Adolescent Brain Development and Drug Abuse

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Research indicates that brain development is still in progress during adolescence; immature brain regions may place teenagers at elevated risk to the effects of drugs.

New scientific discoveries have put a much different perspective on our understanding of adolescent behavior. Research now suggests that the human brain is still maturing during the adolescent years, with significant changes continuing into the early 20s. The developing brain of the teenage years may help explain why adolescents sometimes make decisions that seem to be quite risky and may lead to safety or health concerns. And it may add insights into unique vulnerabilities and opportunities associated with youth.

Work in Progress

Advanced technologies in brain imaging have provided windows to the developing brain. Based on the pioneering work of Jay Giedd and colleagues at the National Institute of Mental Health (Giedd, 2004), evidence is accumulating that the brain is not fully formed at the end of childhood as earlier thought. The juvenile brain is still maturing in the teenage years and reasoning and judgment are developing well into the early to mid 20s.

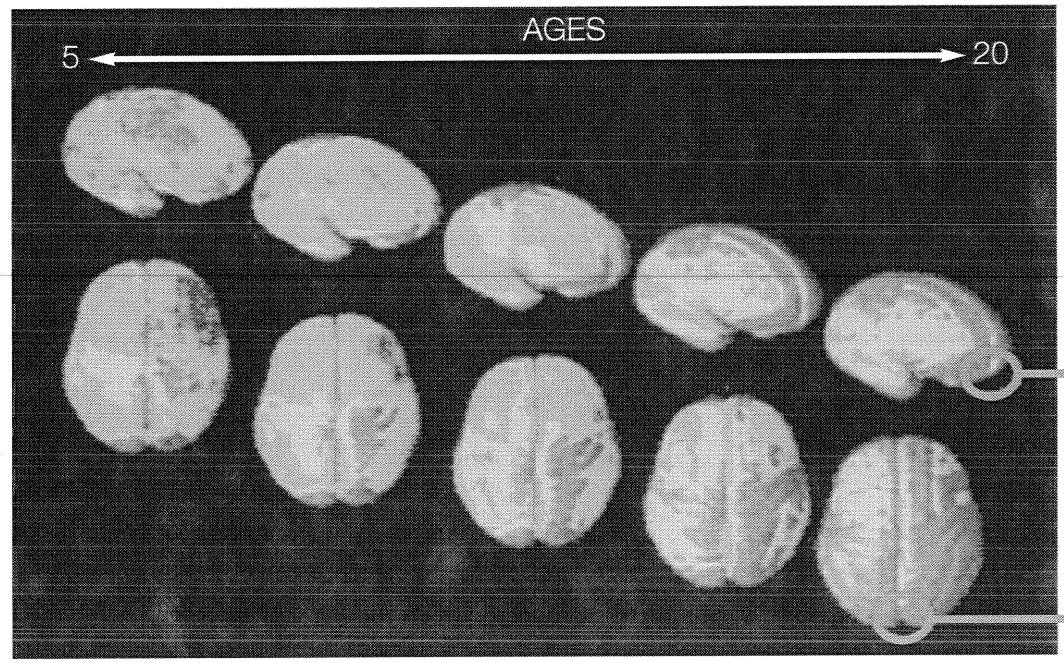
During childhood, the brain grows an excessive number of connections between brain cells. At about year 11 or 12, a young person begins to lose or "prune back" a substantial fraction of these connections. This loss is healthy in the long run and is a vital part of growing up. The pruning process clears out unneeded wiring to make way for more efficient and faster information-processing as we become adults. And it promotes building the long chains of nerve cells that are required for the more demanding problem-solving needed during adulthood.

The pruning process appears to follow the principle of "use-it-or-lose-it," according to experts. Thus, neural connections or circuitry that gets exercised as we grow up are retained, while the connections that are not activated or used, get pruned away. Dr. Giedd refers to this process in this way: "Ineffective or weak connections are pruned in much the same way a gardener would prune a tree or bush, giving the plant the desired shape."

