Alcohol and Dopamine

Because alcohol is a small molecule it interacts with many neurotransmitter systems in the brain; this makes the action of alcohol in the brain very different from and much more complex than large molecules such as opiates, THC, or amphetamine which simulate a specific neurotransmitter and interact with a specific neurotransmitter system. Some of the better researched neurotransmitter systems with which alcohol interacts are the following:

- GABA: Alcohol affects the GABA system in a manner similar to valium leading to relaxation and drowsiness

- Endorphins: Alcohol affects the endorphin system in a manner similar to opiates, acting as a pain-killer and giving an endorphin "high"

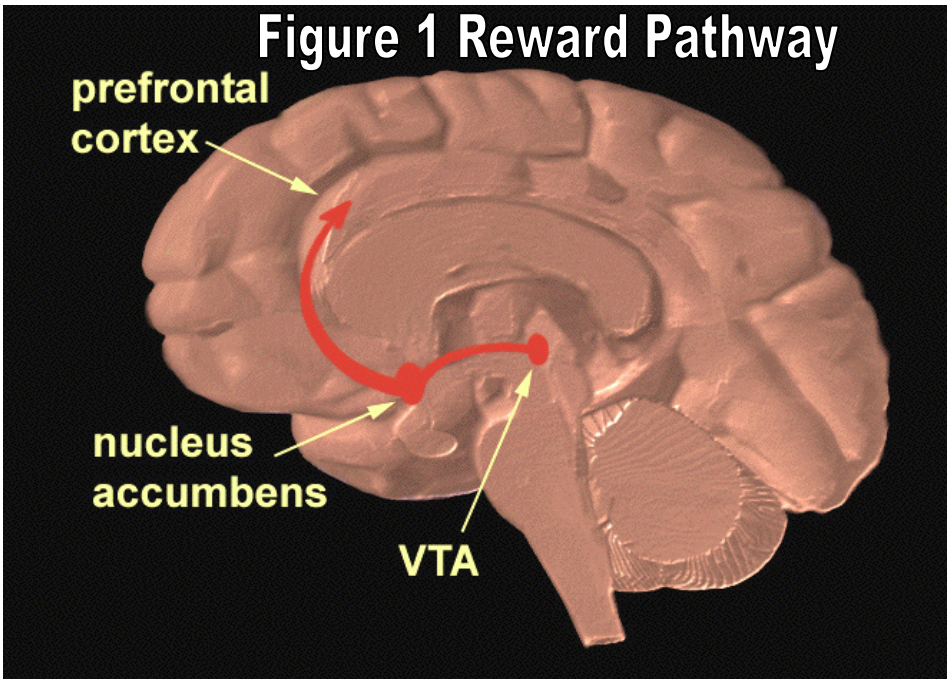
- Glutamate: It is alcohol's effects on the glutamate system which lead to staggering, slurred speech, and memory blackouts

- Dopamine: All drugs which lead to dependence appear to affect the dopamine system. Stimulants like amphetamine and cocaine affect dopamine directly whereas other drugs appear to affect it indirectly. In this article we will review the research on the effect of alcohol on dopamine

- Norepinephrine: Also known as noradrenalin. Alcohol causes a release of norepinephrine in the brain which is one reason why alcohol acts as stimulant and not just as a depressant.

- Adrenaline: Alcohol causes the adrenal glands to release adrenaline--this is another reason why alcohol has stimulant properties. The adrenaline is carried to the brain via the bloodstream.

Alcohol does not lead to an increase of dopamine throughout the brain; it only causes an increase in dopamine in the area of **the reward pathway** (Boileau et al 2003). This **reward pathway** is comprised primarily of the **nucleus accumbens,** the **VTA (ventral tegmental area)**, and a part of the **prefrontal cortex** as shown in Figure 1.



Moreover, the experimental evidence suggests that alcohol does not cause the increase in **dopamine** directly. Rather, it appears that alcohol directly affects the **GABA system** and the **endorphin system**. Neurons from the **GABA system** extend into the **reward pathway** and when alcohol affects the **GABA system** these neurons release **dopamine** into the **reward pathway**. Likewise, neurons extend from the **endorphin system** into the **reward pathway** and these also release **dopamine** into the **reward pathway** when alcohol directly stimulates the **endorphin system** (Boileau et al, 2003).

All things which give us pleasure, from a symphony to food to sex to drugs and alcohol, cause a release of **dopamine** in the **reward pathway** as well as triggering a number of other events in the brain including **endorphin release** and activation of the **orbitofrontal region** of the prefrontal cortex. Researchers from the 1950s who implanted electrodes into the reward pathway thought that they had discovered the pleasure center of the brain (Olds, 1956). However, research since then has demonstrated that pleasure is a far more complex phenomenon which involves many parts of the brain. Contemporary researchers believe that pleasure has several components such as "liking," "wanting," "learning (pavlovian conditioning)," "reward," and "valuation" (Berridge and Kringelbach, 2008).

Many researchers currently believe that **dopamine** in the **reward pathway** is involved in the phenomena of "wanting," "learning," and "reward," but that it is not involved "liking" or "valuation." In other words, the **dopamine** in the **reward pathway** may make you crave drugs or alcohol or sex or a symphony, and it may also reinforce habitual drug use, sex, or symphony listening, but it is not responsible for the pleasure you get from these activities. The pleasure which we get from these things seems to involve neurotransmitters called **endorphins** and to involve **hedonic hot spots**. Researchers identify the **hedonic hot spots** as existing in the Nucleus Accumbens, Ventral Pallidum, and Parabrachial Nucleus as illustrated in Figure 2 (Berridge and Kringelbach, 2008). You may recall that the Nucleus Accumbens is also a part of the **reward**

pathway; this tells us that part of the Nucleus Accumbens is involved in "liking" and part of it is involved in "wanting." The **orbitofrontal area** of the prefrontal cortex is largely involved in the "valuation" of pleasurable stimuli.

