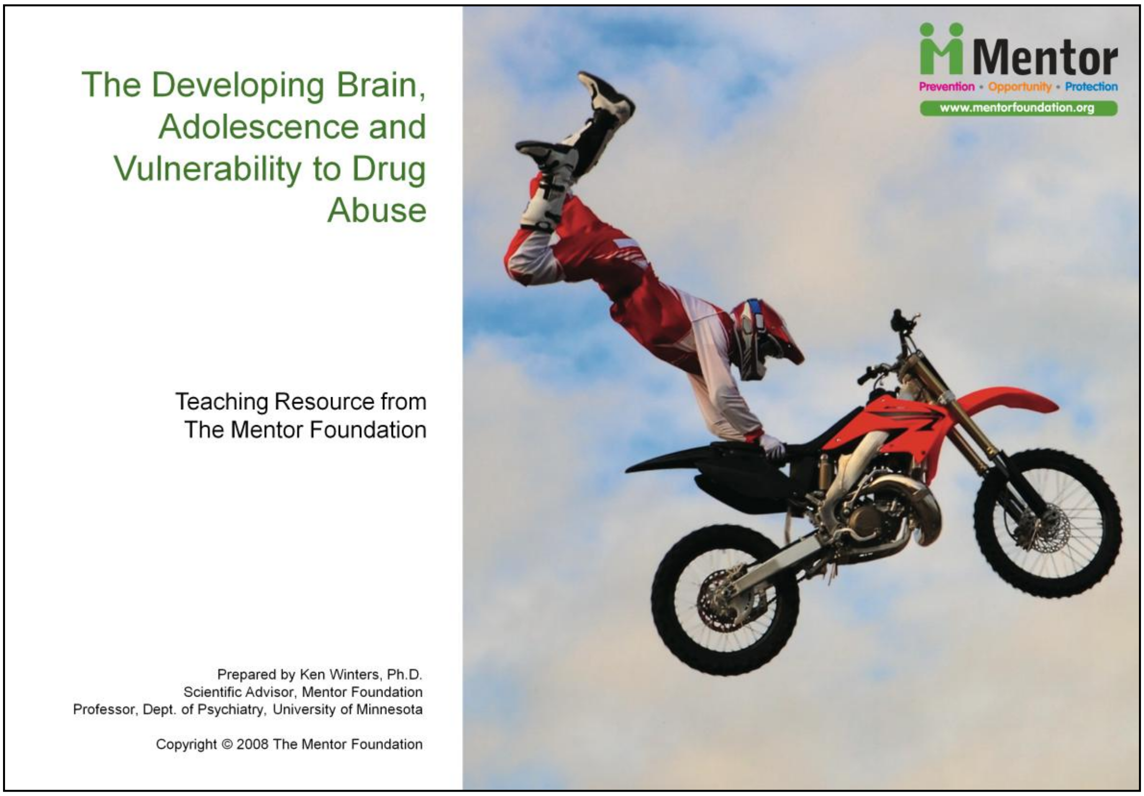
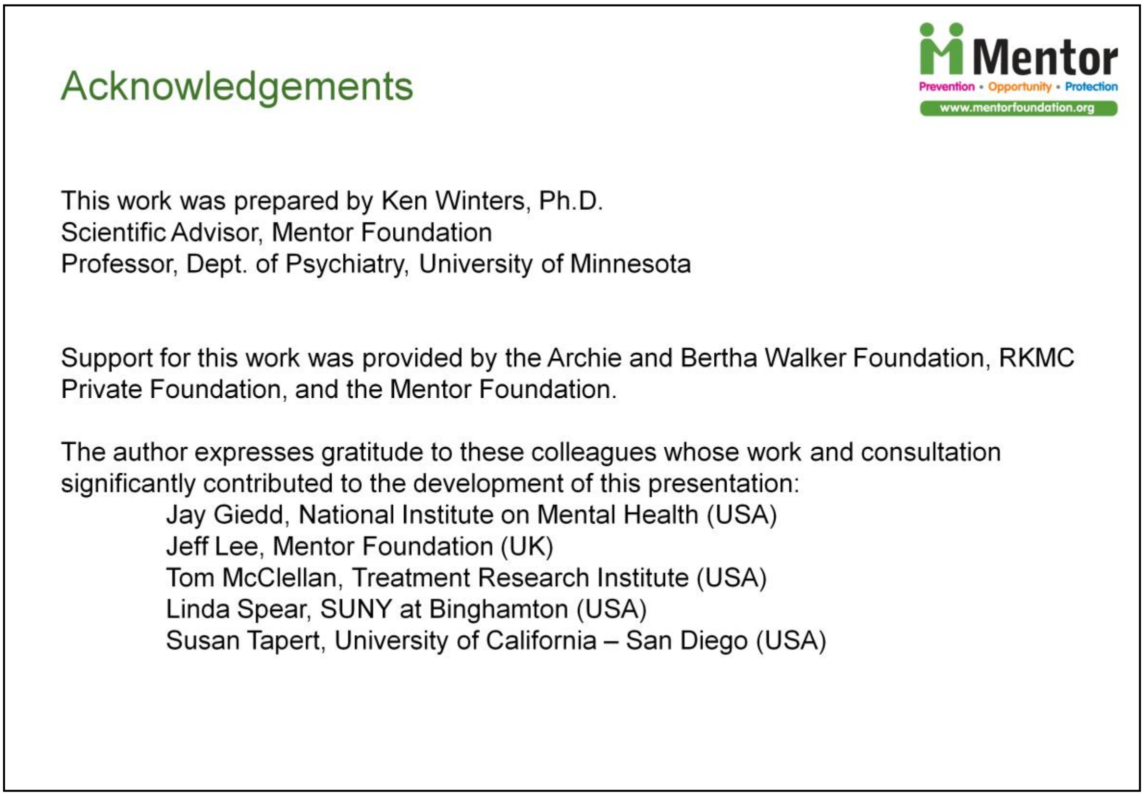


Welcome. This presentation is for you to read and to use in your prevention work. We hope you will review it, learn from it and feel comfortable using it in presentations to colleagues that work in prevention, as well as to parent and youth groups.

This material provides a non-technical summary of the latest findings on adolescent brain development and how drugs can affect everyone's brain – youth or adult. Scientists are now beginning to reach a new understanding of the changes in pre-adolescent and adolescent brains. Scientists caution about making definitive links from neurodevelopmental findings to behavior. However, the discovery that brain construction is still in progress during adolescence offers several suggestive hypotheses. This emerging science can be useful in how we think about adolescent behavior, including their use of drugs.



This presentation was prepared by Ken Winters, Ph.D., member and Chair of Mentor International's Scientific Advisory Network, and Professor, Department of Psychiatry, University of Minnesota (USA).

