SECTION ONE

What's the Difference Between Teenage Brains and Adult Brains?

Vaishnavi Patil

SOURCE: https://www.scienceabc.com/humans/teenage-brain-development-behavior-explained-frontal-lobe-function.html

Adolescence has been romanticized throughout human history. The impulsiveness of teenagers has been both hated and praised, their emotional unpredictability has been scoffed at and eulogized, and their vitality has been mocked envied. So what is it that makes our teenage years so enigmatic?

Adolescence has not just been literature's favorite object of attention. Even neurology has been preoccupied by trying to understand the teenage brain. Fortunately, the results of the research have been shockingly satisfying! Neurology has proven, without a doubt, that the adolescent brain is definitely different from the adult brain.

Hormones

Every time we address the impulsive behavior *cough-*stupidity*-cough* of teenagers, the obvious scapegoat of scientific circles has been the development of sex hormones. Puberty makes the newly sexually active teen seek emotionally charged activities, thus increasing risk-taking behavior. However, there is more to the story than that. Chronic lack of sleep, as it happens, is also an issue.

Sleep is crucial during the adolescent years because major brain redevelopment occurs while teens sleep, due to the release of important growth hormones by the pituitary gland. Teenagers actually require more sleep than adults for this very reason, yet their sleep cycles are largely skewed.

Sleep is regulated by cortisol, a hormone that helps us wake up, and melatonin, a hormone that makes us sleepy. In adults, melatonin is usually released by around 10 pm. In the teenage years, however, melatonin can wait until as late as 1 am to be released! This could be blamed on puberty, but also on the present culture that celebrates staying up late to participate in various global media. At the same time, most schools start quite early in the morning, so the youth, especially those in the new generation, are hardly getting any sleep at all! This naturally makes them more irritable and impulsive.

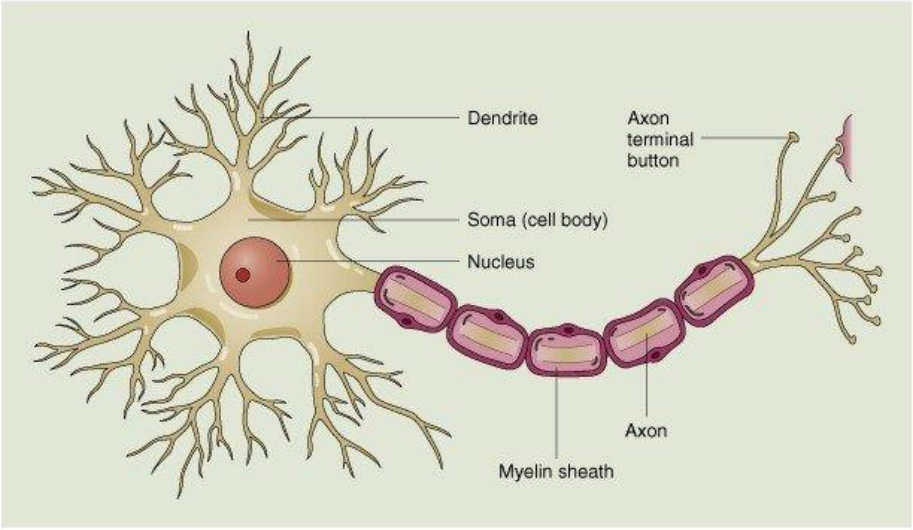
Yes, hormones do play a large part in erratic behavior patterns, but there is so much more going on in the teenage brain! Most of us are under the impression that our brains finish developing by the age of 6, and while it is true that

the size of our brains doesn't change much after that, its inner workings are not done developing by that point. Major changes are made to the connections within the brain that contribute to the passionate frenzy of the teenage years.

Developing Prefrontal Cortex

The prefrontal cortex of your brain is the part where all your rational decisions are made. The neurons in the prefrontal cortex communicate with the neurons in the other regions of the brain through synapses, thus playing a major role in weighing choices, controlling emotional responses and impulses, and making judgments. In adults, this region of the brain is fully developed and connected to the rest of the brain, but to reach this stage, it has to go through a long, drawn-out period of chaotic development that begins with puberty and stretches until the mid-20s.

Additionally, the teenage prefrontal cortex is not as effectively functional as it is in adults. Neurons are partially covered with an insulation called a 'myelin sheath', which increases the speed of transmission of information. This padding can make the transmissions up to one hundred times faster! But again, the myelin sheaths in teenage neurons are still only half-baked.



