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TE HIRINGA HAUORA

AlcoholNZ article

Title

The science of the adolescent brain and alcohol

At a glance

- This article was published in print form in HPA's June 2016 *AlcoholNZ* magazine (available on alcohol.org.nz/alcoholnz).
- Anthea Springford and Sue Wright of Brainwave Trust Aotearoa are the authors of this article. It discusses:
  - what is biologically unique about the developing adolescent brain that makes it vulnerable to the toxic effects of alcohol
  - what happens to the brain when adolescents drink alcohol, in particular the changes that occur with heavy drinking
  - why adolescents are more sensitive to alcohol and why it's important to understand how alcohol affects the adolescent brain.

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Disclaimer

The science of the adolescent brain
and alcohol

The following article has been written by ***Anthea Springford*** *and* ***Sue Wright*** *of Brainwave Trust Aotearoa. Brainwave Trust is a charitable trust whose purpose is to raise public awareness about new findings in brain research and the important implications of this knowledge. More information about alcohol and adolescent brain development can be found at* ***brainwave.org.nz****.*

"If we expose our young people to positive, supportive environments they will flourish. But if the environments are toxic, they will suffer in powerful and enduring ways."

Steinberg, 2014

The adolescent brain is not just a young version of an adult brain – it is biologically different. It is going through an important period of change which makes it more vulnerable to the toxic effects of alcohol – and all other psychoactive drugs. In New Zealand the most common form of problematic substance use in adolescents is binge drinking of alcohol (Fleming, Lee, Moselen, Clark & Dixon, 2014).

What's special about the adolescent brain?

Human brains are extremely complex. There is still a lot more to learn about how and why they work as they do. In the past 25 or so years, technology like magnetic resonance imaging (MRI) has enabled scientists to observe the brains of children and adolescents – while they are alive.

Unlike other organs, brains are only partly formed at birth. Early experiences influence the architecture of the brain, which enables humans to adapt and thrive in the environment they are born into. From conception and through the first few years, a child's brain develops in response to a complex interplay between their genes and their experiences.

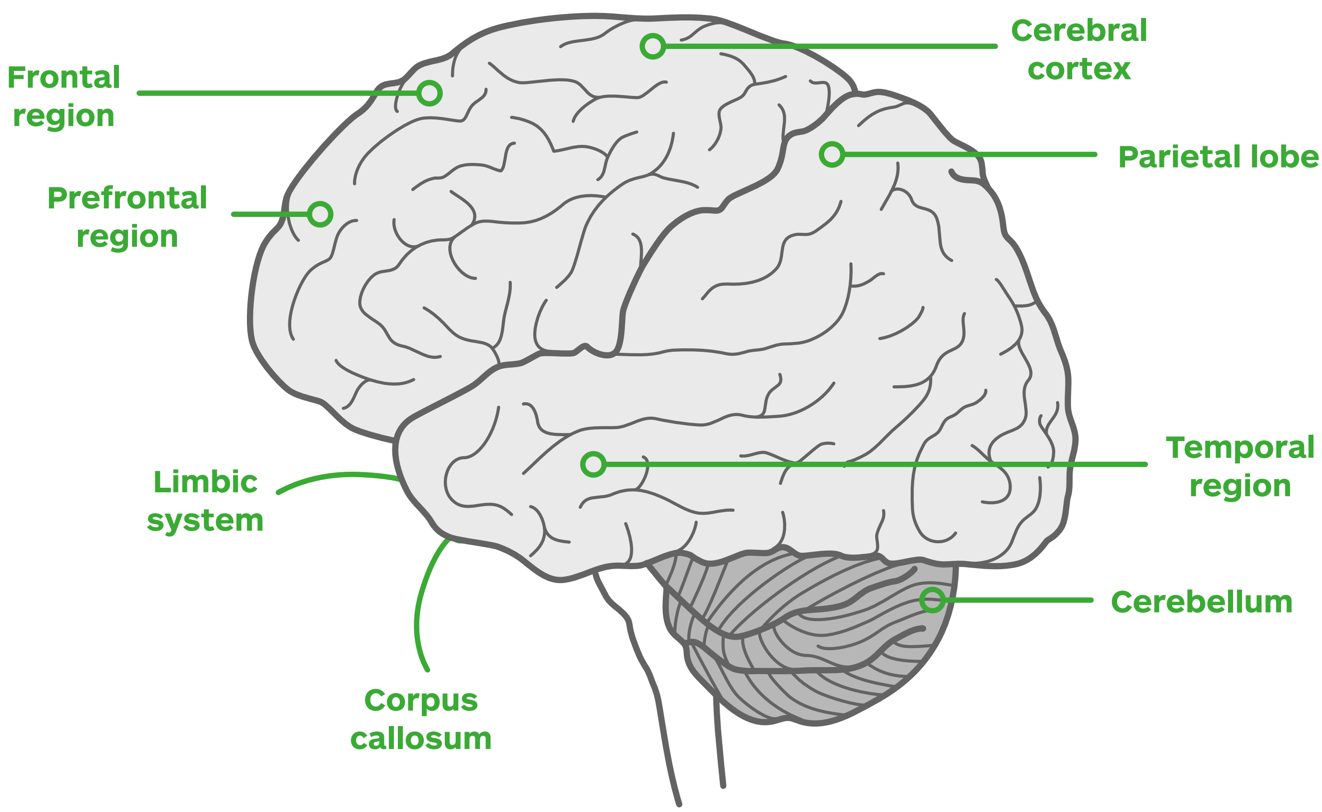
Adolescence is the period of transition from the dependence of childhood and importance of the family to the interdependence of adulthood. There have been many studies of adolescent behaviour, but until recently only limited research on the accompanying brain changes. The scientific community had thought the brain formed in the early years and then completed its development into the adult brain by mid-adolescence.