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Susan Tapert, University of California – San Diego (USA)

Emerging Science:

Teen Brains Are Still "Under Construction"

New insights about:

- Risk taking by teenagers
- How teenagers may be highly vulnerable to drug abuse

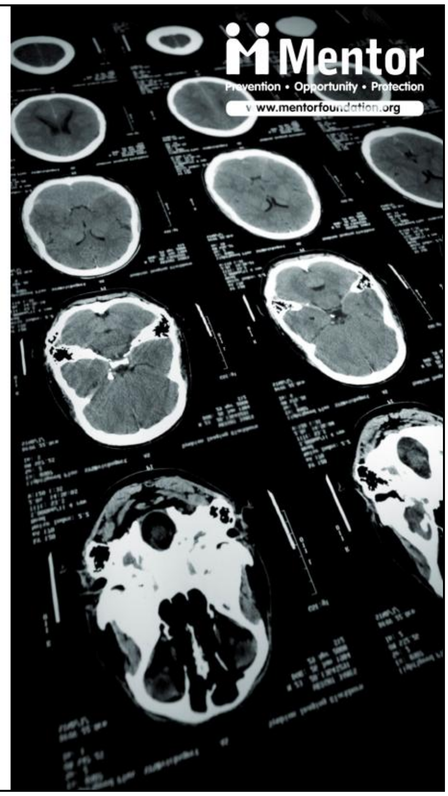
New scientific discoveries are altering out perspective on how to understand adolescent behavior. Now, research into the adolescent brain suggests that the human brain is still maturing during the adolescent years, with changes continuing into the early 20s.

The developing brain of the teenage years can provide clues as to why adolescents may be more prone to take risks and why teenagers are particularly vulnerable to the effects of drugs. These new scientific discoveries provide valuable lessons for parents, and for adults that work with youth. They reinforce the importance that teenagers benefit from guidance provided by adults, and that careful and regular monitoring of their behavior is a high priority for parents.

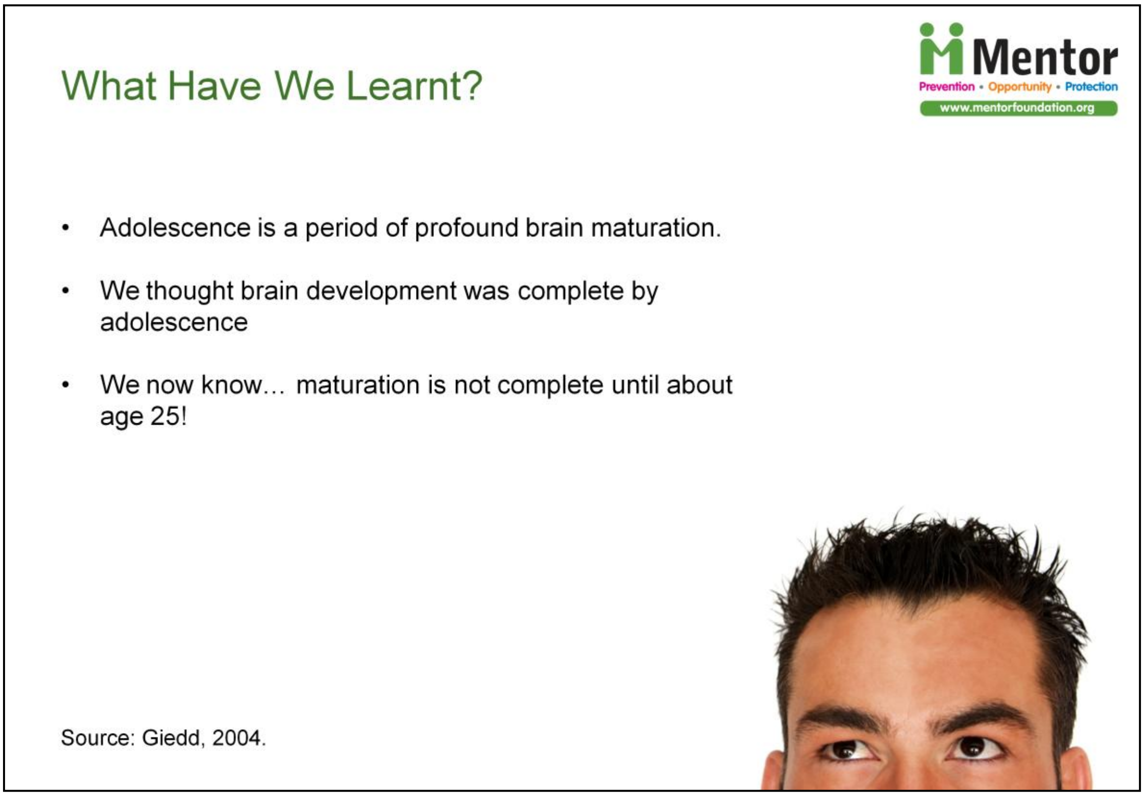
Emerging Science:
Brain Imaging

New insights because:

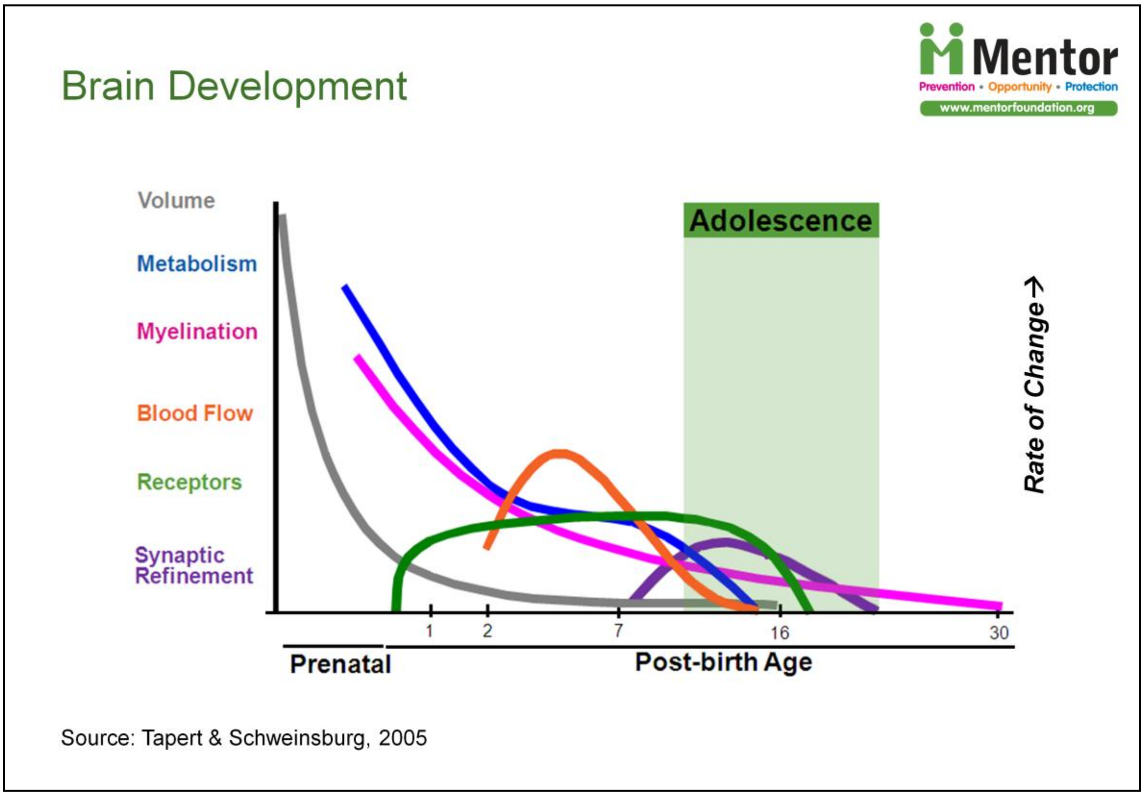
- 1990’s information explosion due to the development of brain imaging techniques (e.g., CT, PET and MRI).