This brain maturation tends to occur from the back of the brain to the front. So the front region of the brain, known as the prefrontal cortex, which is responsible for high-level reasoning and decision-making, does not become fully mature until around the early to mid 20s.

The prefrontal cortex is the part of the brain that enables a person to think clearly, to make good decisions and to control impulses. It is primarily responsible for how much priority to give incoming messages like ''Do this now'' versus ''Wait! What about the consequences?'' Because the emotional, "Do this now" regions, predominantly located behind the front of the brain, have progressed more with the pruning process, it is difficult for the ""Wait" part of the brain to exert much influence. As Psychologist Laurence Steinberg sees it, a teenager's brain "has a well-developed accelerator but only a partly developed brake."

Images of Brain Development in Healthy Children and Teens (ages 5-20)



Gogtay, N., Giedd, J.N., et al. (2004)
Dynamic mapping of human cortical development during childhood through early adulthood.
Proceedings of the National Academy of Sciences, 101 (21), 8174 – 8179.

"Having a scientific perspective on the biological challenges of adolescence will help you interact more objectively with your child, maintain your cool, and offer guidance that can improve his or her life."

Dr. David Walsh, from "Why Do They Act That Way: A Survival Guide to the Adolescent Brain for You and Your Teen" (p.12).

Implications for Understanding behavior

Scientists caution against suggestions of definitive linkages between brain development and adolescent behavior. But there is a growing sentiment among experts that when teenagers are feeling high emotion or intense peer pressure, conditions are ripe for the still-maturing circuitry in the front part of brain to be overwhelmed, contributing to inexplicable behavior and poor decision-making.

This does not mean adolescents can not make a rational decision or appreciate the difference between right and wrong. The teenage brain is quite capable of demonstrating plenty of mental ability. But the teenager, with less than optimal brain-based control mechanisms, is more likely to act impulsively and with gut instinct when confronted with stressful or emotional decisions, without fully appreciating the immediate consequences of their actions.

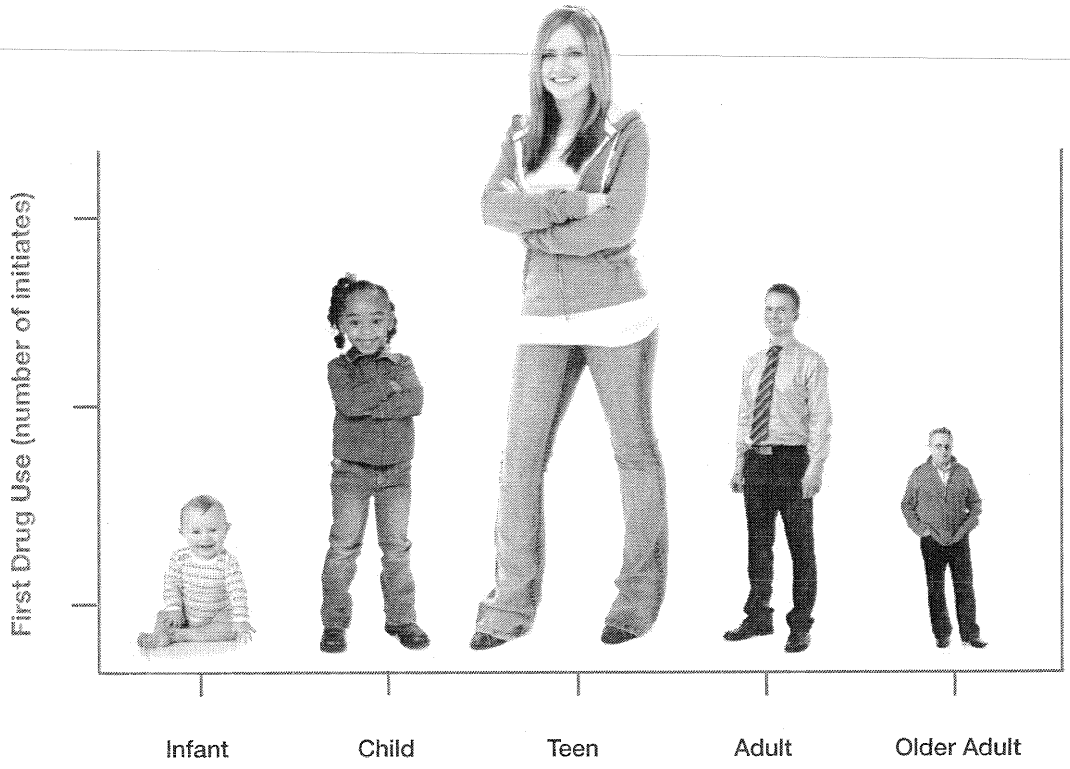
Experts say that even at ages 16 and 17, when compared to adults, adolescents on average are more:

