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Alcohol and the Adolescent Brain

by Megan Mayberry, PhD

Adolescence is a significant developmental period in which numerous changes occur, including the biological changes of puberty; greater autonomy from parents and family; increased time spent with peers; and the tendency to engage in greater exploration and risk-taking behaviors, like experimentation with alcohol. At the same time these changes are occurring, however, adolescents' brains are developing in important ways. From birth through childhood, brain tissue and neurons are overproduced; then, during adolescence, the brain begins to strengthen the connections that are used, and connections that are not used are eliminated (Spear, 2000).

The neurological changes of adolescence are important for two reasons. First, because their brains are still developing, adolescents do not have adults' full capacity to delay gratification, regulate emotion, and make decisions. Second, adolescents' brain development can actually be altered by their life experiences and choices, including their alcohol use behavior.

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Prevalence of alcohol use among teens

According to an annual survey of U.S. youth, approximately 75% of 12th graders, 66% of 10th graders, and 40% of 8th graders have consumed alcohol (Johnston, O'Malley, Bachman, & Schulenberg, 2006). Early alcohol use increases risk for mental health problems, such as conduct disorder, depression, anxiety, and drug dependence (Deas & Thomas, 2002). Additionally, epidemiological studies conducted by the Substance Abuse & Mental Health Services Administration (2005) suggest that adolescence may be a period of vulnerability to future alcohol use and dependence (Grant & Dawson, 1998).

Since there are many risks associated with adolescents' alcohol behavior, a clear understanding of the biological processes of alcohol use is critical in evaluating these risks. Researchers are currently investigating the complexities of adolescent brain development, as well as the effects of alcohol use on that development.

Structural changes in the adolescent brain

Magnetic resonance imagining (MRI) studies show that several areas of the brain undergo substantial change during adolescence (Giedd, 1999). For example, two regions of the brain that show significant development are the cerebellum, which is responsible for physical coordination and supports higher learning activities like music or mathematics, and the amygdala, the region of the brain that modulates emotions. The corpus

Is my teen drinking? Signs to look for

- Slurring speech or difficulties with motor coordination
- Smell of alcohol on clothing or breath (even the morning after)
- Nausea and/or vomiting
- Symptoms of a hangover – excessive thirst in the morning, headache, nausea, shaking, sleep difficulties
- Problems with mood – mood swings, aggressive behavior, depression
- Alcohol paraphernalia – fake ID, bottles saved as souvenirs, empty bottles, or bottle tops
- Peer group involvement with alcohol
- Academic difficulties, or difficulty with concentration and memory

What can I do to help my child avoid problems with alcohol?

- Believe in your own power to help your child avoid alcohol use
- Establish a trusting and open relationship with your child
- Set clear expectations
- Talk to your child about alcohol use and how to avoid drinking in difficult situations
- Encourage healthy friendships and fun alternatives to drinking
- Keep tabs on your teen and communicate with other parents to establish a non-drinking policy
- Set a good example regarding your own alcohol use and your response to teen drinking
- Know the risks and warning signs, and act promptly to get help

Adapted from http://pubs.niaaa.nih.gov/publications/MakeADiff_HTML/MakeAdiff.pdf.

The brain images below show how alcohol may harm teen mental function. Compared with a young non-drinker, a 15-year-old with an alcohol problem showed poor brain activity during a memory task. This finding is noted by the lack of pink and red coloring.

Image from Susan Tapert, PhD, University of California, San Diego.

From www.duke.edu/~amwhite, October 24, 2008

For more information: Dr. Aaron White at Duke University Medical Center has conducted extensive research on the effects of alcohol on the brain. His user-friendly website for educating the public, called Topics in Alcohol Research, is located at www.duke.edu/~amwhite.

callosum, which communicates information from one hemisphere of the brain to the other, also matures during adolescence. Finally, the prefrontal cortex, an area of the brain involved in executive functioning (i.e., working memory, impulse control, planning, and decision making), increases in complexity during adolescence (Spear, 2000; White & Swartzwelder, 2005).

Sedation and motor coordination effects of alcohol

Alcohol has somewhat differing effects on the brains of adolescents than it does on adults' brains. For example, compared with adults, adolescents appear to be less sensitive to alcohol's effects with respect to sedation and motor coordination. In animal research, sedation is often measured by observing the righting reflex, which is the animal's reflex to get on all fours when placed on its back.