What led to this emerging science of brain development? During the 1990’s there was a rapid growth in brain imaging technologies. These advances have provided windows on the developing brain. Scientists are using these new technologies to better understand the process of brain construction during adolescence.



Based on the pioneering work of Jay Giedd (2004) 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. Rather, the brain continues important maturation that is not complete until about age 25.

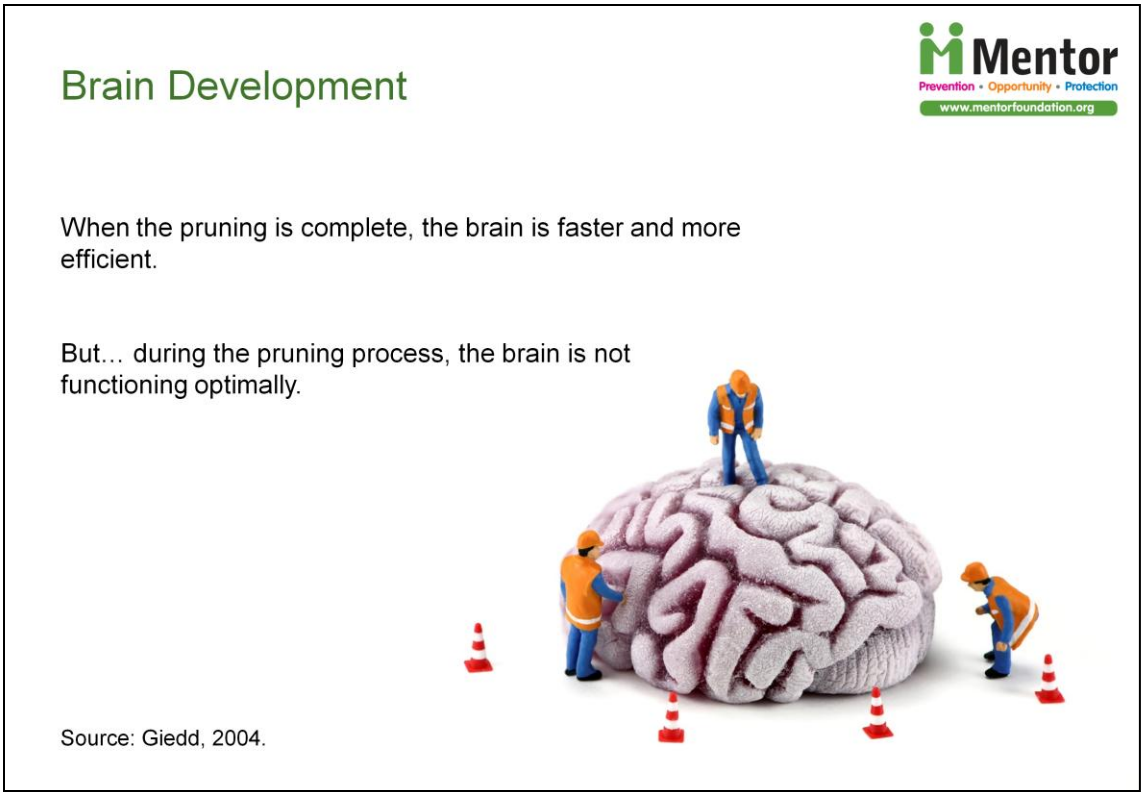


Here is some background about this maturation.

Although most of the brain material and size is in place at the start of adolescence, several important developmental processes continue. Two of them are noteworthy.

One process is myelination. The structures or axons connecting brain cells across which electrical impulses travel continue to become ensheathed in a fatty substance called myelin. This compound insulates axons and speeds the relay of electric impulses within the brain, helping thinking, decision-making, impulse control, and emotional regulation mature.

Another process is synaptic refinement. At the start of adolescence, we have billions of brain cells, each with tens of thousands of connections to other brain cells. Not all these connections are actually needed, and the unnecessary nes become eliminated. This elimination process is shaped by the young person's activities and experiences, and, as with myelination, it helps the brain work more efficiently.



When the pruning and mylenation process is complete, the brain can work faster and will be more efficient. But, during the pruning process, the brain is not functioning at optimal capacity.

Because the pruning process occurs in stages across brain structures, it is informative to examine this process in more detail.

Brain Development

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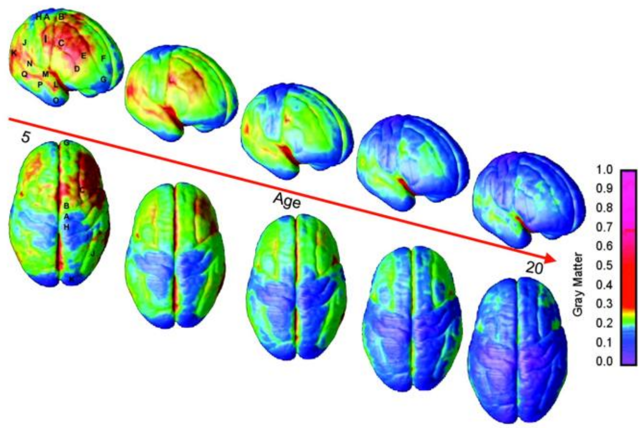
Maturation Occurs from Back to Front of the Brain

Images of Brain Development in Healthy Youth (Ages 5 – 20)

Blue represents maturing of brain areas



Source: Gogtay, Giedd, et al., 2004.

