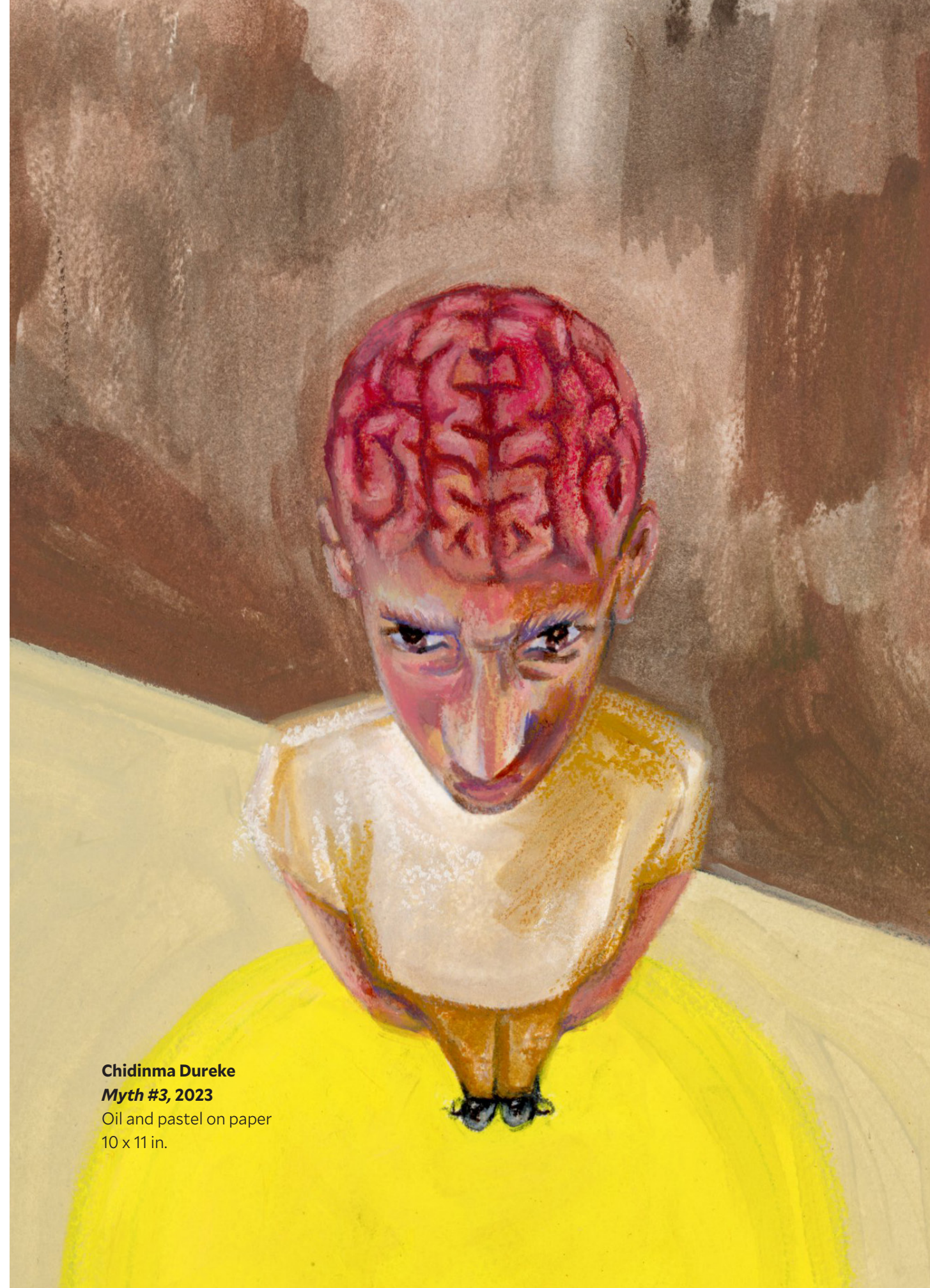


7 Myths about the adolescent brain

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Over the last two to three decades, important discoveries have been made about the developing human brain, especially the adolescent brain. Yet, I continue to hear colleagues, journalists, and educators make overgeneralizations about the adolescent brain and behavior that have been debunked by science.



