Role of Dopamine, the Frontal Cortex and Memory Circuits in Drug Addiction: Insight from Imaging Studies-Part 3

Abstract: Dopamine is a chemical messenger in the brain. It is important in the brain reward system. Dopamine also plays a role in drug addiction. Drug addiction is a disease characterized by drug-induced “highs”, withdrawal, and craving.

Many researchers use PET (positron emission tomography) images of the brain to study drug addiction. PET helps us to learn more about the role of dopamine and the brain pathways it controls.

PET scans show that increases in dopamine occur during drug use. Dopamine causes drug-induced highs. During withdrawal, PET scans show a decline in dopamine. Low dopamine reduces the good feelings from taking drugs. This will cause drug-seeking as a means to experience the high again. It may also cause the uncomfortable moods or cravings of withdrawal.

Using PET scans, we claim that changes in Dopamine levels help cause addiction. Dopamine disrupts parts of the brain that control motivation, drive and self-control.

Background: Dopamine, a chemical messenger in the brain, has many functions. It is important in behavior, thought, movement, motivation, reward, mood, sleep, attention, and learning. Dopamine activates some neurons. Dopamine sometimes attaches to proteins called dopamine receptors and dopamine transporters (DAT). This lowers levels of dopamine in the brain. When dopamine can’t attach to the proteins, dopamine levels in the brain rise.

Images of the human brain in action allow expanded drug addiction research. These images are created by PET scans. PET scans allow researchers to see areas of brain activity during specific events. This has helped understand brain pathways and addiction. PET scans allow scientists to see how dopamine affects brain circuits.

Addiction pathways in the brain are formed during drug-induced highs. These highs feel good and the brain remembers what caused the good feelings. Drug users want to repeat experiences that feel good. Soon, more and more of the drug is needed to get the same good feeling. Withdrawal results when the drug is no longer taken. This is followed by a powerful desire for the drug (craving). Craving leads to repeated use of drugs of abuse. In turn, repeated drug use strengthens addiction pathways in the brain.

All learned behaviors make specific pathways in the brain. These pathways create long-term memories. Brain pathways can change in strength. Strengthening brain pathways helps us to learn and remember things. In this way, addiction becomes a life-long disease.
Methods: This article is a review of over 77 studies. Review articles are useful in pulling together the results of many studies and providing a "current state" of research. This type of effort is especially helpful in rapidly expanding areas of research. The authors of this paper divided the review into five specific areas of drug addiction research; three are included below.

RESULTS AND SUMMARIES OF RESEARCH:

Role of Dopamine in Predisposition to Drug Abuse

Why do some become addicted and others do not? This is one of the most important questions in addiction research. Current studies cannot determine if this is due to 1. continued drug use or 2. genetic and environmental factors.

Whether it is genetics or environment, lab animal studies indicate dopamine is involved (Piazza et al., 1991). Because it is not ethical to cause a person to become addicted to study dopamine levels, another method was devised.

Levels of dopamine in nondrug-abusers were measured. Changes were monitored when subjects were given a drug that acts like cocaine, but is not addictive. As before, the drug MP was used. Half of the test subjects said that the drug was pleasant and half said it was unpleasant. Subjects who thought MP was pleasant had more dopamine.

A major limitation of this research is that there was no way to prove that the MP caused higher dopamine levels. Therefore, researchers designed a study in which alcohol-addicted rats were given a gene to make dopamine receptor proteins. Dopamine levels decreased in rats given the gene. Over time, the rats took 50% less alcohol. This study reveals a way to explain how genetics impact drug abuse (Thanos et al., 2001).

Role of Frontal Cortex in Cognitive Behavioral Processes Related to Drug Addiction

Dopamine is important in memory and learning (Castellano et al., 1991). Memory formation is especially important (Setlow & McCaugh, 1999). Drugs of abuse cause dopamine to increase in the brain reward area. Memories of the experiences that caused the reward are made (DiChiara, 1999).

Long-term drug use disrupts normal learning and memory systems. These disruptions, in turn cause drug-seeking behavior (Everitt et al., 2001). Several memory systems might be involved in drug abuse (White, 1996). Places and people bring back memories of drug use and trigger cravings. PET imaging studies show a complex interaction among these brain memory areas (Karremen et al., 1996).

An unexpected finding was that the frontal cortex may also be involved. This means that drug use changes the part of the brain that controls reason and logic. This may be linked to more drug use and craving.
Drug addiction changes the frontal lobe of the brain (Volkow & Fowler, 2000). Researchers think that changes to the frontal lobes cause loss of personal drive. Over time, the brain is “hijacked” by drugs of abuse. Abnormal behavior becomes automatic because of these changes in the brain. Imaging studies revealed the frontal lobe changes in drug addicted people (Elliott et al., 2000; Francis et al., 1997; Casey et al., 1997; Berns et al., 2001; Carter et al., 2000; Goldstein et al., 2001).

**Conclusion:** Imaging studies show drug-addicted brains have major problems with dopamine function. Genetic and environmental factors are involved in addiction. As memory pathways are formed with repeated drug highs, complex addiction behavior develops. Drug addiction is a long-term disease caused by long-term biological changes.

**References:**


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