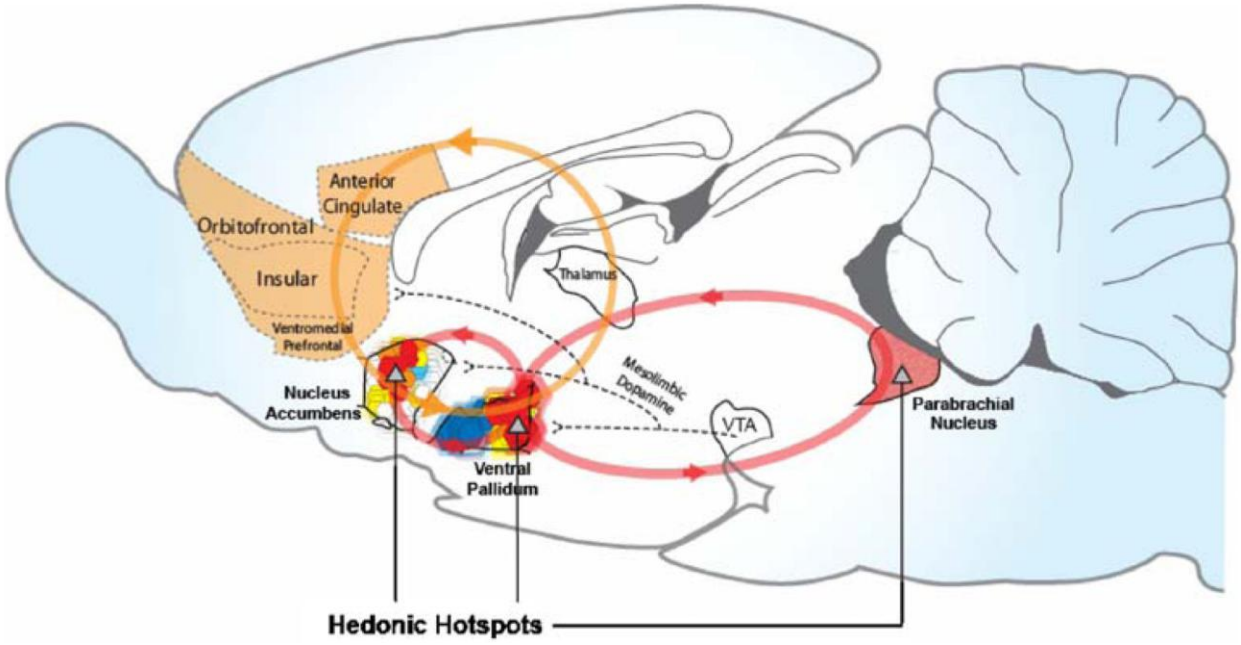


Figure 2

The **reward pathway** is an important survival mechanism for the individual and the species--it fosters learning by rewarding us for actions which result in the acquisition of food or sex. This leads us to learn these behaviors as conditioned responses.

There is also nothing inherently wrong in using alcohol or other drugs to chemically stimulate the **hedonic hot spots** and the **reward pathway**; the vast majority of people who engage in recreational alcohol intoxication or recreational drug use do not become dependent. We should, however, use caution and try to avoid daily use if we wish to avoid alcohol or drug dependence.

It is well known that alcohol has the properties of both a stimulant and a depressant; this is due to the fact that alcohol affects many different neurotransmitter systems. However, it is unlikely that the increase in **dopamine** is responsible for the stimulant properties of alcohol. Although the stimulant properties of cocaine and amphetamine are due to their effect on the **dopamine system**, these drugs differ from alcohol in that they affect **dopamine receptors** directly and hence have an impact on **dopamine receptors** throughout the entire brain, whereas alcohol affects dopamine receptors indirectly and only in one small part of the brain, namely the **reward pathway**.

It is most likely that the stimulating effects of alcohol are due to its effects on **adrenaline**, **norepinephrine**, and the **prefrontal cortex**. Alcohol causes the release of **norepinephrine** in

the brain (McDougle et al 1995). It also causes the pituitary to release hormones which signal the adrenal glands to release **adrenaline** (NIAAA 1996). Finally, alcohol represses the functioning of the **prefrontal cortex** (Volkow et al 1990) which is responsible for decision making. This is why alcohol can cause people to lose their inhibitions and make some really bad ideas, like calling up the boss and chewing him out in the middle of the night, sound perfectly reasonable.

We should also note that the action of alcohol is **biphasic**: when BAC (blood alcohol concentration) levels are rising, the **stimulant** properties of alcohol are more pronounced; when BAC levels are falling, the **depressant** effects of alcohol are more pronounced (Giancola and Zeichner 1997).

It is alcohol's effect on the GABA system which is responsible for its depressant effects. It is also important to note that the term "depressant" refers to drugs which slow down the central nervous system; it does not refer to drugs which induce depression. These are properly referred to as "depressogenic" drugs. The relationship of alcohol to depression is fairly complex; although alcohol can induce depression in some long term heavy drinkers, Denning and Little (2011) note that alcohol can also function as an antidepressant in some drinkers, particularly women. Moreover, some people with depression use alcohol to escape from it.

Agonists are drugs which mimic a neurotransmitter, antagonists are drugs which block a neurotransmitter, and partial agonists are drugs which have some of the properties of both agonists and antagonists. Some dopamine agonists have been shown to increase impulsive and addictive behaviors (Kolla et al 2010); however, dopamine partial agonists may aid in reducing addictive behaviors (Diana 2011).

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