Chidinma Dureke

Myth #3, 2023

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10 x 11 in.

These misconceptions often paint the adolescent brain in a negative light, reducing it to a defective car, with no brakes or steering wheel, just an accelerator. This characterization is typically attributed to the immaturity of the prefrontal cortex, a region implicated in executive functions that enables us to make rational decisions, regulate our emotions and juggle multiple tasks in everyday life. Moreover, this negative depiction of the adolescent brain as defective suggests that adolescents are incapable of making rational decisions, only risky, emotional, and impulsive ones, and implies a condition of deviance rather than development.

The concern with perpetuating negative overgeneralizations about the adolescent brain is that they can influence how we perceive and treat young people within society and our legal system. If we assume adolescents are not competent to make decisions, then that can result in laws and policies that diminish their rights (e.g., limit their ability to make medical decisions or select a family placement for themselves); if we perceive youth to be deviant or even dangerous, then that can result in harsher sentences for young offenders (e.g., transfer to adult court, life without parole). This is especially true for adolescents of color or from low-income families who are disproportionately arrested, transferred to adult courts, and given harsher sentences. So, what does the current neuroscientific evidence tell us about the adolescent brain?

First, it is true that the prefrontal cortex shows marked developmental changes throughout the period of adolescence, which extends roughly from pubertal onset into the early to mid-twenties. However, the prefrontal cortex is not the only brain region that is changing, and importantly, brain development does not suddenly stop the day a youth turns 18, which is when they are deemed an adult within our criminal legal system. Rather, the brain shows the potential for change (plasticity) throughout the life course, but especially in the first few decades of life. With age and experience, connections throughout the brain that are important for integrating cognitive, emotional, and social information are sculpted and strengthened, which increase the efficiency and speed of neural communication among them, facilitating and optimizing decision-making in emotional and social contexts.

Second, while adolescents can be risky, impulsive, appear fearless and engage in criminal behavior more than other ages, there are situations in which adolescents are less risky, less impulsive, and even more fearful than at other ages. The science provides important information about in which circumstances an adolescent appears “adult-like” in their capacity and in which situations that capacity may be diminished.

Within this context, I highlight seven common overgeneralizations about the adolescent brain and behavior and provide empirical evidence that may serve to provide a finer appreciation for and understanding of this amazing—although challenging – period of development. A deeper understanding of adolescence may help to inform and reform current laws and policies to both protect youth from undue harm while still providing them with rights and opportunities necessary for building the very cognitive, social, and emotional skills needed for becoming a contributing adult member of society.

Myth 1

The adolescent has no brain or prefrontal cortex.

Indeed, adolescents not only have a brain but also a prefrontal cortex. At birth, the brain itself is relatively intact, including the part of the brain that makes up the prefrontal cortex, and there is evidence of prefrontal functioning even in infants. For example, by eight months of age, the infant can perform simple executive functions supported by the prefrontal cortex, such as holding onto information in memory over time and inhibiting inappropriate responses to obtain a goal (e.g., reaching around a partition as opposed to trying to go through a partition for a blocked object or finding a hidden toy in a new location rather than looking in the original location in which it was hidden; Diamond, 1990). It logically follows then that if an infant has a functioning prefrontal cortex, then so too does an adolescent who is even further along in their development. Moreover, if adolescent risky behaviors were solely due to immaturity of the prefrontal cortex, then the less mature prefrontal cortex of the child’s brain should lead to even more risky behavior than that observed in the adolescent. Yet, we do not see the same behavioral profile in children that we generally see in adolescents, such as increased risk taking and sensation seeking. Therefore, attributing bad choices or risky behavior in adolescents solely to the immaturity of the prefrontal cortex does not logically follow.

What might explain the changes we see in adolescent behavior? While the prefrontal cortex continues to show significant changes in structure and function well into the 20s, other brain regions and circuits involving emotions show peak changes during the teen years. These regions include deep subcortical and medial cortical areas of the

brain important for detecting, processing, and reacting to social and emotional information (e.g., rewards, threats, and peers). In part, these observed changes in the prefrontal cortex and emotional systems are due to changes in gonadal hormones and neurochemicals in the brain, such as dopamine, which has been implicated in reinforcement and fear learning. These systems show peak developmental changes by the late teen years, which is earlier than the extended changes that we see in the prefrontal cortex, especially in the lateral prefrontal cortex, which continue well into the 20s.

