concentration of Dopamine presence in the synaptic cleft, which is a region between neurons where electrical signals are converted into a chemical signal in order or transmission between neurons. Amphetamine binds to the transporter proteins for monoamines like dopamine. Hence an increase in dopamine in the cleft increases this binding activity and the amphetamine can be taken up into the neurons. Then, amphetamine disrupts dopamine storage in the synaptic vesicles. This disruption, the dopamine transporter proteins run in reverse and this leads to the increased concentration of dopamine in the synaptic cleft (Friedman, 1999). Hence, Amphetamines affect the functioning of the dopamine neurotransmitter system by increasing dopamine concentrations in the synaptic cleft, which leads to the reinforcing effects of using amphetamine that largely contribute to the formation of an addiction to amphetamine and other amphetamine derivatives.

Cycles of Relapse and Addiction Due to Changes to the Dopamine System

Understanding the neurological and psychological processes involved in the dopamine neurotransmitter reward systems such as the mesolimbic dopamine pathway is essential in furthering our understanding of drug addiction and dependence. The dopamine system is also known to create cravings for a pleasurable stimuli and reward seeking behaviour via ac-

tivating the dopamine reward system in anticipation of a pleasurable stimuli or in this case, in anticipation of amphetamine usage (Dubol, 2018). When amphetamine is initially used, a number of risk factors such as loneliness and pre-existing mental illnesses increase likelihood of developing an addiction in the future. (Mayo Clinic, 2017). Overuse of Amphetamine results in a tolerance build-up in the user' s brain. The excessive amphetamine usage will result in over firing of neurons which results in neurotoxicity in the synaptic cleft. In order to counteract this, the neurons automatically use two mechanisms known as Desensitisation and Dow-regulation to protect the neurons from super-optimal receptor binding (Rawson, 1999). As the tolerance is built up, the intensity of the drug ' s effects reduces. This creates a cycle of overuse, as the user will naturally increase the dosage over time to feel the initial effects of the drug and build a dependence. Withdrawal from Amphetamine use will initially result in strong cravings for the drug for 1-10 weeks (Gawin FH, 1986). Due to chemical dependence to the substance the ex-user may Anhedonic, this amphetamine craving may lead them to relapse into addiction. This was studied by (Volkow, 2001), where he compared PET scans of methamphetamine users between 1 to 14 months in abstaining from stimulant usage. It was found that the withdrawal caused a significant reduction in dopamine activity in the mesolimbic dopamine pathway. This would build craving for the abstainer to re-use the drug and fall back into the cycle of dependence. The psychological theory of Pavlovian-to-instrumental learning is discussed with relation to drug addiction in cocaine seeking rats by (LeBlanc KH, 2012). This concept suggests that psychological factors such as pre-conditioned drug cues may make drug abstinence more difficult. In humans, pre-conditioned physiological reflexes due to pavlovian conditioning in anticipation of drug usage coupled with ' instrumental ' drug seeking behaviour such as opening a syringe. In a separate study (O ' Brien C.P., 1984) it was suggested that environmental cues such as the location of where a person once relapsed would lead to a drug relapse in the future due to negative reinforcement effect. These are some of the mechanisms that lead to drug users falling into a cycle of relapse and addiction.

Conclusion

Amphetamine abuse is a large issue that affects every aspect of society. In-depth research into the stimulant reveals various neurological and psychological factors that lead to the growth of this issue across the globe. Further research into the misuse of ADHD prescription drugs containing amphetamine derivatives by young students to be able to focus for long periods of time would yield valuable data as this is a growing issue that has the potential to cause psychological and physical harm to the next generation of professionals leading to a loss in overall productivity of the members of society.

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