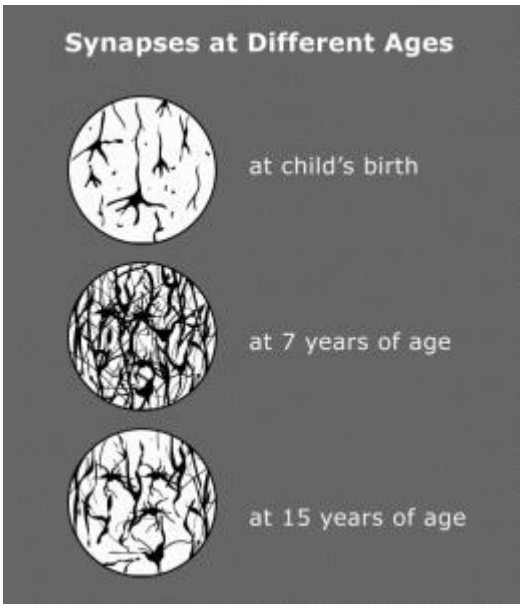
The process of developing myelin sheaths first begins at the back of the brain, where the more fundamental brain parts reside, and slowly progress towards the more advanced parts at the front. The prefrontal cortex is the last to "transform" to this more advanced cerebral network. So, while adults can make rational decisions quicker, teenagers are not as adept at doing so.

This would explain why teenagers experience such frequent mood swings! The other emotional regions behind the prefrontal cortex are much better connected in teenage brains, so all their decisions are immediately associated with emotional impulses, without running those choices by the more sensible prefrontal cortex.

Synaptic Pruning

It is not just the quality of the neural connections that change during adolescence. Even the quantity changes, as the number of connections in the brain decreases. So… does that mean you grow stupider as you age? No! On the contrary, your brain actually becomes more structured with the passage of time.

During your adolescent years, you start losing those connections that you don't use anymore. Imagine the brain as a complex city with lots of roads. Some houses have 15 roads leading up to them, while others have just two. If the house with 15 roads is empty, it makes no sense to maintain those 15 roads. That is essentially what your brain does during the adolescent years. It breaks down all the connections that are no longer necessary, making your brain more structured and efficient. This process is called synaptic pruning. It starts at the threshold of puberty and tapers off at some point during your 20s.



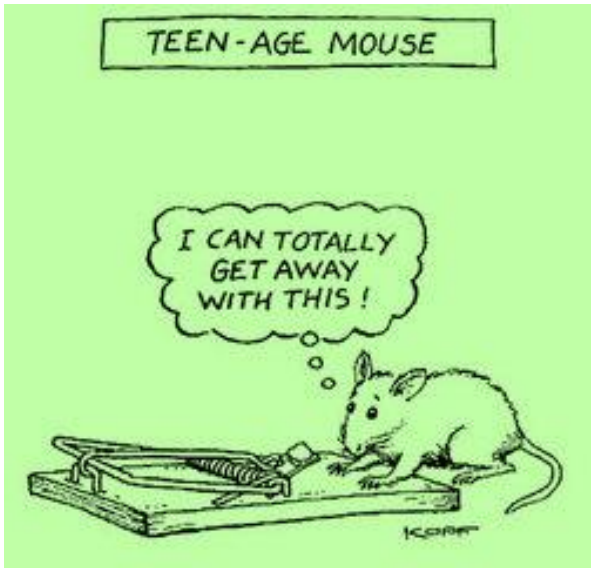
This also means that adolescence is an important time to use your brain! If you spend time doing mindless activities like stalking people on Facebook, your brain will start abandoning important connections that could have otherwise developed. Instead of playing Candy Crush, play an instrument, write poetry, learn a language, solve mathematical puzzles, or try out for a sport! By doing this, you are giving greater plasticity to the connections that your brain forms during these years.

Developed Amygdala

This remodeling of the brain manifests itself in other ways as well. A group of scientists once hooked up a number of adults and a group of teenagers to MRI devices and asked them to identify expressions of adult faces on screens. While adults correctly recognized these expressions, teenagers usually misread them. The MRI devices also revealed that while the adults were using their prefrontal cortex to understand the expressions, teens were using their amygdala. The amygdala is responsible for inducing emotions and impulses, not logic and rational reasoning.

The prefrontal cortex also helps you relate to other people, which might be why the teens misread the expressions. Perhaps now you understand why teenagers are usually at such odds with adults? If the amygdala and the prefrontal cortex are not effectively linked, then concern can be misread as anger and worry misconstrued as disappointment, as teens cannot productively work through these emotions.