This differential development has been described as an imbalance between rational and emotional centers of the brain, with emotional centers showing peak changes during adolescence relative to childhood and adulthood, but the prefrontal cortex showing continued steady development from infancy into adulthood.

As such, in emotionally charged situations, emotional systems in the adolescent brain are postulated to hijack the more slowly developing regions of the prefrontal cortex, leading to less rational or optimal decisions and actions (Casey, 2015).

It is important to underscore that it is the continued refinement and strengthening of connections among different brain regions with age and experience that show extended development. This developmental pattern is manifested behaviorally in different ways depending on the social context and

underlying brain networks. For example, adolescents have the capacity to make rational decisions by the teen years in low stress situations, but this capacity is diminished when making decisions in emotionally or socially charged and stressful situations, the latter of which involves communication among several brain networks. Optimal decision-making and self-regulation in these arousing situations

continue to develop into the 20s. As such, different cognitive and psychological abilities develop at different time points, along with brain development. Therefore, there is not one age demarcation for the development of these abilities but rather several that map onto separate and interacting cognitive, emotional, and social abilities.

Myth 2

Adolescents are riskier than adults.

A common characteristic of adolescence is that it is a time of risk taking and sensation seeking. It is true that as a group, adolescents show greater risk taking and sensation seeking than younger and older individuals. Yet, the circumstances in which adolescents make risky decisions vary greatly, and in some situations, they are actually more risk averse (make less risky choices) than adults.

Tymula and colleagues (2012) have shown that when the odds of a gamble are known and there is a definite option of a smaller win versus a gamble of a potential larger win but also larger loss, teens do not take the gamble.

They tend to take the gamble less in these situations even though the gain is less than what they could potentially have won if they had taken the gamble. In other words, adolescents will take the sure bet even though

the winnings are smaller than what they could have potentially won if they took the gamble where there was also the potential for loss. Adults in this situation tend to gamble more. However, if the odds of an outcome are ambiguous, adolescents tend to go for the gamble where they could win more money but also potentially lose more money, rather than taking a sure bet of a smaller reward. Therefore, they take more risks in their choices than adults do in these ambiguous situations.

Given that adolescents have less decision-making experience than adults, there are likely more ambiguous or uncertain outcomes of choices for adolescents than for adults. This tolerance of risk in uncertain situations may facilitate more exploratory trial-and-error choice behavior. This type of trial-and-error learning has been suggested to facilitate adolescents' rapid learning about their social world and societal rules on their own in preparation for ultimately transitioning into an independent adult within society.

Myth 3

Adolescents make bad choices and decisions.

The period of adolescence is one of significant learning as the individual gains knowledge that helps to prepare them for assuming adult roles. As stated, this learning impacts their choices and actions. Often, it is assumed that their heightened sensitivity to rewards leads teens to make bad choices and decisions in pursuit of winning over losing. However, teens are better than adults at learning about the probabilities of rewards and optimizing their

gains in gambling tasks (Barkley-Levinson & Galván, 2014) and during reinforcement learning (Davidow et al., 2016). Therefore, their decisions are not always bad. In a given moment in time, an adolescent's decision can appear risky or bad, but with time and experience and the right supportive environment, that exploratory learning style can be beneficial and can alter their behavior positively.

Myth 4

Adolescents are more impulsive than adults.

It is true that adolescents can be impulsive, but there are circumstances in which they appear less impulsive than even adults. When events or cues in the environment that have been reinforced previously (e.g., a smiling face, a peer, substance) are used as distractors or are irrelevant to the task at hand, adolescents appear to be drawn to them more than children and adults, which ultimately can interfere with goal-directed behavior and lead to mistakes when instructed to ignore or not respond to these cues. This behavioral pattern is paralleled by increased activity in reward-related brain regions such as the nucleus accumbens (Galván et al., 2006; Bramms et al., 2015), which has been related to risky choice behavior in some circumstances (Galván et al., 2007).

