

The Adolescent Brain and Nicotine

Who currently has an adolescent/young adult in their household?

When they do something, you say “what were you thinking??” and you realize they WEREN’T thinking, which is good – because if they WERE thinking, and they did that anyway, you would worry even more!

Aristotle concluded more than 2,300 years ago that “the young are heated by Nature as drunken men by wine”

A shepherd in Shakespeare’s *The Winter’s Tale* wishes “there were no age between ten and three-and twenty. . .for there is nothing in the between but getting wenches with child, wronging the ancients, stealing, fighting”

G. Stanley Hall, who studied adolescence in the early 1900s, believed this period of “storm and stress” replicated earlier, less civilized stages of human development.

It wasn’t until the late 20th century when researchers developed brain-imaging technology that enabled them to see the teen brain in enough detail to track both its physical development and its patterns of activity. It turns out our brains take much longer to develop than we had thought!

The first scans of the developing brain (from NIH project that studied over a hundred young people as they grew up during the 1990s) showed that our brains undergo a massive reorganization between 12 and 25 years of age. It doesn’t actually GROW that much (like in the little kids birth to 3) but it undergoes a “network wiring upgrade”.

First, the axons – the long nerve fibers that neurons use to send signals to other neurons – become more insulated with a fatty substance called myelin (brain white matter) – so they can transmit up to a hundred times **faster**.

At the same time, the most heavily used synapses (the little chemical junctures across which axons send “messages” to neurons) grow richer and stronger. Synapses that see little use begin to wither. This synaptic “pruning” makes the brain **more efficient**. (this will be important to remember a little later when we talk about addiction potential)

These changes move in a slow wave from the back of the brain (where we have more basic functions like vision and movement) to the newer and more complicated thinking areas of the frontal cortex.

In addition, stronger links develop between the hippocampus (a sort of memory directory) and the frontal cortex (that sets goals and weighs different agendas) – this allows us to generate and weigh far more variables and agendas than before. Become more able to “learn from past mistakes” and make more complex and sophisticated decisions.

When this development proceeds normally, we get better at balancing impulse, desire, goals, self-interest, rules, ethics and even altruism. Our behavior is more complex and hopefully more sensible.

Before we look at the story of addiction (and more specifically, nicotine addiction), let’s pause for a moment and acknowledge what is good and beautiful about the adol brain!

Beautiful Brains:

- Lover of the thrill, seeker of novel experiences, openness to the new – can lead to useful experience ,
- Risk-takers – teens take more risks not because they don't understand the dangers, but because they weigh risk vs reward differently – in situations where risk can get them something they want, they value the reward. Over the course of human evolution, the willingness to take risks during this period has an adaptive edge – succeeding often requires moving out of the home and into less secure situations. The more you seek novelty and take risks, the better you do.
- Teens prefer the company of peers. More novel than boring, predictable adult. We enter a world made by our parents, but will live most of our lives and prosper (or not) in a world run and remade by our peers.
- SO – the delay in “completion” of the brain heightens flexibility as we confront and enter the world we will face as adults. This slow development not completed until the mid-20s is a uniquely human adaptation. It can seem weird that humans don't “wisen up” earlier in life, but it allows us to end up smarter in the end.

So where does smoking and nicotine fit in with the adolescent brain?

Well, it makes perfect sense that an adolescent would want to try smoking, or other nicotine containing products: it would be a novel experience, there would be risk involved, but the reward, the thrill of it, would be worth it – could gain you status in your peer group, so it is all good. Until you get addicted.

Tobacco exposure is the most important preventable cause of illness, disability, and death among adults in the US. The rate of decline has begun to slow for the use of cigarettes, and use has increased significantly for nicotine products such as hookahs and e-cigarettes. Almost all new users of all these products are children, adolescents and young adults.

Pediatrics just published an extensive technical report on Nicotine and Tobacco as substances of Abuse in Children and Adolescents. This report, with almost 100 references, explains how Nicotine can permanently affect the growing adolescent brain and lead easily to addiction to nicotine, as well as making these AYA develop addiction to other substances because of these brain changes.

What happens in the brain when an adolescent smokes?

Nicotine gets into the brain and binds to certain synapses in the prefrontal cortex, and causes an increase in the neurotransmitter dopamine – the result is that you feel pleasure. The growing brain changes in response to this by quickly increasing the number of these receptors – every time a young person lights up, the brain extends its desire for more nicotine by creating more of these “docking stations”. When these docking stations or receptors are full of nicotine, the level of dopamine remains high, and the person is happy. When the increased number of receptors are NOT plugged the dopamine level drops leaving the smoker feeling lousy. The way to feel good again is to add more nicotine. Craving more nicotine quickly follows. The adult brain, on the other hand, has a fairly fixed set of nicotine receptors.

So adol smokers develop differences in brain structure in areas that are correlated with memory, motivation, executive function, and mood. The “reward center” of the brain is permanently changed.

Epidemiologists have understood the “gateway drug model” of substance use. Now we have a better understanding of this from the brain level. If smoking in childhood and adolescence permanently increases the number of receptors in the reward center, these people will go through life forever needing to fill those neurons in order to feel “good”. Quitting smoking will be more difficult. And becoming addicted to other substances will be easier. Nicotine also increased the expression of a particular gene which increases the vulnerability to cocaine dependence.

Key Points:

- The earlier you start using nicotine products, the easier it is to become addicted – that is, it takes fewer cigarettes. For adolescents, even infrequent smoking, such as monthly intervals, is enough to put the individual at risk of dependence
- The earlier you start, the more likely you will continue to be a smoker as an adult:
 - 2/3 of children who smoke in 6th grade become regular adult smokers
 - Almost half (46%) of smokers in the 11th grade become regular adult smokers.
 - Of tobacco-dependent adults, 90% started smoking before 18 and 99% started before 26
- The prevention and cessation of nicotine use may decrease the future risk of addiction to illicit drugs.
- Nicotine is also linked to numerous diseases, including some cancers, kidney disease, inflammatory bowel disease, osteoporosis, and obesity.
- Adverse developmental impact on babies of mothers who smoke.

ANYTHING we can do to prevent the start of smoking and nicotine use by children and adolescents would reap great benefits. The Adult Brains of our current children and adolescents will surely thank us in the future!