- impulsive
- aggressive
- emotionally volatile
- likely to take risks
- reactive to stress
- vulnerable to peer pressure
- prone to focus on and overestimate short-term payoffs and underplay longer-term consequences of what they do
- likely to overlook alternative courses of action

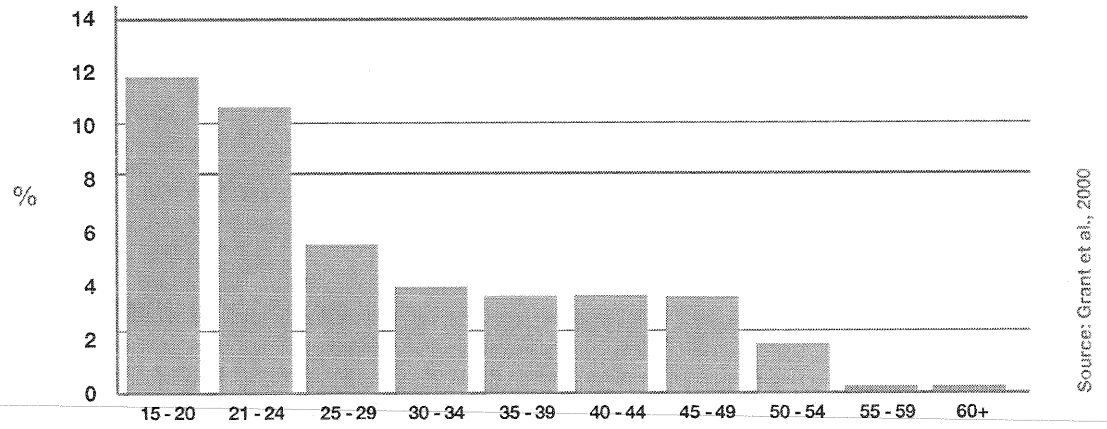
The Developing Brain and Drug Use

Scientists are beginning to explore whether these new discoveries explain adolescent drug use and related impulsive behaviors. Adolescence is a time of experimentation and novelty seeking. One way this occurs with young people is their curiosity about drugs. We know from national surveys in the United States that use of alcohol, tobacco and other drugs is relatively common among youth (Johnston et al., 2006). Over half of young people will try an illicit drug at least once during their teenage years, and nearly all of them will have tried either alcohol, tobacco or both at least once before they reach legal age.

And we also know from cross-cultural surveys that for alcohol - the drug used most by individuals – young people show higher rates or percentages of alcohol problems compared to older age groups. See the graph below that shows this pattern in the United States. For American youth aged 15-20 years old, 12.2% met the definition of an alcohol dependence disorder within the past 12 months of the survey. This rate was much higher compared to the other age groups. For individuals in the 30-34 age group, the rate of alcohol dependence was 4.1%.



Prevalence of Past-Year DSM-IV Alcohol Dependence: United States, 2001-2002



Science has examined two issues regarding the effects of drugs on brain development:

1) Does brain maturation contribute to the seeking and abuse of alcohol and other drugs by adolescents?

