GETTING RESULTS fact sheet

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The Adolescent Brain and Substance Use

Recent research findings on brain development call the adolescent brain "a work in progress."[1] Contrary to earlier wisdom, the brain continues to develop until we reach our early twenties. The areas of the brain that are last to develop are those responsible for decision making, impulse control, learning, and memory. Because teen brains are not yet mature, teens are especially vulnerable to the harmful consequences of substance use.[2]

A Brief Explanation of Brain Development

Until recently, many believed that the human brain develops by the age of three and matures by around age ten. However, advanced brain imaging techniques now show that brain development is not completed until around age twenty-four.

Between the ages of six and twelve, the brain's nerve cells that are responsible for thinking and information processing multiply and develop new communication pathways. After this growth in nerve cells, a process of "pruning" occurs in the early twenties, where connections between neurons that are not used die away, and those that are used remain—a "use it or lose it" process.[3] At the same time, there is a thickening of the brain's myelin (a white fatty material that covers parts of the nerve cell and makes transmission of nerve signals faster and more efficient).

Brain Regions and Functions[4]

Brain Region	Function	Developmental Age
Frontal lobe	Self-control, judgment, emotional regulation	Restructured in teen years
Corpus callosum	Intelligence, consciousness, self-awareness	Reaches full maturity in twenties
Parietal lobes	Integration of auditory, visual, and tactile signals	Immature until age sixteen
Temporal lobes	Emotional maturity	Still developing after age sixteen

Effects of Substance Use on a Developing Brain

During puberty, hormones (estrogen and testosterone) associated with risk taking and sensation seeking are surging at a time when the brain's ability to make decisions, weigh consequences, understand and accept responsibility, and control impulses is not yet fully developed.[5]

The combination of "raging hormones" and an immature brain explains why teens are vulnerable to experimenting with alcohol, tobacco, and other drugs. These substances, however, also affect brain chemistry and can have a long-term impact on brain functions.

Alcohol. The average age of a child taking the first alcoholic drink is now twelve. Nearly 20 percent of twelve- to twenty-year-olds are considered binge drinkers.[6] Recent studies show that heavy, ongoing use of alcohol by adolescents can have a long-term impact on brain functions such as learning and memory. On brain scans, teens with alcohol-use disorders had significantly smaller volume in the hippocampus (the primary brain structure for memory) than did teens who did not abuse alcohol.[7] In another study of adults in alcohol treatment programs, heavier involvement in substance use during adolescence was associated with lower scores on tests of learning and memory.[8]

Tobacco. Structural and chemical changes in the brain can result from nicotine exposure. Adolescent brains have shown substantial cell damage and loss as a result of even low levels of nicotine exposure. These cellular changes affect the way brain cells transmit messages.

Nicotine also causes changes in the levels of the brain chemicals (neurotransmitters) dopamine, norepinephrine, and serotonin, all of which are associated with the development of alcohol and other drug abuse and mental health disorders.[9] Teens are more sensitive to nicotine and more vulnerable to addiction than are those who begin smoking as adults.

The Addicted Brain

The brain chemical dopamine produces feelings of pleasure when it is released. Biologically, dopamine is released when an action is taken that satisfies a basic need or desire. This is called the "reward pathway."[10] Drugs provide a shortcut to the reward pathway.

Alcohol and other drugs activate the pleasure-producing chemistry of the brain. But when a drug is used repeatedly, the brain's natural capacity to produce dopamine is reduced. This process is called *neuroadaptation,* in which receptor cells in the reward and pleasure centers of the brain adapt to high concentrations of neurotransmitters stimulated by drug use.[11]

Neuroadaptation interferes with the normal experience of pleasure as the brain loses access to other sources of reward. Without drugs, the user feels depressed, angry, bored, anxious, and/or frustrated. Neuroadaptation is the mechanism for the disease of addiction, as the user needs drugs to feel pleasure.

The part of the brain (the prefrontal cortex) that provides cognitive control (in this case, the decision to stop taking a drug) is not fully developed in adolescence. This finding may explain why many addictions are formed during the teen years.[12]

Implications for Prevention Education

This picture of adolescent physical brain development, combined with the biological understanding of addiction, provides a fuller understanding of the complexity of working with adolescents on issues of substance use. This picture lends an even greater urgency to prevention efforts because of the evidence that the brain can be permanently compromised by adolescent substance use.

Students should be educated about their developing brains and why they feel and act as they do. Understanding how substances alter the brain and can "hijack" it to create addiction may enhance the ability of school prevention programs to better relate to students' own real-life experiences with substance use.

Resources

National Institute on Drug Abuse (NIDA)

- Teaching Packets and "Mind Over Matter" series on drugs and the brain, for parents and teachers. http://www.drugabuse.gov/parent-teacher.html
- NIDA for Teens: Includes facts on the brain and addiction, "Ask Dr. NIDA," a section for parents and teachers, and additional resources. http://www.teens.drugabuse.gov
- The Science of Addiction: In-depth description of how the brain functions. http://www.drugabuse.gov/scienceofaddiction/brain.html

National Institutes of Health

- The brain and interactive explanations of its functions. http://www.nimh.nih.gov/health/publications/the-teen-brain-still-under-construction/index.shtml

National Campaign to Prevent Teen Pregnancy: *The Adolescent Brain: A Work in Progress* (June 2005)

Endnotes

[1]*Teenage brain: A work in progress.* N.d. Bethesda, Md.: National Institute of Mental Health. NIH Publication No. 01-4929.

[2]American Medical Association (2007). *Brain damage risks.*

[3]"Adolescent Brain Development." ACT for Youth Upstate Center of Excellence, May 2002. http://www.actforyouth.net/documents/may02factsheetadolbraindev.pdf (Outside Source)

[4]Ibid., page 2.

[5]*Tobacco: The smoking gun.* (2007). New York: the National Center on Addiction and Substance Abuse at Columbia University.

[6]See note 2.

[7]Winters, K. C. *Adolescent brain development and drug abuse.* PowerPoint presentation.

[8]White, A. *Alcohol and the adolescent brain.* Durham, N.C.: Duke University, 2004.

[9]National Center on Addiction and Substance Abuse, pages 3-4.

[10]Nestler, E. J., and R. C. Malenka. The addicted brain. *Scientific American* (February 9).

[11]Bechara, A. (2005). Decision making, impulse control and loss of willpower to resist drugs: A neurocognitive perspective. *Nature Neuroscience,* 8: 1458-63.

[12]Weinberger, D. R., Elvevag, B., and Giedd, J. N. (June 2005). *The adolescent brain: A work in progress.* Washington, D.C.: National Campaign to Prevent Teen Pregnancy.