This kind of emotional behavior also leads to more risk-taking. The nucleus accumbens forms early on in teens, which is the pleasure and reward zone of the brain. Studies show that when presented with a potentially large reward, adolescent brains light up far more than children's brains or adult brains. If the rewards are small, teen brains hardly fire up at all. Thus, they are more likely to do anything to access psychological rewards through risky behaviors, drugs, alcohol, etc. Unfortunately, this period is also when the brain is most vulnerable, as it is still developing.



Peer pressure also plays a large role in defining what teens do because it is a large reward in itself. In a study where both adults and teens were driving at risky speeds, when the two were exposed to friends in the car, the risk-taking behavior significantly increased with the teens, but not so much with the adults.

Another reason why teens value peer acceptance so much is because of evolution! Teens are also becoming sexually mature, so it makes sense for them to seek out peers outside the family to ensure genetic diversity and avoid inbreeding.

In other words, don't blame teenagers for acting stupidly or rashly. They are still living in a befuddling vertigo of fiery passions, oblivious to the harsh realities of the world. They really can't help it though. After all, their brains haven't finished developing yet!

References

1. The National Institute of Mental Health
2. HowStuffWorks

SECTION TWO

Inside the Teenage Brain

SOURCE: https://www.pbs.org/wgbh/pages/frontline/shows/teenbrain/interviews/giedd.html

Interview: Jay Giedd

Giedd is a neuroscientist at the National Institute of Mental Health. Recently, he spearheaded research showing for the first time that there is a wave of growth and change in the adolescent brain. He believes that what teens do during their adolescent years -- whether it's playing sports or playing video games -- can affect how their brains develop.

What has surprised you about looking at the adolescent brain?

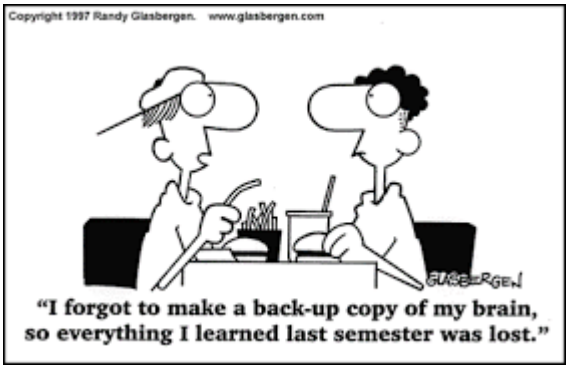
The most surprising thing has been how much the teen brain is changing. By age six, the brain is already 95 percent of its adult size. But the gray matter, or thinking part of the brain, continues to thicken throughout childhood as the brain cells get extra connections, much like a tree growing extra branches, twigs and roots. In the frontal part of the brain, the part of the brain involved in judgment, organization, planning, strategizing -- those very skills that teens get better and better at -- this process of thickening of the gray matter peaks at about age 11 in girls and age 12 in boys, roughly about the same time as puberty.

After that peak, the gray matter thins as the excess connections are eliminated or pruned. So much of our research is focusing on trying to understand what influences or guides the building-up stage when the gray matter is growing extra branches and connections and what guides the thinning or pruning phase when the excess connections are eliminated.

And what do you think this might mean, this exuberant growth of those early adolescent years?

I think the exuberant growth during the pre-puberty years gives the brain enormous potential. The capacity to be skilled in many different areas is building up during those times. What the influences are of parenting or teachers, society, nutrition, bacterial and viral infections -- all these factors -- on this building-up phase, we're just beginning to try to understand. But the pruning-down phase is perhaps even more interesting, because our leading hypothesis for that is the "Use it or lose it" principle. Those cells and connections that are used will survive and flourish. Those cells and connections that are not used will wither and die.

So if a teen is doing music or sports or academics, those are the cells and connections that will be hard-wired. If they're lying on the couch or playing video games or MTV, those are the cells and connections that are going [to] survive.

