ADOLESCENT BRAIN DEVELOPMENT: IMPLICATIONS FOR DRUG USE PREVENTION

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New scientific discoveries have put a much different perspective on the understanding of adolescent behavior. Research now suggests that the human brain is still maturing during the adolescent years, with changes continuing into the early 20s. The immature brain of the teenage years may not only explain why adolescents are prone to make poor decisions, but it may also place teenagers at an elevated risk to the harmful effects of drugs.

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 in the United States, evidence is accumulating that the brain is not fully formed at puberty as earlier thought, but continues important maturation that is not complete until about age 24.

Three brain structures that undergo maturation during youth – nucleus accumbens, amygdala and prefrontal cortex – are noteworthy in terms of their implications for understanding adolescent behavior. While scientists caution about suggesting definitive linkages between neurodevelopmental findings and behavior, the discovery that brain construction is still in progress during adolescence offers several suggestive hypotheses.

The nucleus accumbens, which directs motivated behavior, is responsible for how much effort the organism will expend in order to seek rewards. In teenagers, an immature nucleus accumbens is believed to result in preferences for activities that require low effort yet produce high excitement. Real-world observations bear this out: most teenagers tend to favor activities such as playing video-games, skate boarding and, unfortunately, substance use.

The amygdala is the structure responsible for integrating emotional reactions to pleasurable and aversive experiences. It is believed that a developing amygdala contributes to two behavioral effects: the tendency for adolescents to react explosively to situations rather than with more controlled responses, and the propensity for youth to mis-read neutral or inquisitive facial expressions of others as a sign of anger.

And one of the last areas to mature is the prefrontal cortex, located just behind the forehead. Sometimes referred to as "the seat of sober second thought," it is the area of the brain responsible for the complex processing of information, ranging from making judgments, to controlling impulses, foreseeing consequences, and setting goals and plans. An immature prefrontal cortex is thought to be the neurobiological explanation for why teenagers show poor judgment and too often act before they think. What is particularly important about this finding is that the "judgment" part of the brain is the last to mature!

The Developing Brain and Drug Use

Scientists are now beginning to explore what these new discoveries may help explain adolescent drug use and related impulsive behaviors. This is an important issue given that adolescence is a time of experimentation and novelty seeking. The 2003 Monitoring the Future study found that 70.1% of high school seniors had used alcohol in the past year and 34.9% had used marijuana. Over half had tried an illicit drug at least once in their lifetime. Even among 8th graders, 45.6% had already tried alcohol and 22.8% reported illicit drug use in their lifetime (Johnston et al., 2003). And we know that most adult regular smokers begin using in adolescence, as do a majority of adults who meet alcohol abuse or dependence criteria (Clark et al., 1998). Youth who report first using alcohol before age 15 are more than five times as likely

to report being an alcoholic compared to persons who first used alcohol at age 21 or older (Substance Abuse and Mental Health Administration, 2004).

From a neurodevelopment standpoint, two central questions merit scientific attention: Do neurodevelopmental factors predispose adolescents to seek out and abuse alcohol and drugs? And, are there any deleterious effects on brain development as result of drug use in adolescence? Evidence from both animal and human data pertain to each question.

Are adolescents more vulnerable than adults to abuse drugs? Several neurodevelopmental findings provide provisional answers to this question. As already noted, an immature prefrontal cortex increases the propensity of teenagers to act impulsively and to ignore the negative consequences of such behavior. In addition, an immature nucleus accumbens increases the adolescent's tendency to seek out activities that are exciting but require little effort. And there is growing evidence that one direct result of a developing amygdala is that adolescents subjectively report greater feelings of social disinhibition when drinking alcohol compared to adults (Spear, 2002). This effect would create a more pleasurable social experience (e.g., feeling less shy) while drinking compared to adults. All these effects of the developing brain – poor impulse control, favoring low-effort yet thrilling experiences, and heightened sensitivity to the social benefits of intoxication – may contribute to an initial decision to use drugs and make the experience rewarding enough to repeat it.

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 as well. Hormones encourage novelty seeking and promote social competitiveness. Increased hormonal production during adolescence may promote drug use to the extent that drug involvement represents a novel experience to the youth who is also seeking social approval from peers during the experience.

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 brain scanning studies, adolescents with alcohol use disorders had significantly smaller volume in the hippocampus (the primary structure for memory), which led to greater memory retrieval deficits, compared to non-alcohol abusing controls (Brown et al., 2000).

Implications for Drug Prevention

Prevention can learn from this new science of brain development and the biology of addiction. Since many teens begin using substances at a young age and because of their effects on the developing brain, prevention programs should begin as early as elementary school. Delaying the onset of drug and alcohol use, especially if it is delayed until adulthood, is better for both brain development and for preventing escalation of use.

Adolescents should be educated about their developing brain. We believe three themes should be emphasized: (1) how the "judgment" part of the brain (pre-frontal cortex) is slow to mature, (2) drugs can "hijack" the brain to create addiction, and (3) the adolescent brain is particularly vulnerable to the effects of substances. By incorporating

neurodevelopmental education into the curriculum, adolescents can improve their understanding of themselves and will hopefully make better decisions regarding the use of alcohol and drugs.

Because parents are vital in prevention efforts, they should also be educated about the findings from this emerging science. Here are 6 ways that principles of neurodevelopment can reinforce prevention efforts by parents:

P = Promote activities that capitalize on the strengths of the developing brain (e.g., sports and music)

A = Assist your child when faced by challenges that require a lot of planning.

R = Reinforce the value in seeking advice and input from you and other adults.

E = Educate your child that risk taking can have negative consequences not foreseen.

N = Never minimize the developing brain's susceptibility to substance abuse.

T = Tolerate the "oops" behaviors that may be the result of an immature brain.

Summary

The unique susceptibility of the adolescent brain to drug addiction reinforces what we already know: Prevention is important.

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Suggested Readings

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