However, rewards themselves can improve decision-making and diminish impulsivity when used as an outcome or as feedback for correct or optimal choices (as opposed to as a distraction). We tested this idea in adolescents and adults. We gave them choices of either pressing a left or right button to indicate

the direction of motion of moving dots on a computer screen where a correct response for one direction of motion (e.g., left) was associated with a large reward (e.g., 5 points), but only a very small reward (1 point) was given for a correct response for the other direction (e.g., right). I should note that no points were given if the response was incorrect and the number of dots moving left or right among several randomly moving dots was manipulated to maintain similar levels of difficulty for each participant.

We found that adolescents were less impulsive than adults in their decision-making when a larger reward was at stake (Teslovich et al., 2014). In other words, they took their time before finalizing their decision about the direction of motion when 5 points were at stake.

However, they were faster than adults when a smaller reward was at stake. This behavior was associated with more engagement of prefrontal circuitry implicated in decision-making and suggested that they let sufficient evidence accumulate before making a final decision, rather than responding impulsively. In other words, they wanted

Myth 5

Adolescents are only influenced by their peers.

Adolescents show a heightened sensitivity to peers that decreases with age. A sensitivity to peer influences in this developmental period is not surprising given that adolescence is a time when we form deep connections with peers and begin to form an identity separate from our parents in preparation for becoming an independent member of society as an adult. Psychological and imaging experiments have shown that the mere presence of a peer during a decision-making task (e.g., whether or not to drive through a yellow light) increases risky decisions that are paralleled by activation of dopamine-rich reward brain circuitry in adolescents (Chein et al., 2011). Such behavioral and brain patterns are less common in adults and in adolescents when alone. The heightened influence of peers on the brain and behavior can lead adolescents to engage in potentially harmful behaviors beyond risky driving (e.g., use and abuse of illicit substances or stealing when spurred on by a peer). This sensitivity to peer influences in adolescents is also reflected in criminal-related behavior. Crimes committed by young offenders more often involve accomplices than those committed by adults. Although peers can negatively influence adolescent choices and actions, they can also have a positive influence on behavior. For

to be sure that they chose the correct direction of motion so as not to lose the large reward option. Thus, teens are not always more impulsive than adults, and we can use their heightened sensitivity to rewards to reinforce and potentially change their behavior in positive ways.

example, group interactions that are coordinated toward a positive common goal (e.g., team sports, team debates, or organized civic activities) are prosocial goal-directed activities and can facilitate agency, purpose and pride; importantly, they have been related to a lower risk of mental health problems, such as depression.

Although peers have a significant impact on adolescent behavior, they are not the only ones. Adults and parents also influence adolescent behavior and serve as prosocial role models that can have lasting effects on adolescents' development. Often, we hear of how a mentor or parent helped facilitate a teen's passion for the arts, sciences, athletics, or civic activities and that a specific adult is credited for the subsequent success and accomplishments of that youth later in life. We also know from the psychological literature that an adult's presence (Silva et al., 2016) and advice can influence adolescent decision-making even more than same-aged peers (Lorenco et al., 2016), both positively and negatively. As such, youth need the opportunity to learn from prosocial group activities and from prosocial role models, which is limited in our punitive legal system and in its treatment of young offenders.

Myth 6

Adolescents are fearless and believe they are immortal.

I don't know how many times I've come across lay articles or lectures that suggest that teens engage in risk behaviors because they are fearless and think that they are immortal. If this is truly the case, then why do we see a peak in anxiety- and stress-related disorders at this age, illnesses that are undoubtedly related to aspects of fear? Moreover, studies that examine adolescents' perceptions of their own risk for disease and mortality when engaging in risky behaviors (e.g., unprotected sex or smoking) are not less but greater than or equal to those of adults (Henley & Donovan, 2003; Johnson et al., 2002; Reyna et al., 2006).

The notion that adolescents are fearless has been countered by a large collection of independent studies across species showing exaggerated responses to threats and stressors. For example, while children, adolescents and adults alike can very quickly acquire a fear memory (e.g., fear a tone that previously has been paired with shock), human and rodent adolescents show a diminished ability to extinguish a fear memory once learned (Pattwell et al., 2012).