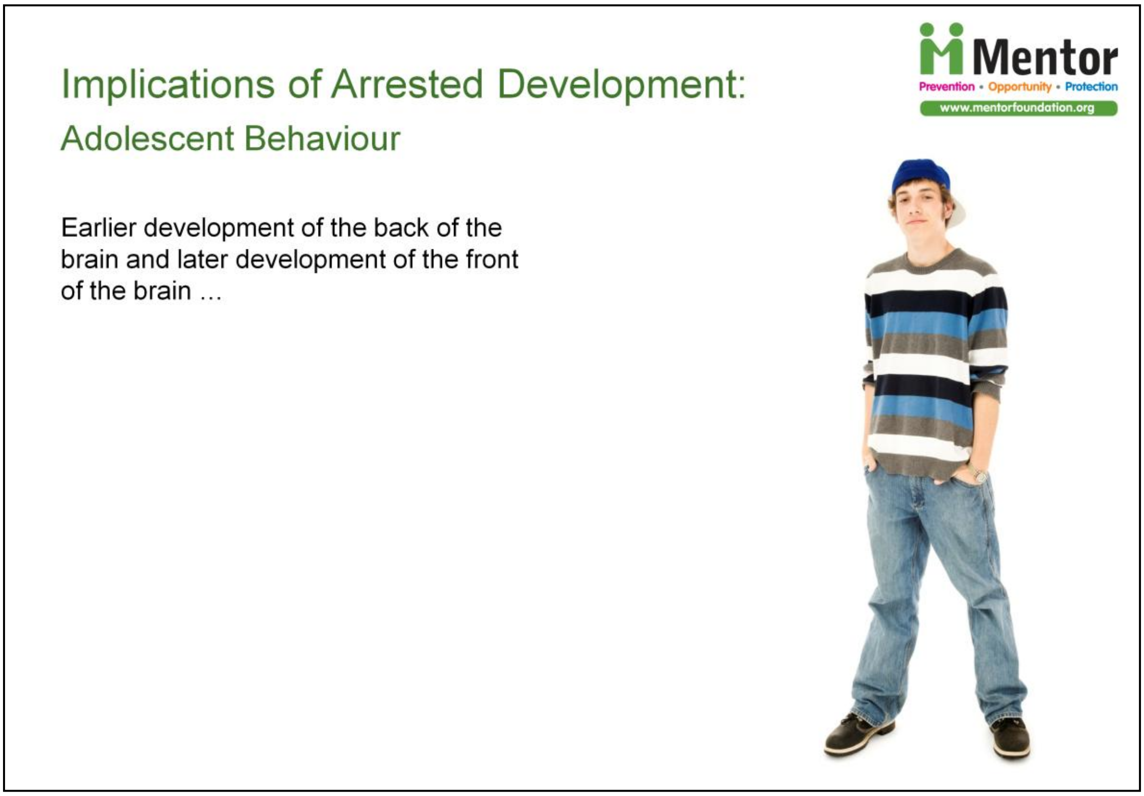
Gogtay, N., Giedd, J.N., et al. (2004)
Dynamic mapping of human cortical development during childhood through early adulthood
Proceedings of the National Academy of Sciences, 101 (21), 8174 – 8179

The maturation of brain structures generally occurs from the back of the brain to the front. There are four primary brain structures from the back to the front of the brain – cerebellum, nucleus accumbens, amygdala and prefrontal cortex – that are noteworthy in terms of how their differential maturation may impact adolescent behavior.

A major brain structure at the back of the brain is the <u>cerebellum</u>. This structure controls physical or motor coordination, and is a region that is involved in the playing of sports.

The <u>nucleus accumbens</u>, which is responsible for motivation, and the <u>amygdala</u>, which identifies and controls emotion, are brain regions located more in the middle of the brain. The nucleus accumbens is responsible for how much effort the organism will expend in order to seek rewards. A developing nucleus accumbens is believed to contribute to the often-observed tendency that teenagers prefer activities that require low effort yet produce high excitement. Real-world observations may bear this out: many teenagers favor playing video-games, for example. The amygdala is responsible for integrating how to emotionally react to pleasurable and aversive experiences. It is hypothesized that a developing amygdala contributes to two behavioral effects: the tendency for adolescents to react to situations with "hot" emotions rather than more controlled and "cool" emotions, and the propensity for youth to mis-read neutral or inquisitive facial expressions from other individuals as a sign of anger.

And one of the last brain regions to complete maturation is the structure named the <u>prefrontal cortex</u>, 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 the consequences of ones' actions, and setting goals and plans. A developing prefrontal cortex may contribute to poor judgment and risk taking..



Let's put this developmental picture into a boarder perspective of general adolescent behavior.

Neurodevelopment suggests that the adolescent is more "under the influence" of the physical activity and the emotional structures of brain, compared to the judgment (prefrontal cortex) portion of the brain. Thus, we can expect that teenagers tend to . . . . .

(GO TO NEXT SLIDE)

Implications of Arrested Development:
Adolescent Behaviour

Earlier development of the back of the brain and later development of the front of the brain …

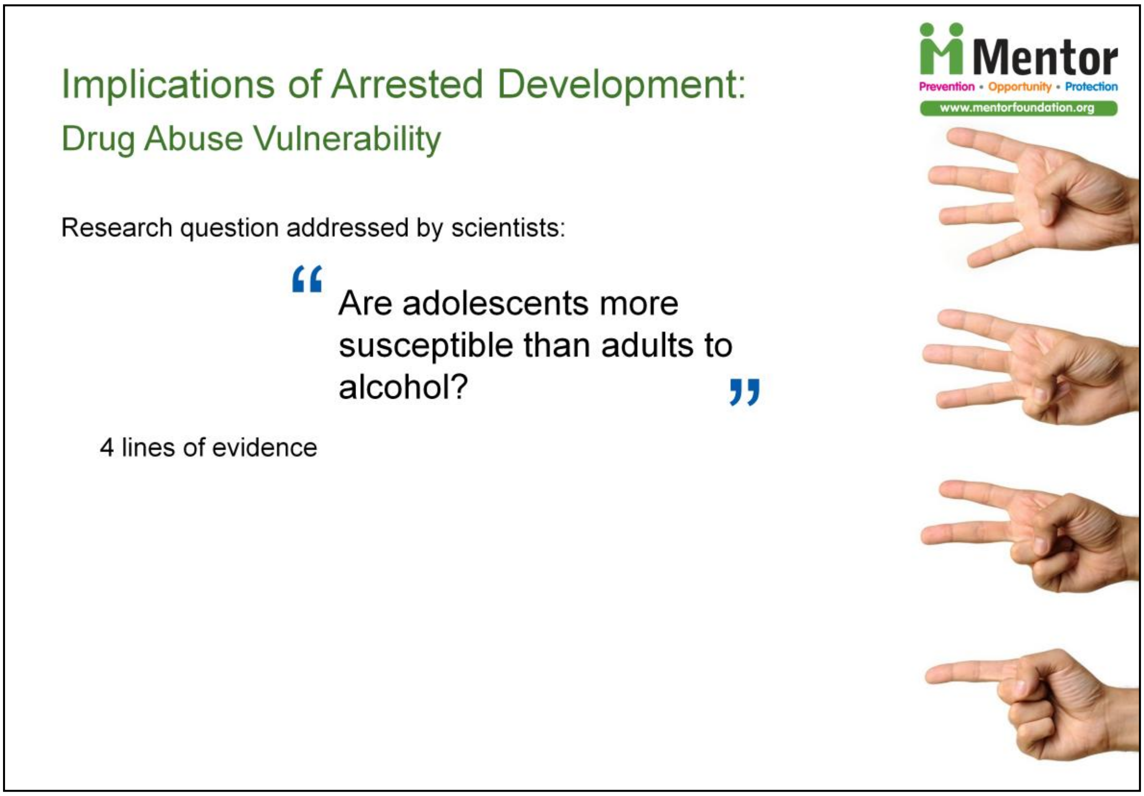
- Preference for physical activity
- Less than optimal planning and judgment
- More risky, impulsive behaviours
- Minimal consideration of negative consequences