To understand alcohol's effect on the developing brain, Little and colleagues (1996) gave alcohol to three age groups of rats: child, adolescent, and adult. When animals were given the lowest dose of alcohol, none of the adolescent animals lost their righting reflex, whereas half of the child rats and two-thirds of the adult rats did. Moreover, once adolescent rats did experience the sedative effects of alcohol, the effects lasted for a shorter period of time. Finally, the researchers found that adolescent rats were able to function with a higher blood alcohol level than adults.

In addition to being less sensitive to the sedative effects of alcohol, adolescent rats are also less sensitive than their adult counterparts to motor coordination impairment. Alcohol impairs the ability to perform tasks that require motor coordination (i.e., walking, running, balance). Because motor coordination is one of the primary functions of the cerebellum, a brain region still developing during adolescence, it is reasonable to assume that alcohol might affect motor coordination in adolescents differently than

in adults. White and colleagues (2002) examined the effects of alcohol on the motor coordination of adolescent and adult rats by placing a rat on a horizontal platform and gradually tilting it so the rat had to adjust to maintain its balance. These researchers found that the adolescent rats were less impaired than adult rats at every assessment point as the dose of alcohol was increased.

Why are these findings regarding the sedative and motor coordination effects of alcohol so important? It is because these very effects – sedation and motor coordination – serve as cues to limit the amount of alcohol a person consumes in one sitting. Because adolescents have less sensitivity to these effects, they may be more likely to continue drinking for longer periods of time. This is dangerous because, as described next, adolescents are more sensitive than adults to the cognitive deficits produced by alcohol.

Cognitive effects of alcohol

Excessive drinking during adolescence seems to have harmful and serious consequences, specifically in regards to learning and memory. Evidence suggests that, compared to adults, adolescents are more vulnerable to the effects of alcohol on learning and memory. This phenomenon has been observed both in animal research (Markwiese, Acheson, Levin, Wilson, & Swartzwelder, 1998) and in studies with humans. For example, Acheson and colleagues (1999) showed that after two to three drinks, people ages 21-24 performed worse on a delayed recall memory task than subjects ages 25-29. Repeated alcohol exposure during adolescence is also related to lasting cognitive deficits. Adolescents with an extensive history of alcohol use showed decreased hippocampal volume and less brain activity during memory tasks than those adolescents who did not have a history of extensive use (Brown, Tapert, Granholm, & Delis, 2000; DeBellis, et al, 2000). Tapert and colleagues (2002) extended these studies by assessing adolescents in treatment for substance use problems over a period of eight years. Results indicated that higher levels of substance use during adolescence were associated with lower scores on tests of learning and memory eight years later. These studies provide compelling evidence that heavy alcohol use during adolescence impairs cognitive abilities, both in the short- and long-term.

Environmental and genetic risk factors for adolescent alcohol use

Research has begun to explore the specific environmental and genetic factors that may make an adolescent susceptible to alcohol use. One environmental risk factor for adolescent alcohol use is peer group usage – that is, a teenager is more likely to use alcohol if his or her friends are using alcohol. Additionally, research shows that when parents have a positive relationship with their child, communicate openly, and monitor their child's behavior, their adolescents tend to use less alcohol. Therefore, both peers and family appear to influence and/or buffer adolescents' drinking behavior.

In addition to these environmental risk factors, research suggests that children with alcoholism in their family are at greater risk for the development of alcohol problems (see Tapert and Schweinsburg, 2005, for a review). While it is beyond the scope of this article to consider the ways in which genes interact with environment to influence alcohol behavior, it is important to be aware of increased risk for those genetically vulnerable to alcohol use problems.

Conclusion

Alcohol is a drug that adolescents often receive mixed messages about – for example, popular culture and beer commercials suggest it is cool and fun to drink, but research shows it can be

harmful and dangerous. Scientists are still trying to understand the daunting complexity of the brain and, in doing so, better explain its development and impact on behavior. As research accumulates regarding the developmental consequences of alcohol use during adolescence, it will be important to continue to educate adolescents, parents, and services providers.

Author Biography

Megan Mayberry, PhD, is the Madigan Family Fellow at The Family Institute at Northwestern University. Dr. Mayberry received her undergraduate degree from Cornell University and completed her MS and PhD in counseling psychology from the University of Illinois at Urbana-Champaign. Prior to coming to The Family Institute, she completed her predoctoral internship residency training at Yale University School of Medicine. Dr. Mayberry has clinical experience with children, adolescents, and families and emphasizes the integration of developmental and systems perspectives on psychopathology and treatment. Dr. Mayberry has also received specialized training in Dialectical Behavioral Therapy and the assessment and treatment of alcohol and substance abuse. Dr. Mayberry has published several studies focusing on adolescents and families.

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