The Brain Under Construction [2]: the effects of alcohol on the brain

This briefing paper is **part of a series** produced by Mentor-ADEPIS to support the delivery of effective alcohol and drug education and prevention in schools and other settings.

About Mentor

Mentor promotes best practice around building young people's resilience to prevent alcohol and drug misuse.

About ADEPIS

The Alcohol and Drug Education and Prevention Information Service (ADEPIS) is a platform for sharing information and resources aimed at schools and other professionals working in drug and alcohol prevention. In 2017, ADEPIS was recognised by UNESCO, UNODC and WHO as a 'prime example' of best practice in alcohol and drug education.

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This extended briefing paper forms part of a mini-series on the 'Brain under Construction'. It is intended to be read alongside the other brain-related papers in the series (available on the Mentor-ADEPIS website).

From a scientific perspective, it is surprising that research has found most people do not consider alcohol a drug. If we define a drug as "a psychoactive substance that changes the body and brain in some way", alcohol, which contains the chemical ethanol, is particularly notorious. It impacts so many different areas of the brain and body that scientists are still finding new effects of alcohol consumption and proving theories on a frequent basis.

This briefing paper provides a snapshot of alcohol's effects on the brain. It aims to explain the science behind what happens when we consume one of the most widely used drugs in the world.

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It is well established that substance use has negative consequences for the brain (Oscar-Berman & Marinkovic, 2003). Now, with the advancement of neuro-imaging, we can see that not only does alcohol affect different regions of the brain in different ways, but it influences us differently depending on our age. It is now evident that alcohol directly and significantly alters our brain chemistry.

An ancient cultural tradition

The widespread cultural influence of alcohol is staggering. Most ancient cultures in history have been found to consume it (starting with China, in 7000 BC) and it has been used recreationally for over 10,000 years.

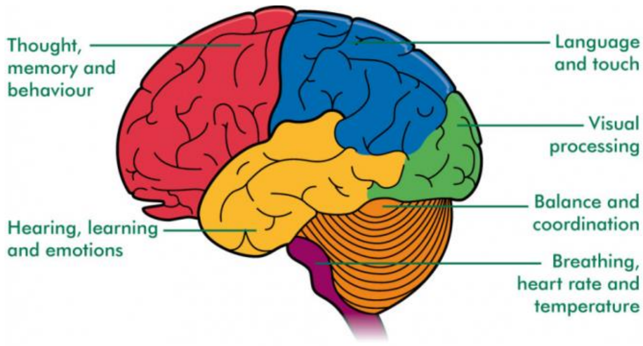
In 1720 BC in Mesopotamia (present-day Iraq), tavern keepers were punished with drowning if they overcharged customers for alcohol!

The Brain's Highways

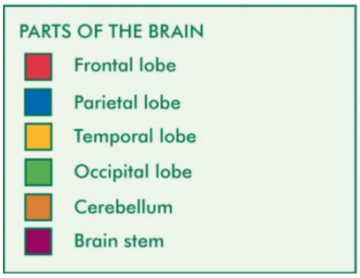
If asked how alcohol affects the brain, many people may say, 'it makes you depressed.' While this is partially true, just because a drug is a "depressant" does not mean it will bring you down; it means that it depresses (inhibits) parts of the brain that usually make us worried, anxious, and aware of the consequences of our actions (Spiritual Awareness, 2017).

While alcohol is a depressant, it is also a stimulant (as well as playing other roles). It directly affects the brain's chemistry by altering levels of neurotransmitters, i.e., the chemical messengers that transmit signals, via brain 'highways' (technically called 'neural pathways') around the body, giving different commands, to each other to control our emotions, thought processes and behaviour.

In short, as seen in the diagram below, certain parts of the brain are responsible for specific functions, and nerve cells or neurons connect one area to another via pathways to send and integrate essential information.



The lobes and functions of the brain



Neurotransmitters

Alcohol affects both excitatory neurotransmitters, which we can think about as "Go!" signals, and inhibitory neurotransmitters, which we can think about as "Stop!" signals.

An example of a "Go!" signal is the neurotransmitter **glutamate**, which increases our energy levels and brain activity. Glutamate is the body's most prominent excitatory neurotransmitter.

An example of a "Stop!" signal is **gamma-aminobutyric acid (GABA)**, the most potent depressive neurotransmitter in the human brain, which plays an opposing role - reducing our levels of energy, fear and anxiety and helping to make us calm.

Alcohol is a **depressant** drug, so it decreases the 'Go!' signals while increasing the 'Stop!' signals. It suppresses the release of glutamate, resulting in a slowdown along the neural pathways. The increase in GABA causes drowsiness which leads to slower thought processing and impaired speech and movement. The 'slow down' in cognitive behaviour is why we should not consume certain drugs, for example, benzodiazepines, at the same time as alcohol – doing this enhances the effect, leading to dangerously low blood pressure and heart rate and a lower speed of the respiratory system.

Dopamine and the Pleasure Principle

A signature trait of pleasure in the brain is the release of the neurotransmitter **dopamine**. When drinking alcohol, the extreme surge of dopamine in the nucleus accumbens (known as the 'reward centre' of the brain) tricks us into thinking that we are feeling good. The result of this is that we drink more to feel better, while at the same time altering the brain chemicals that enhance our feelings of depression.