…..prefer sensation seeking and physical activities over ones that require a great deal of complex thinking;

…..show less than optimal planning and judgment;

…..engage in more risk-taking and impulsive behaviors compared to when the person is older; and

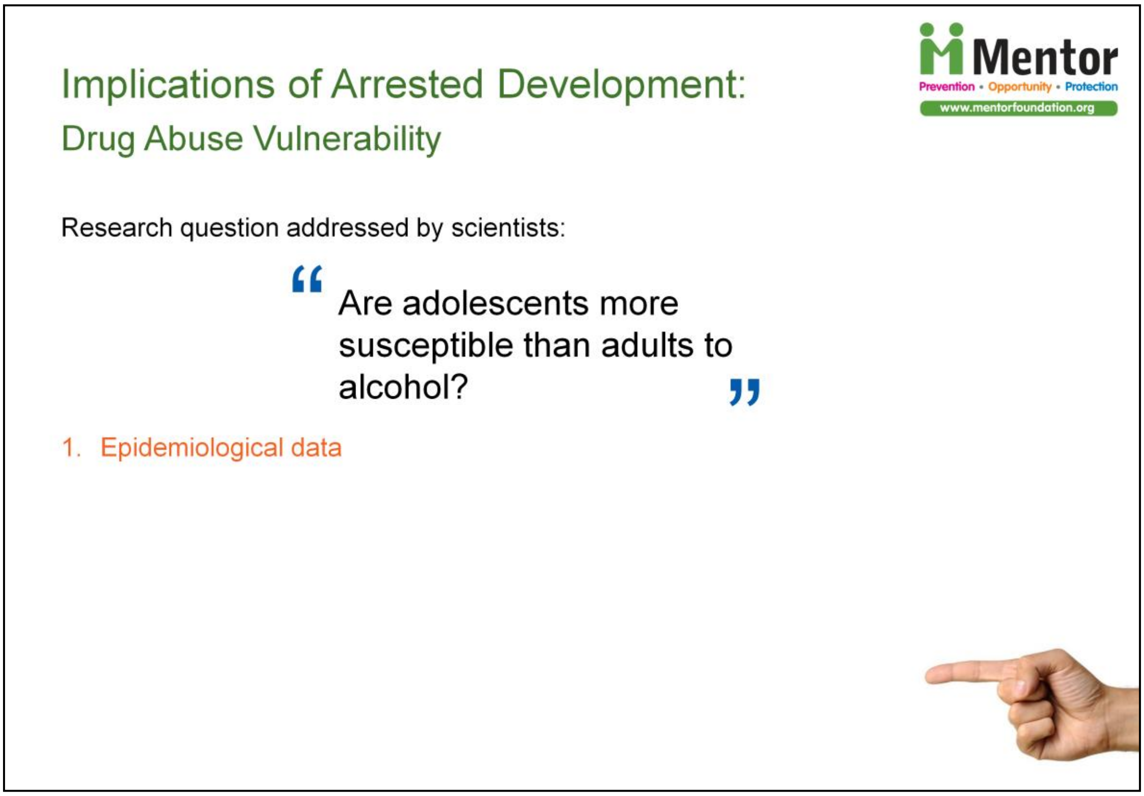
…..be less inclined to consider the possible negative consequences of such risky behaviors.



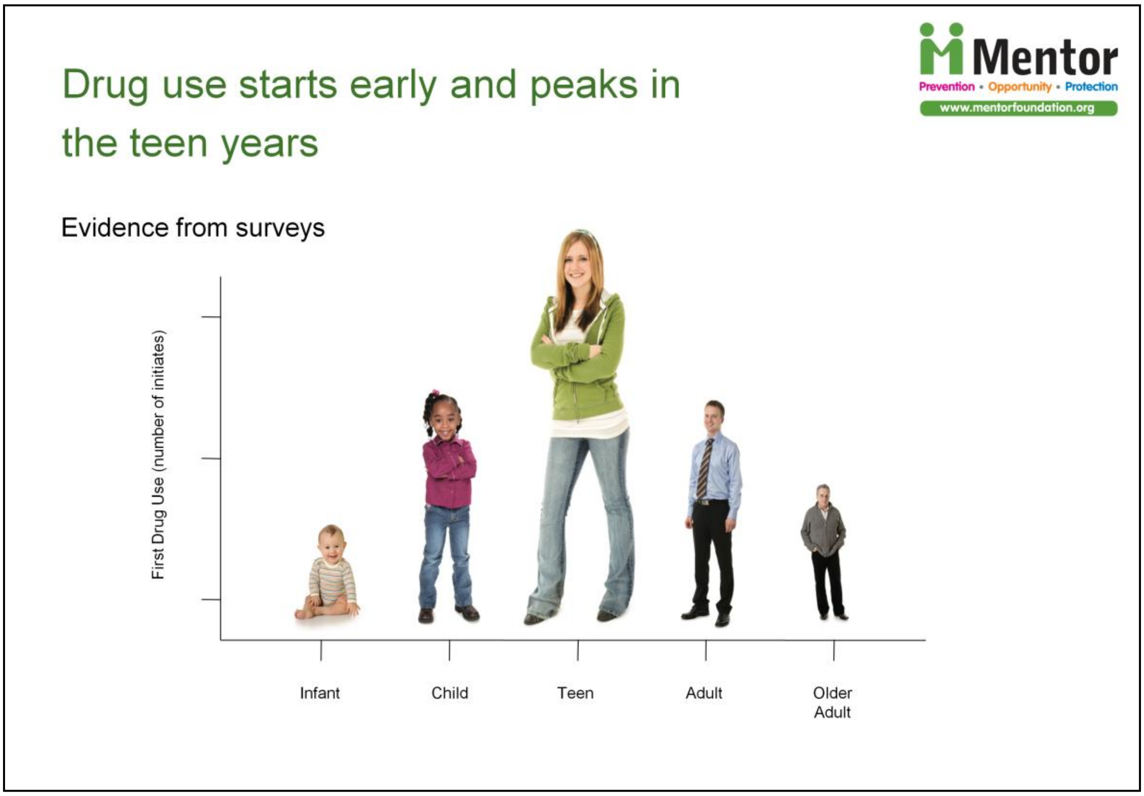
Let's further explore this topic of adolescent development in the context of drug abuse. Scientists are also now beginning to explore how these new discoveries of neurodevelopment may give us insights about adolescent vulnerability to drug use. This is an important issue given that adolescence is a time of experimentation and novelty seeking.