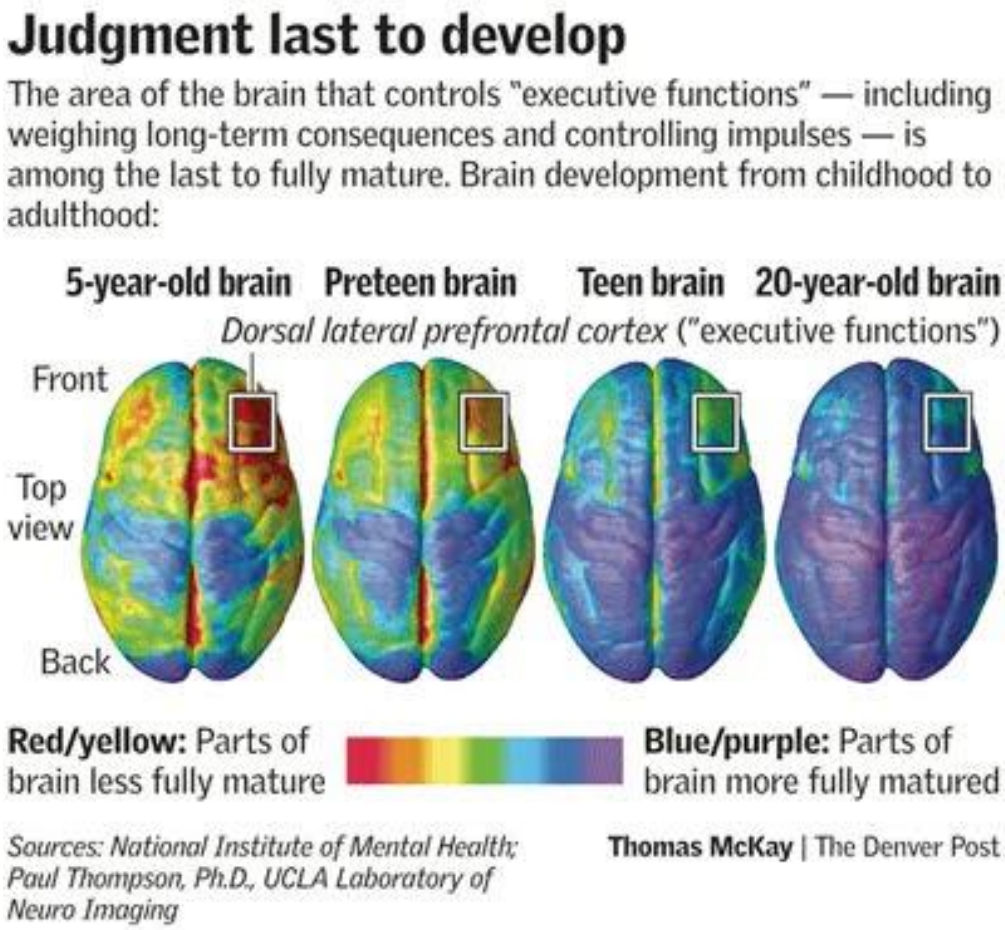


Right around the time of puberty and on into the adult years is a particularly critical time for the brain sculpting to take place. Much like Michelangelo's David, you start out with a huge block of granite at the peak at the puberty years. Then the art is created by removing pieces of the granite, and that is the way the brain also sculpts itself. Bigger isn't necessarily better, or else the peak in brain function would occur at age 11 or 12. ... The advances come from actually taking away and pruning down of certain connections themselves.

[It's] not that the teens are stupid or incapable of [things]. It's sort of unfair to expect them to have adult levels of organizational skills or decision making before their brain is finished being built.

The frontal lobe is often called the CEO, or the executive of the brain. It's involved in things like planning and strategizing and organizing, initiating attention and stopping and starting and shifting attention. It's a part of the brain that most separates man from beast, if you will. That is the part of the brain that has changed most in our human evolution, and a part of the brain that allows us to conduct philosophy and to think about thinking and to think about our place in the universe. ...

I think that [in the teen years, this] part of the brain that is helping organization, planning and strategizing is not done being built yet ... [It's] not that the teens are stupid or incapable of [things]. It's sort of unfair to expect them to have adult levels of organizational skills or decision making before their brain is finished being built. ...



It's also a particularly cruel irony of nature, I think, that right at this time when the brain is most vulnerable is also the time when teens are most likely to experiment with drugs or alcohol. Sometimes when I'm working with teens, I actually show them these brain development curves, how they peak at puberty and then prune down and try to reason with them that if they're doing drugs or alcohol that evening, it may not just be affecting their brains for that night or even for that weekend, but for the next 80 years of their life. ...

Tell me a little bit about how the brain develops.

How does the brain -- arguably the most complicated three-pound mass of matter in the

known universe -- how does the brain become the brain? It does so through two simple but powerful processes.

The first one is over-production. The brain produces way more cells and connections than can possibly survive. There's only so many nutrients, there's only so many growth factors, there's only so much room in the skull. After this vast over-production, there is a fierce, competitive elimination, in which the brain cells and connections fight it out for survival. Only a small percentage of the cells and connections make it.