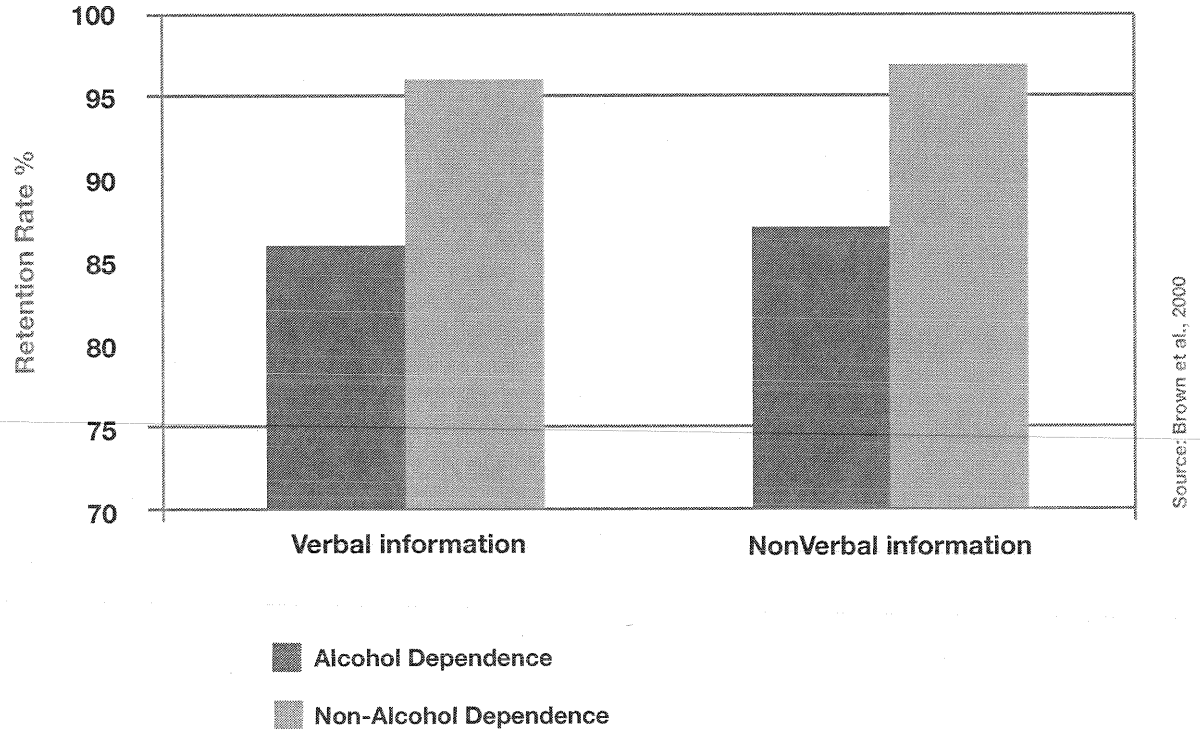
2) Will drug use during the teenage years contribute to damage to the developing brain?

We review below the evidence from animal and human studies that address these questions.

Are adolescents more vulnerable than adults to abuse drugs? Several neuro-developmental findings provide provisional answers to this question. As already noted, a developing prefrontal cortex may contribute to more emotional and impulsive decisions by teenagers and to a tendency to ignore the negative consequences of such decisions. And there is some evidence from animal studies that a developing teenage brain may be particularly sensitive to alcohol's effects that reduce social discomfort (Spear, 2002). This effect would create a more pleasurable social experience (e.g., contribute to feeling less shy) while drinking compared to alcohol's effects on adults.

There are other considerations. In studies of adolescent rats, they are observed to be less sensitive to the effects of intoxication than adult rats. They typically consume two to three times as much alcohol for their body weight as adults (Spear, 2002). Adolescent humans also show this diminished sensitivity to intoxication; their higher metabolic rates allow them to consume higher amounts of alcohol (Spear, 2002). A lower sensitivity to alcohol's effects would be consistent with the observation that young people are capable of drinking large amounts of alcohol without feeling all that intoxicated. Hormones have a role here as well. Hormones encourage novelty seeking and promote social competitiveness. The revved-up hormonal production during adolescence may promote drug use to the extent that such use represents a novel experience to the youth who is also seeking social approval from peers during the experience.