Questions and Answers

Why does alcohol make us clumsy?

The area of the brain responsible for this is the **cerebellum**. Alcohol affects this centre of movement and balance, resulting in the staggering, off-balance swagger we associate with 'falling-down drunk'

Why does alcohol make us feel less inhibited?

The region responsible for this is the **cerebral cortex**, the area of the brain where thought processing and consciousness are centred, alcohol depresses the behavioural inhibitory centres, making the person less inhibited; it slows down the processing of information from the eyes, ears, mouth and other senses; and it inhibits the thought processes, making it difficult to think clearly.

Why does alcohol make us sleepy?

The **medulla** region of the brain is responsible for this. It handles functions such as breathing, consciousness and body temperature. By acting on the medulla, alcohol induces sleepiness. It can also slow breathing and lower body temperature, which can be life-threatening.

Source: Watson, S. (2017)

As we drink more, the effect of the **dopamine** decreases until it almost disappears. However, at this point, depending on the individual, we experience so much of the 'good' feeling (as a result of the dopamine release in the reward centre) that we want more of it – something that can lead to addiction. The powerful surge of dopamine causes the brain of an addicted person to become overwhelmed, and the brain responds by reducing the release of dopamine. As a result, it has less impact on the brain's reward centre and in time alcohol (or other substances with the same effect) no longer give the person as much pleasure as before, causing them to intake more because their brains have adapted to it. The memory of the 'good' feeling and the need to recreate it persists, despite the decrease in dopamine release.

The hippocampus and the amygdala store information about environmental cues associated with the desired substance, so that a person can relocate it (Understanding Addiction, 2017). These memories help to create a conditioned response (craving) whenever the person encounters those environmental cues. These can contribute not only to addiction but also relapse. A person addicted to heroin may be in danger of relapse when he sees a hypodermic needle, for example, while another person might start to drink again after seeing a bottle of vodka. Conditioned learning helps explain why people develop a risk of relapse even after years of abstinence (Understanding addiction, 2017).

Dopamine also plays a role in memory and learning – two things which play a vital role in the transition from simply liking something to becoming addicted to it (ibid). Dopamine interacts with glutamate to hijack the brain's system of reward-related learning, which helps to sustain life by linking activities needed for human survival with pleasure and reward.

As well as pleasure, the reward circuit of the brain includes areas involved with motivation and memory. Addictive substances stimulate the same circuit and overload it. Repeated exposure to an addictive substance or behaviour causes nerve cells in the nucleus accumbens and the prefrontal cortex (the region responsible for tasks like decision-making and planning) to communicate in a way that pairs are liking something with wanting it, in turn leading us to chase after it. This process motivates us to take action to seek out the source of the pleasure (ibid).

Addiction is not discussed in detail here as it is a complex issue that deserves detailed consideration and discussion. However, it is worth stating that not everyone who drinks alcohol will become an alcoholic. Even though alcohol and other drugs can intensely change our brain transmission and function, our brain is plastic enough to cope with the changes and return to its usual behaviour.

Depending on how much a person drinks, and particularly how often they drink, the capability of the brain to shift back to normal is affected. If we are continually changing our brain transmission by regularly drinking, the alcohol-induced state becomes the norm, and the body starts requiring alcohol to function properly. Addiction is a very complex and multi-layered process, and it goes far beyond the simple idea that "if something is good we want to do it again." It relates to positive and negative reinforcing effects and drug-induced brain changes that often only come about with repeated use - and target DNA itself.

Along with weight gain and an increased chance of early death, the excessive consumption of alcohol over an extended period can cause over sixty different health conditions, including seven types of cancer, high blood pressure, cirrhosis of the liver and depression. It can wear down and damage the body's organs, including the heart, liver, and pancreas and as we have outlined – the brain. It can also weaken the immune system and bones as, within minutes of taking the first sip, alcohol enters the bloodstream through the stomach wall and circulates to every part of the body (Hampson, 2017).

It is evident that alcohol has a significant impact on the brain and consequently on behaviour. Certain lifestyle changes can limit the effects of alcohol, and there are ways to boost the brain's response to alcohol, including exercise, omega-3 fatty acids and vitamins. Other Mentor-ADEPIS briefing papers consider brain development as well as the unique effects of alcohol and drugs on the adolescent brain.

Why do some people get "Asian Flush" after drinking?

Approximately 36% of East Asians experience an alcohol-induced reaction popularly termed "Asian Flush" or "Asian Glow". Symptoms include red flushed skin, nausea and a raised heart rate after drinking alcohol. This reaction is the result of an inheritable genetic deficiency in the enzyme **aldehyde dehydrogenase**, responsible for breaking down the toxic alcohol metabolite **acetaldehyde**.

Having this deficiency means that people break down Acetaldehyde less efficiently, so they are exposed to its toxic effects for longer. This is important because Acetaldehyde is a known carcinogen, so people who get "Asian Flush" have a higher risk of having alcohol-induced cancer.

On the other hand, having "Asian Flush" has been shown to protect against alcoholism, perhaps because this particular negative effect of drinking outweighs the positive ones for some people.

Source: Brooks et al. (2009)

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