At the turn of the century, Professor Jay Giedd (Giedd et al., 2006) was concerned he had made a mistake when he detected further growth in a number of key areas of the brain which continued through to the early twenties in women and mid-twenties in men. Just as happens in the early years, another exuberant growth of connections occurs. Those used most often, both positive and negative, are strengthened and made more efficient through a process known as myelination. This myelinated part of the brain is known as white matter. The pathways used less often function less efficiently and may be eliminated (or 'pruned' away). This is 'use it or lose it' in action.

Unlike brain development in the first few years of life, which occurs throughout the brain, the brain development in this second phase occurs mainly in a few specific areas.

The adolescent changes start with the onset of puberty, as early as 8 or 10. During adolescence the brain undergoes particularly extensive changes in the areas that control how pleasure is experienced, how we view and think about other people, and our ability to self-regulate. These three areas of the brain are moulded by experiences during adolescence, but they are also the ones that are most easily harmed (Steinberg, 2014).

The *limbic system* is located in the middle of the brain and is sometimes called the centre of emotion. It contains the reward centres, which are highly sensitive during early and mid-adolescence and are not strongly wired up to the parts for exercising judgement and impulse control in the *prefrontal region*. This sensitivity is linked to risk taking, particularly in the presence of peers (Gardner & Steinberg, 2005). Interestingly, adolescents are just as capable as adults in assessing risks (Reyna & Farley, 2006). However, their finely tuned reward centres, combined with the social influence of their peers, mean they get a bigger return for taking a risk compared with an adult.



The upper areas of the brain, known as the *cerebral cortex*, undergo extensive restructuring as new connections form and strengthen in waves across the regions. This includes the *parietal lobe* (logic and spatial reasoning), the *temporal region* (language) and the *frontal region*, including the prefrontal cortex.

The *prefrontal cortex* plays a critical role in self-regulation, planning, decision making, working memory and impulse control, for example, and is the last region to mature. In adolescence sometimes the connections to the prefrontal cortex work, but sometimes they don't. Emotionally charged adolescents often make impulsive, emotional decisions until the ability to more consistently control behaviour emerges into the mid-twenties.

Two other regions also demonstrate significant change. The *corpus callosum* connects the left and right sides of the brain and is involved in creativity and higher-level thinking. During adolescence these connections are significantly strengthened and made more efficient. The *cerebellum*, which controls movement and contributes to a wide range of cognitive and emotional functions, also matures in adolescence.

So, adolescence is a second wave of brain development, where experience moulds the brain ready for adulthood. This is a time of great opportunity but also vulnerability.

What happens when alcohol is drunk?

There are many obvious and well-researched risks and consequences of heavy drinking, including car accidents, crime, violence, injuries and sexual risk taking, as well as depression and suicidal behaviour (Ferguson & Boden, 2011). But alcohol consumption, particularly excessive consumption, during this time may also have profound effects on both the structure of the brain and the way it functions.

Alcohol affects a developing adolescent brain differently from an adult brain. The imbalance in the way the brain develops, with limbic/reward systems (think social-emotional) maturing before prefrontal/cognitive control (thinking), may leave adolescents more vulnerable to engage in risk-taking behaviours like alcohol use. Adolescent drug taking, including alcohol, may further alter these developmental processes and increase the imbalance between reward and regulatory control systems (Squeglia et al., 2015). Alcohol exposure during adolescence not only has an immediate impact on brain function, it also may lead to consequences for various brain functions that last even into adulthood (Hiller-Sturmhöfel & Swartzwelder, 2004/2005).