From a scientific standpoint, the central question that has received the most research attention by scientists is this: "Are adolescents more susceptible to alcohol compared to adults?" For several reasons it is easier for scientists to study the effects of alcohol compared to other drugs, so there is a lot more alcohol research on this topic.

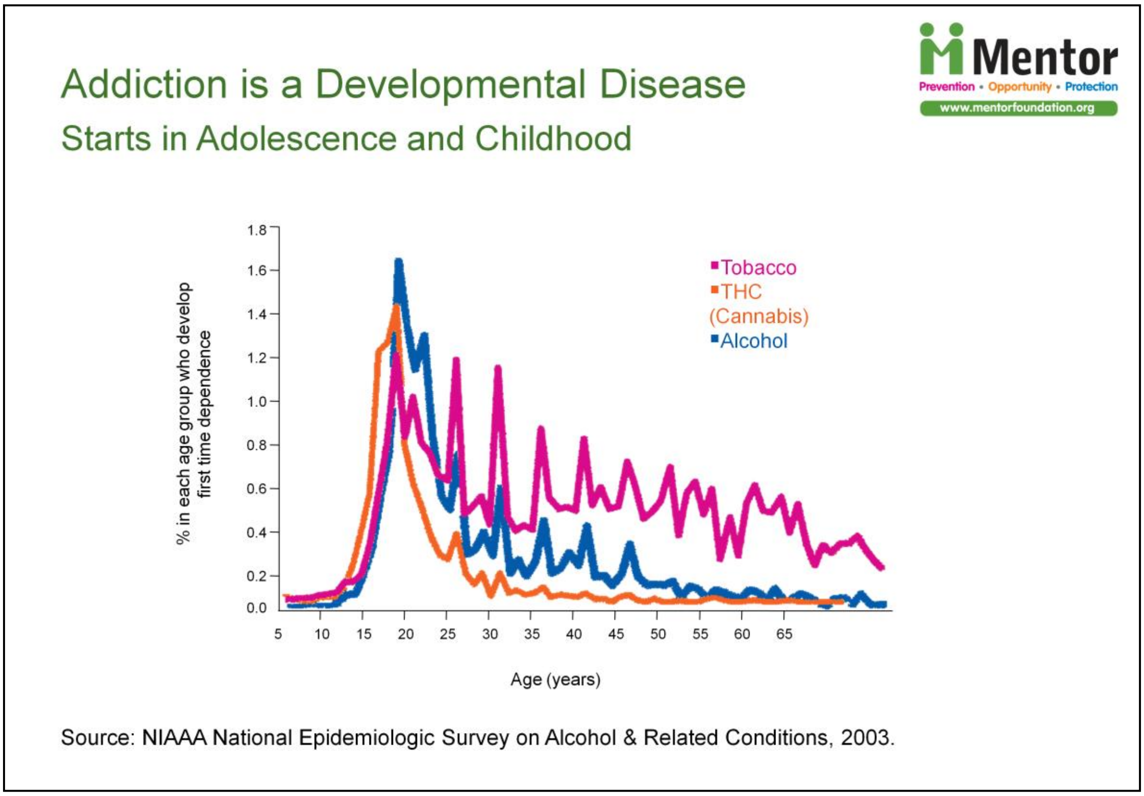
There are four lines of evidence we will review that are relevant to this research question: Are adolescents more susceptible than adults to alcohol?



One line of evidence to consider in answering this question comes from survey studies.



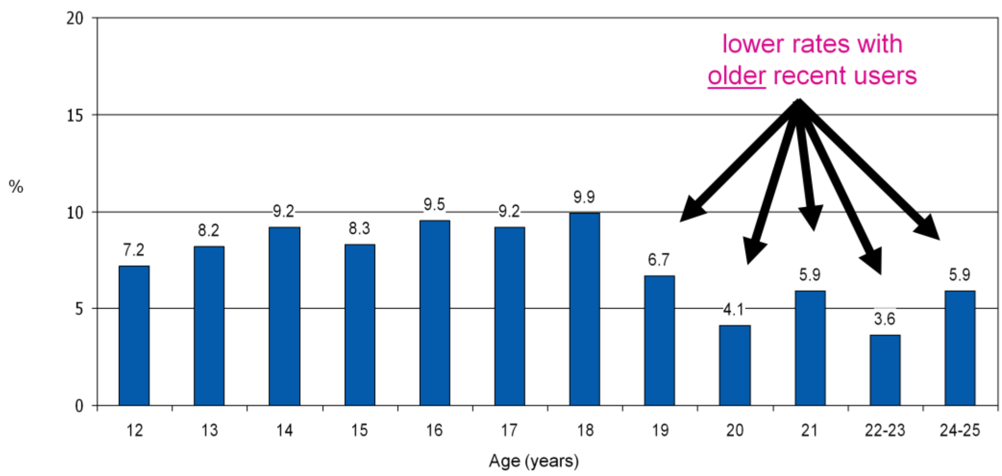
If adolescents are more susceptible to the effects of alcohol, it would be expected that adolescents reveal early susceptibility to developing an alcohol use disorder, and also would show higher rates of alcohol use compared to adults. There are data to support these trends.



In most Westernized countries, the drug that is abused the heaviest during the teenage years is alcohol – with marijuana and tobacco a close second. Here is a graph of data from the United States that shows drug use trends from youth to the elderly years.

The age group that is associated with highest rate of getting drug dependent for the fist time is youth (before the age of 25).