This is a process that we knew happened in the womb, maybe even the first 18 months of life. But it was only when we started following the same children by scanning their brains at two-year intervals that we detected a second wave of over-production. This second wave of over-production is manifest by an actual thickening in the gray matter, or the thinking part, in the front part of the brain.

As this second wave of over-production is occurring, it prepares the adolescent brain for the challenges of entering the next stage of life, the adult years. There's enormous potential at that time. People can take many different life directions. But about around that time of puberty, people start specializing, so to speak. They start deciding, "This is what I'm going to be good at, whether it be sports or academics or art or music." All the life choices, even though they are still there, start getting whittled away, and we have to start sort of focusing in on what makes us unique and special. ...

Do you have particular concerns about that period, too, though?

Yes. It's a time of enormous opportunity and of enormous risk. And how the teens spend their time seems to be particularly crucial. If the "Lose it or use it" principle holds true, then the activities of the teen may help guide the hard-wiring, actual physical connections in their brain. ...

Can you describe to me what people used to believe about the brain, actually, very recently?

One of the most exciting discoveries from recent neuroscience research is how incredibly plastic the human brain is. For a long time, we used to think that the brain, because it's already 95 percent of adult size by age six, things were largely set in place early in life. ... [There was the] saying. "Give me your child, and by the age of five, I can make him a priest or a thief or a scholar."

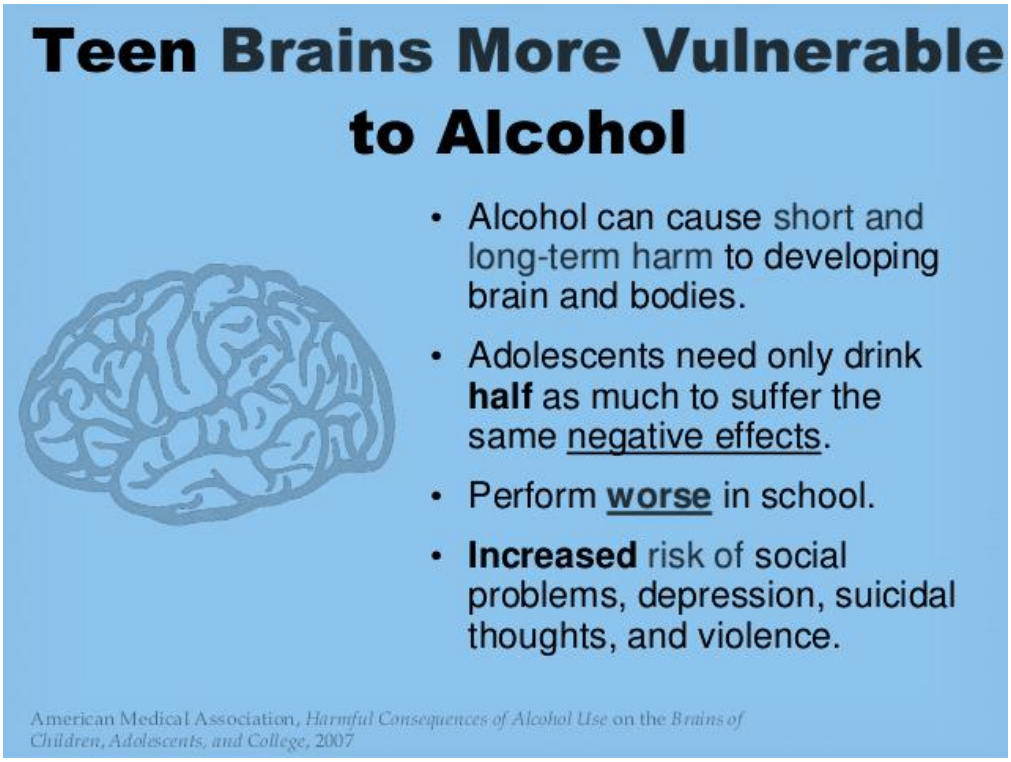
[There was] this notion that things were largely set at fairly early ages. And now we realize that isn't true; that even throughout childhood and even the teen years, there's enormous capacity for change. We think that this capacity for change is very empowering for teens. ...

This is an area of neuroscience that's receiving a great deal of attention ... the forces that can guide this plasticity. How do we optimize the brain's ability to learn? Are schools doing a good job? Are we as parents doing a good job? And the challenge now is to ... bridging the gap between neuroscience and practical advice for parents, teachers and society. We're not there yet, but we're closer than ever, and it's really an exciting time in neuroscience. ... The next step will be, what can you do about it, what can we do to help people? What can we do to help the teen optimize the development of their own brain? ...