Changes that can occur with heavy drinking

Numerous studies have investigated in either, or both, rats and humans the effects of alcohol on the structure of the adolescent brain and how it functions. This evidence is now being corroborated by longitudinal human studies, which can track the changes over time, identifying cause and effect. The effects, while not always dramatic, can be significant. The following list is not exhaustive but illustrates the fact that changes in the structure and/or function of the adolescent brain have been observed in many different parts of the brain:

- A longitudinal study found that adolescents who went on to develop heavy alcohol use started with significantly smaller brain matter volumes in several areas of the brain involved with inhibitory functioning, self-regulation, impulsivity and attention compared with those who remained alcohol free (Squeglia et al., 2014).
- There was a decrease in the volume of the hippocampus (a key region for learning new information and emotional memory) in heavy-drinking adolescents (Medina, Schweinsburg, Cohen-Zion, Nagel & Tapert, 2007).

- A reduction was observed in the prefrontal cortex in heavy-drinking adolescents and young adults (De Bellis et al., 2005).
- There was a reduction in the integrity of the *corpus callosum* (which connects the two sides of the brain) among heavy-drinking adolescents (Tapert, Theilmann, Schweinsburg, Yafai & Frank, 2003).
- It is the drinking to the point of being drunk (binge drinking – usually defined as four or five standard drinks in a session) rather than how often and how much is drunk overall which appears to cause damage to cognitive functioning, such as spatial working memory and pattern recognition (Weissenborn & Duka, 2003).
- Binge-drinking adolescents, even those with no history of alcohol use disorder, showed widespread areas of compromised white matter, particularly those underlying learning, memory and executive functions (McQueeny et al., 2009).
- A number of studies have demonstrated that even after a period of abstinence from alcohol, attention performance and other activities were worse in those who had abused alcohol (Brown, Tapert, Granholm & Delis, 2000).
- Adverse effects can happen in a gender-specific way, which may reflect the fact that the brains of boys and girls mature at different rates. Differences have been observed in both brain structure and brain function. For example, in terms of brain structure, the prefrontal cortex volumes of adolescent females with alcohol use disorders were shown to be smaller than controls and those of males larger than controls (Caldwell et al., 2005).
- In terms of gender differences in brain function, in females more drinking days in the year were correlated with worsening visuospatial functioning. In males, more severe hangover symptoms in the preceding year were correlated with worsening sustained attention (Squeglia, Schweinsburg, Pulido & Tapert, 2011).

Are adolescents more sensitive to alcohol?

Conventional wisdom might say that adolescent drinkers would be more sensitive to the effects of alcohol than adults. This is only partly true. Adolescents are more sensitive than adults to the rewarding effects of alcohol, such as reduced shyness in social settings (Varlinskaya & Spear, 2004). However, they are less sensitive than adults to the physical effects which are indicators that too much alcohol has been drunk, like sleepiness (Varlinskaya & Spear, 2004) and hangovers (Doremus, Brunell, Varlinskaya & Spear, 2003). In a time before ethical conditions were a consideration, Behar et al. (1983) found no behavioural signs of intoxication in 8 to 15-year-old boys who were given a dose of pure ethanol that caused peak blood alcohol levels to within the intoxicating range for adults. So, for adolescents it takes more alcohol for the physical warnings of toxicity to hit than for adults, while the pleasurable effects of drinking occur with less alcohol.

Insensitivities to alcohol may be particularly pronounced during the early stages of adolescence (Varlinskaya & Spear, 2004).

Why understanding how alcohol affects the adolescent brain is important

Adolescent brain development hasn't changed just because research has now highlighted this as a period of vulnerability. The study of brains is ongoing and complex and is likely to explain even more about how and why the brain is affected over time. Our current understanding of how alcohol affects the adolescent brain must inform all alcohol-related interventions and prevention activities developed by professionals.

What parents do does matter. Many people begin to experiment with alcohol during adolescence, often with the blessing of their parents, who, according to New Zealand research, are the main providers of alcohol to their adolescents. However, a large study in the US and Australia explored the influence of parental use, attitudes and supervision on alcohol use. Adult-supervised alcohol use resulted in higher levels of harmful alcohol consequences than when adults discouraged the use of alcohol in Australia (McMorris, Catalano, Kim, Toumbourou & Hemphill, 2011). When parents understand the impact of alcohol on the adolescent brain, they are empowered to limit access to alcohol and to discourage its use, particularly for younger adolescents.

We know that adolescents' brains are biologically tuned to take higher risks, especially in the company of their friends, and also that they do not experience the negative effects of excess alcohol in the same way as adults. The reconstruction of the adolescent brain from puberty through to the twenties means it is especially vulnerable to toxic insults, such as from alcohol and other drugs. There are many and varied ways in which both the structure of the brains of adolescents and their brain function can be affected by the use of alcohol, both in the short term and permanently. It appears to be binge drinking in particular that causes changes to the brain. This is before the confounding effects of marijuana and other drug use.

When adolescents boast that they "killed off a few brain cells last night", everyone needs to understand that research now shows that is exactly what they may have done.

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