This sustained fear response is correlated with more activity in the amygdala, a region implicated in threat and emotional processing,

and less activity in the prefrontal cortex, a region implicated in the extinction of fear memories. Chronic stress and uncertain threats are likewise associated with decreased prefrontal activity and increased impulsive behavior in adolescents up to 21 years relative to adults 25 or older (Cohen et al., 2016; Rahdar & Galvan, 2014). These findings suggest that adolescents are not fearless but rather show heightened stress and threat responses relative to adults that are associated with behavioral reactivity (impulsivity). Threats activate the body's fight or flight response, which likely is even more critical for the survival of adolescents in potentially dangerous situations given their immaturity and given that their caregiver is less often present to protect them at this developmental stage relative to earlier ones. Therefore, being reactive or impulsive in these situations may be more adaptive than engaging prefrontal functions such as impulse control. Unfortunately, threatening and stressful situations can lead to inappropriate reactivity in other contexts, which are often the very circumstances in which young offenders come into contact with our criminal legal system.

Myth 7

Adolescence ends at 18 years of age.

The definition of adolescence and when it ends varies greatly depending on the perspective and situation. From a legal perspective, the age of majority—when an individual can sign legal documents without the need for an adult to

co-sign and when they can vote—is currently 18 in the US. Thus, one assumption of the age of majority model is that an individual has full adult cognitive capacity at 18 and thus the same responsibility for their actions as an adult

in our criminal legal system, as they are no longer a minor.

In contrast, an emerging definition of adolescence from a neurodevelopmental perspective is that it extends from approximately 10 years of age—around pubertal onset—to 25 years of age, based on empirical evidence of significant neurocognitive changes throughout this time (Sawyer, 2018).

Many expert organizations and institutions recognize that psychological development continues well into the 20s (National Institutes of Health, the United Nations, and the World Health Organization). In fact, several US laws and policies also recognize this continued development (e.g., purchase of alcohol, age one can stay on parent's insurance or in foster care). Yet, the treatment of young offenders too often ignores developmental research and treats youth as adults. For example, even young children can be transferred from the juvenile

system to adult courts for certain crimes and situations, with 20 states having no minimum age for transfer. Assigning adult status to a young child is not supported by either biological or psychological evidence, nor is it for youth in their early 20s who commit a crime in an emotionally charged situation based on the imaging and behavioral evidence presented above.

A better understanding of circumstances in which youth have adultlike capacity and those in which that capacity may be diminished can help to inform and reform laws and policies related to the treatment of youth in our legal system. These reforms hopefully will protect youth from cruel and unusual punishments for their offenses while still providing youth with rights to make personal decisions for themselves and opportunities for cognitive, social, and emotional development necessary for becoming a contributing member of society.

Conclusions

The adolescent brain is not defective but has evolved to help meet the demands of this challenging developmental period as the individual learns from their social world and about societal rules to effectively transition from dependence to relative independence from the caregiver. It is a time of exploration and trial-and-error learning, the formation of deep bonds with peers and the emergence of a self-identity. Rather than perpetuating a negative narrative about the adolescent brain that can detrimentally impact how we view and treat young people in society, it is important to reflect on how the adolescent brain may be programmed to meet the very challenges of this developmental period. As such, how can we use defining characteristics of adolescence (e.g., heightened sensitivities to rewards, threats, and external influences)

to both protect and benefit them? An all-or-none perspective of adolescent capacity does not allow us to understand in which contexts prosocial behavior can be fostered and in which contexts adolescents are susceptible. Labeling adolescents as “all bad” means that when people counter this view, it is then viewed in black and white terms rather than shades of gray, when what is important are the contextual differences that promote protection and risk. If we simply focus on adolescents as bad decision-makers, then that can significantly influence laws and policies that diminish their rights to make their own health- and family-related decisions, or worse it can lead to perceptions of young offenders as deviant (and even deserving of adult sentences for adult crime as was promoted in the 1990s), when in fact they are in a transitory phase of development.



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Myth #6, 2023
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