Alcohol and Youth Memory



Arrested development? A limited amount of science suggests that the developing brain is prone to the deleterious effects of alcohol. Adolescent rats exposed to various amounts of alcohol have significantly more brain damage in their frontal cortex than their adult counterparts (Spear, 2002). They also show greater damage to their working memory. With long-term use, adolescent rats have shown massive neuronal loss in their cerebellum, basal forebrain, and neocortex (Spear, 2002). In human studies, adolescents with alcohol use disorders ("Alcohol Dependence" group in the following table) had nearly 10% smaller volume in the hippocampus (the primary structure for memory) and greater memory retrieval deficits than healthy adolescent comparisons ("Non-Alcohol Dependence group") (Brown et al., 2000).

In summary, the developing brain's tendency toward impulse control problems, coupled with the adolescent's heightened sensitivity to the social benefits of intoxication and lower sensitivity to the negative effects of alcohol, may contribute to the decision to use drugs.

Opportunities for Drug Prevention and Treatment

Where does this new science lead us? Can an understanding of neuro-development help us do a better job preventing and treating drug use and addiction among teenagers? It is too early to say if this new knowledge will dramatically impact prevention, but there are several issues to consider.

- Because many teens begin using drugs at a young age and because of drugs' possible deleterious effects on the developing brain, the urgency for prevention is real. Delaying the onset of drug use, especially if it is delayed until adulthood, is better for both brain development and for preventing escalation of use. Teenagers who already abuse drugs may avoid permanent neurological damage if they can cut down or abstain from use.

- The possible dangers of drug use to the developing brain should be emphasized to both youth and parents. The findings from brain development research reinforce the argument that drug use by youth can be associated with more dangers than the general social and legal consequences often highlighted in prevention messages. This new science suggests deeper consequences - possible brain damage - as well as a greater vulnerability than faced by adults.

- There is a need for age-appropriate curriculum to educate youth about their developing brain. The sciences of the neurobiology of addiction and of brain development are providing new insights about how drugs affect the brain and how teenagers make critical and life influencing decisions, including their decisions about drug use. Resources are needed to educate youth about this critical new knowledge in brain development. This information can be harnessed to reframe and strengthen current drug prevention approaches by encouraging youth to capitalize on the assets of the developing brain, avail themselves of alternatives to potentially health-compromising risk-taking, and to promote personal growth and healthy lifestyles.

- This new science also places importance on educating youth about the skill of using the "thinking breaks" when faced with an emotional or arousing situation. Conditions under which the developing judgment region of the brain are likely to be challenged, and how to engage in "second thought" mechanisms, should be part of health education classes in schools.

- There is also the vital need to educate parents about these important findings – both because they better explain adolescent behavior and because they present cautionary signs that parents may want to heed. If the seemingly irresponsible behaviors of teens are not truly willful acts but are the result of the brain still "under construction," parents will want to be more tolerant of such annoying behaviors common during adolescence. Parents have a more scientific justification for being actively involved in their child's life. Rather than the message: "I need to know where you are and who you are with because you are too immature to be trusted," the more scientifically justified message is: "I need to help you anticipate a risky situation until your brain is fully developed and capable of recognizing the danger signs on your own."

Summary

Adolescence is a time when a young person forges a sense of self, experiments with independence and seeks new experiences. This developmental period is also likely to be the years when we observe behaviors that reflect how social pressures and thrill-seeking can override common sense. The adolescent brain responds more quickly and more intensively to excitement, arousal and rewards. Channeling this exuberance toward healthy and growth-enriching experiences are among the important tasks for parents as they raise their teenager and for youth-serving professionals who work with young people.

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