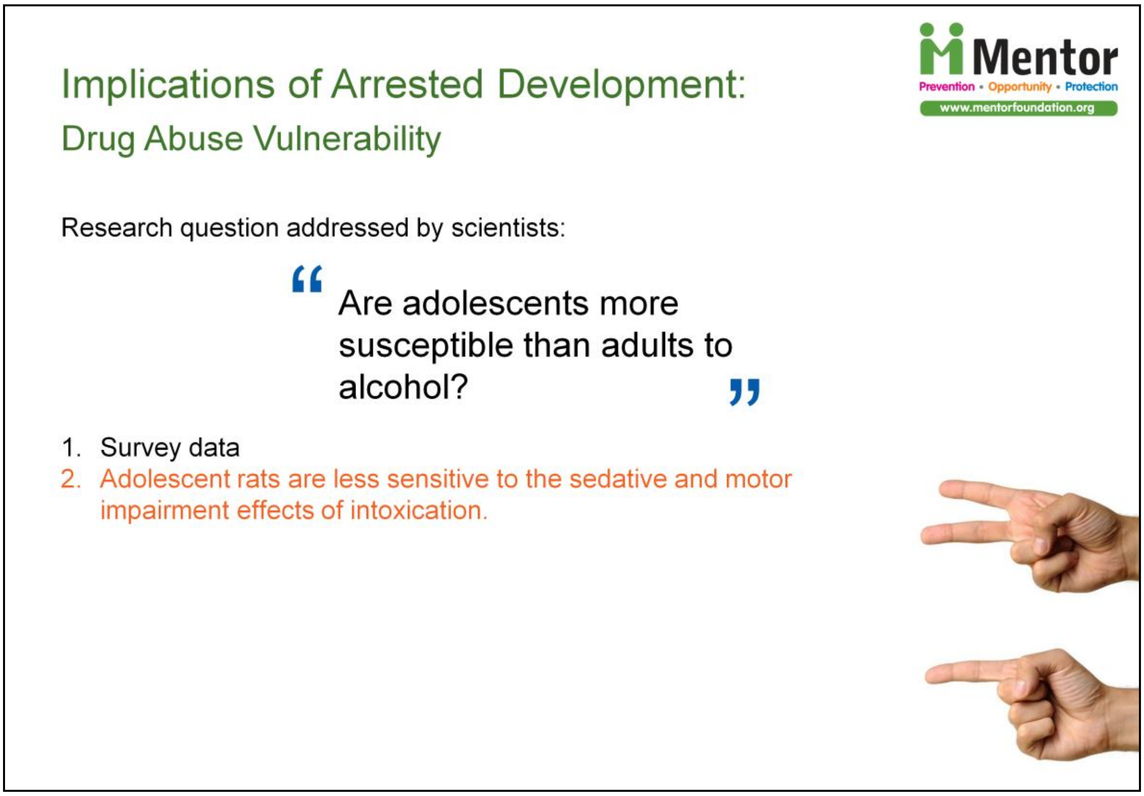
Percentages of Past Year Alcohol Use Disorder Among Those with a Recent Onset (Prior 2 Years) of Alcohol use (N = 4058)



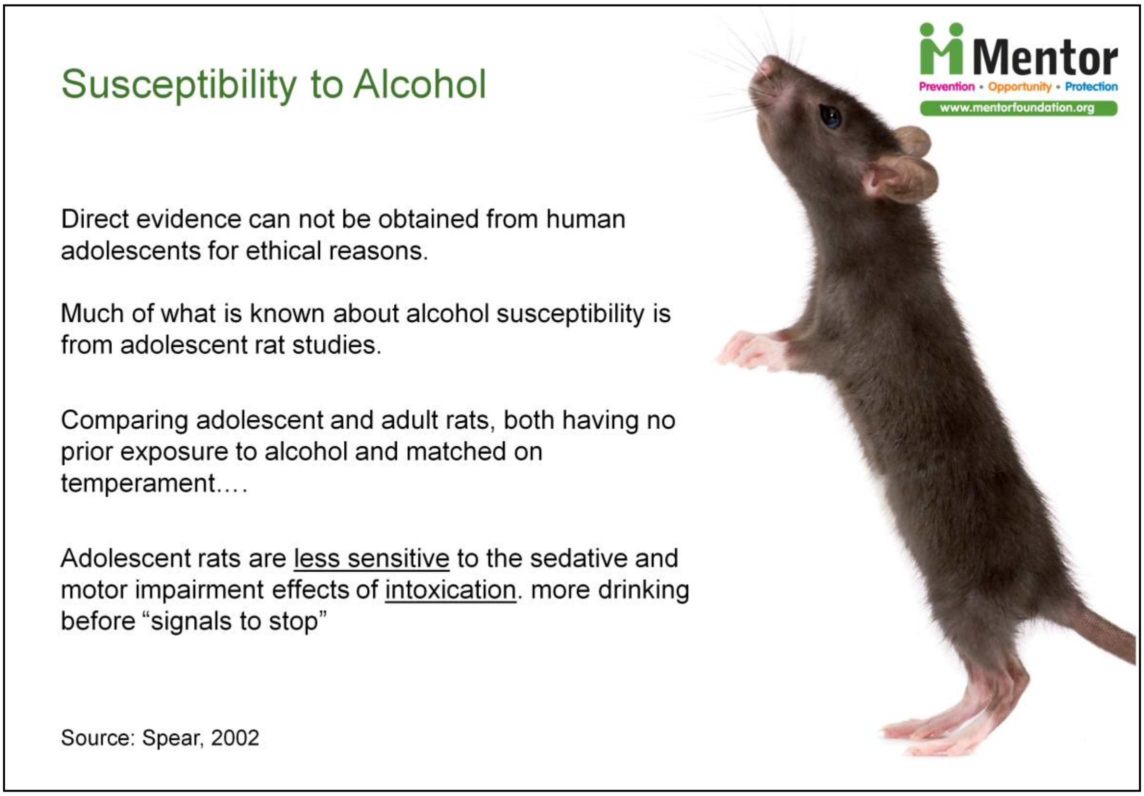
Source: Winters & Lee, 2008

Survey data from a national study in the U.S. provides further supporting evidence.

These data show the rates of alcohol abuse or dependence among recent-onset users of alcohol (prior 2 years) by chronological age. Exposure to alcohol is controlled by examining just recent onset users. The findings indicate that there is a general steady increase of the rate of an alcohol use disorder from age 12 to age 18. Then the rate drops rather noticeably at age 19, and stays relatively lower throughout the remaining years into young adulthood. The results support the view that youth, particularly during the teenage years, is a high risk period for developing an alcohol use disorder.