There has been a great deal of attention on the early years, and particularly on stimulating the early brain. What do you think of that work and that popularization of that brain science?

There's been a great deal of emphasis in the 1990s on the critical importance of the first three years. I certainly applaud those efforts. But what happens sometimes when an area is emphasized so much, is other areas are forgotten. And even though the first 3 years are important, so are the next 16. And the ages between 3 and 16, there's still enormous dynamic activity happening in brain biology. I think that that might have been somewhat overlooked with the emphasis on the early years. ...

Not so long ago, people were emphasizing teaching little children through flashcards, through particular kinds of mobiles with black-and-white checks on them, playing Mozart. In fact, some states have sent CDs back with new mothers. What do you think of that? Has that been a misinterpretation of brain science?



... We all want to do the best for our children. And what I fear is happening is that we're leaping too far from the neuroscience to such things. I don't think there is any established videotape or CD or computer program or type of music to play that we've shown with any scientific backing to actually help our children.

The more technical and more advanced the science becomes, often the more it leads us back to some very basic tenets of spending loving, quality time with our children. The brain is largely wired for social interaction and for bonding with caretakers. And sometimes it's even disappointing to people that, with all the science and all the advances the best advice we can give is things that our grandmother could have told us generations ago: to spend loving, quality time with our children. ... I think [it] probably does more harm than good for parents to be confronted with so many of these conflicting reports in the media without any scientific basis. ...

What directions is the research taking to explore how we can optimize brain development?

Now that we've been able to detect the developmental path of different parts of the brain, the next phase of our research is to try to understand what influences these brain development paths. Is it nutrient or parenting or video games or the activity of the [child]? Or is it genes? By studying twins, we can begin to address some of these very basic nature/nurture-type of questions.

For instance, when twins are in the first grade, their parents often dress them in the same clothes. They get the same haircut. It's sort of cute how alike they are. But that's not as cool in high school anymore. And so a lot of the twins as teens in high school start doing different things. The one who was a little bit better in sports may become an athlete. The one who was a little bit better at academics may become a scholar. Or one may turn to music and one to art. But they often have different daily activities.

So we can scan the brains when the twins are young and doing everything very much alike; then we can scan them as teenagers, when they start having different daily activities. This gives us a sense of which parts of the brain are influenced by behavior and which parts by the genes themselves.

We've already got some interesting early data on this. One part of the brain is called the corpus callosum. It's a thick cable of nerves that connects that two halves of the brain and is involved in creativity and higher type of thinking. It's very popular for imaging studies because it leaps out of the picture. It's very easy to measure and quantify.

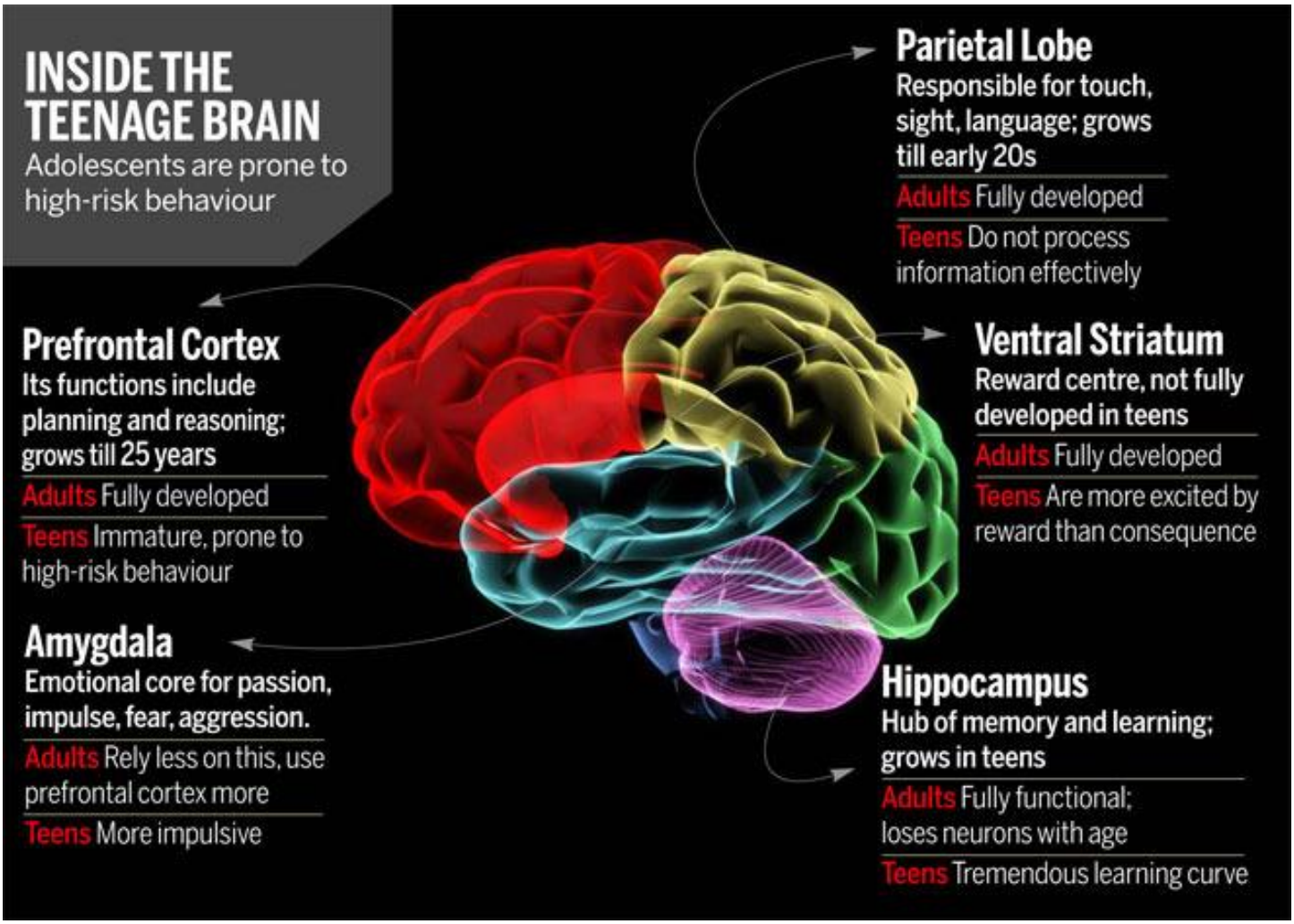
It's also interesting because it changes a lot throughout childhood and adolescence. It's been reported to be different in size and shape in many different illnesses that happen during childhood ... many higher cognitive thought [processes] like creativity and ability to solve problems. So it's been of great interest, especially to child

psychiatrists. And what we find is that the size and shape of the corpus callosum is remarkably similar amongst twins ... and [so] seems to be surprisingly under the control of the genes.

But another part of the brain -- the cerebellum, in the back of the brain -- is not very genetically controlled. Identical twins' cerebellum are no more alike than non-identical twins. So we think this part of the brain is very susceptible to the environment. And interestingly, it's a part of the brain that changes most during the teen years. This part of the brain has not finished growing well into the early 20s, even. The cerebellum used to be thought to be involved in the coordination of our muscles. So if your cerebellum is working well, you were graceful, a good dancer, a good athlete.

But we now know it's also involved in coordination of our cognitive processes, our thinking processes. Just like one can be physically clumsy, one can be kind of mentally clumsy. And this ability to smooth out all the different intellectual processes to navigate the complicated social life of the teen and to get through these things smoothly and gracefully instead of lurching ... seems to be a function of the cerebellum.

And so we think it's intriguing that we see all these dynamic changes in the cerebellum taking place during the teen years, along with the changes in the behaviors that the cerebellum sub-serves.



What would influence the development of the cerebellum?

Traditionally it was thought that physical activity would most influence the cerebellum, and that's still one of the leading thoughts. It actually raises thoughts about, as a society, we're less active than we ever have been in the history of humanity. We're good with our thumbs and video games and such. But as far as actual physical activity,

running, jumping, playing, children are doing less and less of that, and we wonder, long term, whether that may have an effect on the development of the cerebellum.

The recess and play seems to be the first thing that is cut out of school curriculums in tight times. But those actually may be as important, or maybe even more important, than some of the academic subjects that the children are doing. ... We think that the "Use it or lose it" principle holds for the cerebellum as well. If the cerebellum is exercised and used, both for physical activity but also for cognitive activities, that it will enhance its development.

... One analogy that computer people use is that [the cerebellum is] like a math co-processor. It's not essential for any activity. People can get by quite well without large chunks of it. But it makes many activities better. The more complicated the activity, the more we call upon the cerebellum to help us solve the problem. And so almost anything that one can think of as higher thought -- mathematics, music, philosophy, decision making, social skills -- seems to draw upon the cerebellum. ...

The relationship between the findings that we have in the cerebellum and sort of practical advice or the links between behavior are not well worked out yet. That's going to be one of the great challenges of neuroscience -- to go from these neuroscience facts to useful information for parents, for teachers or for society. But it's just so recently that we've been able to capture the cerebellum that no work has yet been done on the forces that will shape the cerebellum or the link between the cerebellum shape or size and function.

When you look at the recent work that you've done in terms of the frontal cortex, do you see a difference between girls and boys?

Yes. One of the things that we're particularly interested in as child psychiatrists is the difference between boys' brains and girls' brains, because nearly everything that we look at as child psychiatrists is different between boys and girls -- different ages of onset, different symptoms, different prevalences and outcomes. Almost everything in childhood is more common in boys -- autism, dyslexia, learning disabilities, ADHD, Tourette's syndrome -- are all more common in boys. Only anorexia nervosa is more common in girls. So we wonder if the differences between boys' and girls' brains might help explain some of these clinical differences.

The male brain is about 10 percent larger than the female brain across all the stages of ... 3 to 20; not to imply that the increased size implies any sort of advantage, because it doesn't. The IQs are very similar. But there are differences between the boy and girl brains, both in the size of certain structures and in their developmental path. The basal ganglia which are a part of the brain that help the frontal lobe do executive functioning are larger in females, and this is a part of the brain that is often smaller in the childhood illnesses. I mentioned, such as ADD and Tourette's syndrome.

So girls, by virtue of having larger basal ganglia, may be afforded some protection against these illnesses. But in the general trend for brain maturation, it's that girls' brains mature earlier than boys' brains. ...

SECTION THREE

Roper v. Simmons (2005)

SOURCE: https://www.oyez.org/cases/2004/03-633

Petitioner

Donald P. Roper, Superintendent, Potosi Correctional Center

Respondent

Christopher Simmons

Location

Meramec River

Docket no.

03-633

Decided by

Rehnquist Court

Lower court

Supreme Court of Missouri

Citation

543 US 551 (2005)

Granted

Jan 26, 2004

Argued

Oct 13, 2004

Decided

Mar 1, 2005

Advocates

James R. Layton argued the cause for Petitioner

Seth P. Waxman argued the cause for Respondent

Facts of the case

Christopher Simmons was sentenced to death in 1993, when he was only 17. A series of appeals to state and federal courts lasted until 2002, but each appeal was rejected. Then, in 2002, the Missouri Supreme Court stayed Simmon's execution while the U.S. Supreme Court decided Atkins v. Virginia, a case that dealt with the execution of the mentally disabled. After the U.S. Supreme Court ruled that executing the mentally disabled (or "mentally retarded" in the vernacular of the day) violated the Eighth and 14th Amendment prohibitions on cruel and unusual punishment because a majority of Americans found it cruel and unusual, the Missouri Supreme Court decided to reconsider Simmons' case.

Using the reasoning from the Atkins case, the Missouri court decided, 6-to-3, that the U.S. Supreme Court's 1989 decision in Stanford v. Kentucky, which held that executing minors was not unconstitutional, was no longer valid. The opinion in Stanford v. Kentucky had relied on a finding that a majority of Americans did not consider the execution of minors to be cruel and unusual. The Missouri court, citing numerous laws passed since 1989 that limited the scope of the death penalty, held that national opinion had changed. Finding that a majority of Americans were now opposed to the execution of minors, the court held that such executions were now unconstitutional.

On appeal to the U.S. Supreme Court, the government argued that allowing a state court to overturn a Supreme Court decision by looking at "evolving standards" would be dangerous, because state courts could just as easily decide that executions prohibited by the Supreme Court (such as the execution of the mentally ill in Atkins v. Virginia) were now permissible due to a change in the beliefs of the American people.

Question

Does the execution of minors violate the prohibition of "cruel and unusual punishment" found in the Eighth Amendment and applied to the states through the incorporation doctrine of the 14th Amendment?

Conclusion

- **5–4 decision**
  majority opinion by Anthony M. Kennedy

Yes. In a 5-4 opinion delivered by Justice Anthony Kennedy, the Court ruled that standards of decency have evolved so that executing minors is "cruel and unusual punishment" prohibited by the Eighth Amendment. The majority cited a consensus against the juvenile death penalty among state legislatures, and its own determination that the death penalty is a disproportionate punishment for minors. Finally the Court pointed to "overwhelming" international opinion against the juvenile death penalty. Chief Justice William Rhenquist and Justices Antonin Scalia, Sandra Day O'Connor, and Clarence Thomas all dissented.

"Roper v. Simmons." *Oyez,* 8 Dec. 2017, www.oyez.org/cases/2004/03-633.