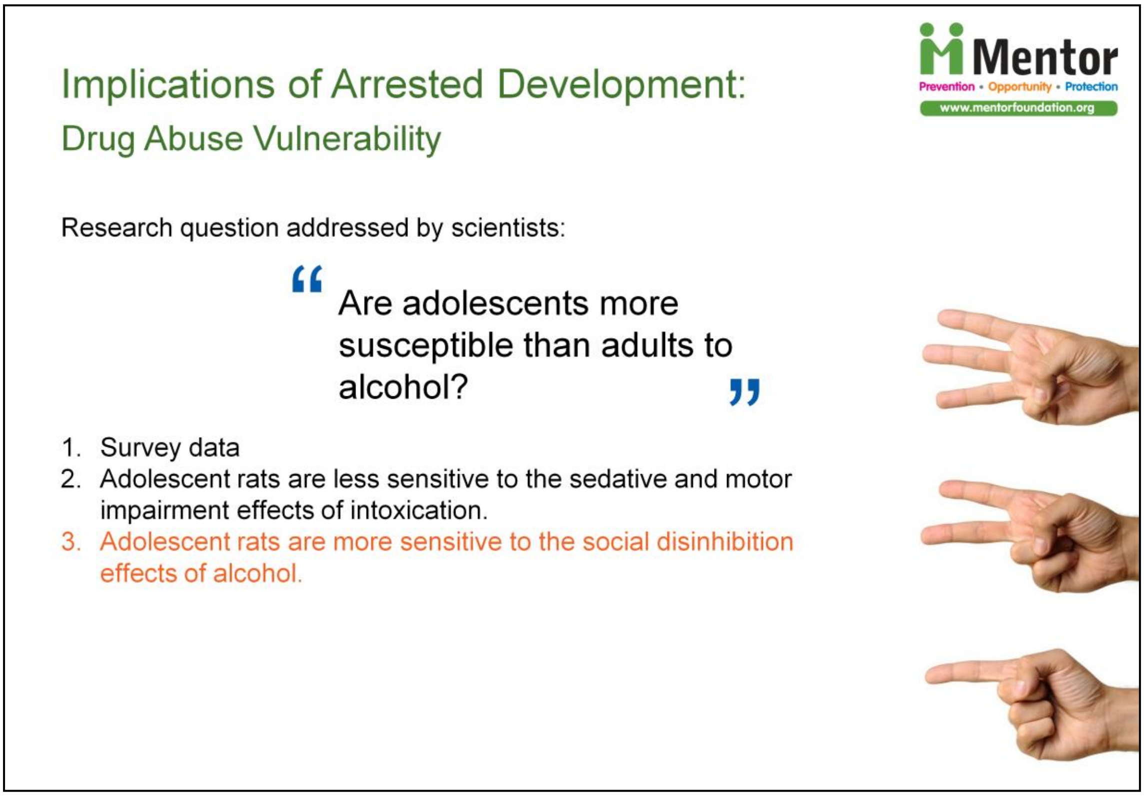
Next we turn to research from laboratory studies. Given that ethical reasons prohibit collecting direct evidence from underage drinkers, the effects of alcohol have been studied using adolescent and adult rates in controlled experiments.



These rat studies have identified two phenomenon that suggest adolescents are more vulnerable to the effects of alcohol compared to adults.

One set of studies conducted by Professor Linda Spear at SUNY at Binghamton in New York indicates that adolescent rats are less sensitive to the effects of intoxication than adult rats. Adolescent rats typically consume two to three times as much alcohol for their body weight as adults. Adolescent humans also show this diminished sensitivity to intoxication; their higher metabolic rates allow them to consume higher amounts of alcohol.

A lower sensitivity to alcohol's effects would be consistent with the observation that young people are capable of drinking large amounts of alcohol before feeling intoxicated.



Another laboratory study provides the third line of evidence.

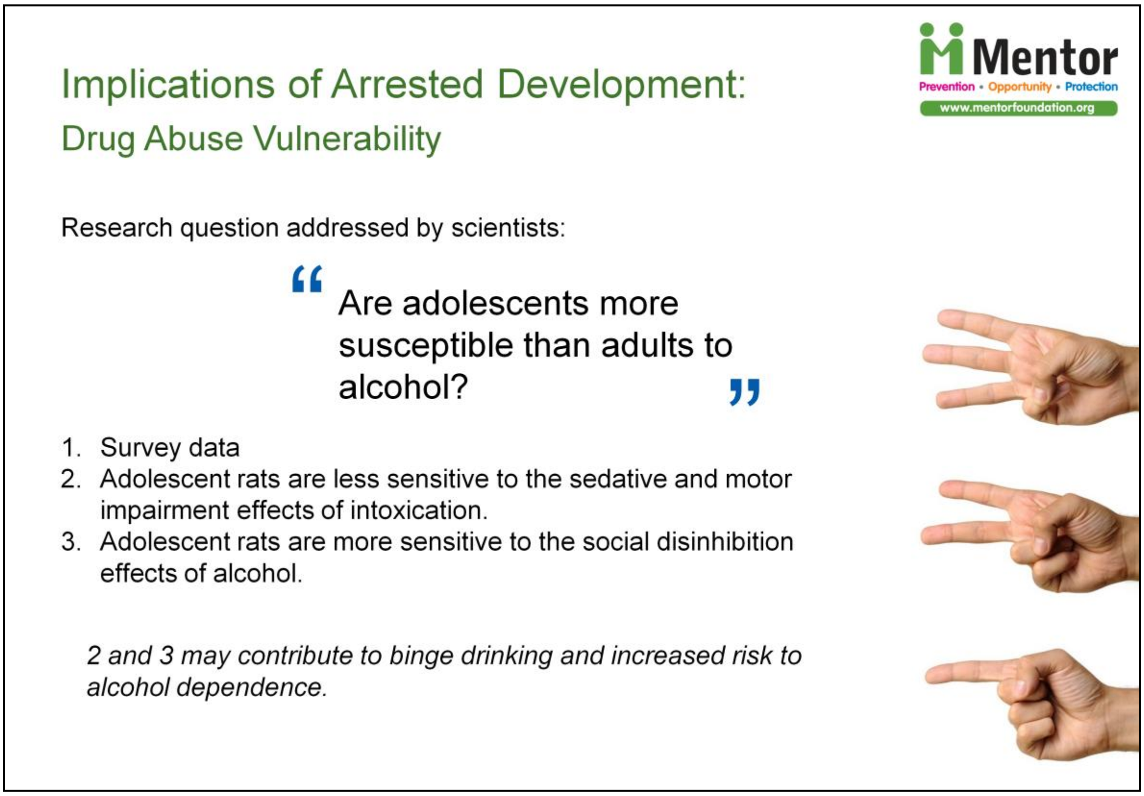
Social Disinhibition

Adolescent rats are <u>more sensitive</u> to the social disinhibition effects of alcohol compared to adults.

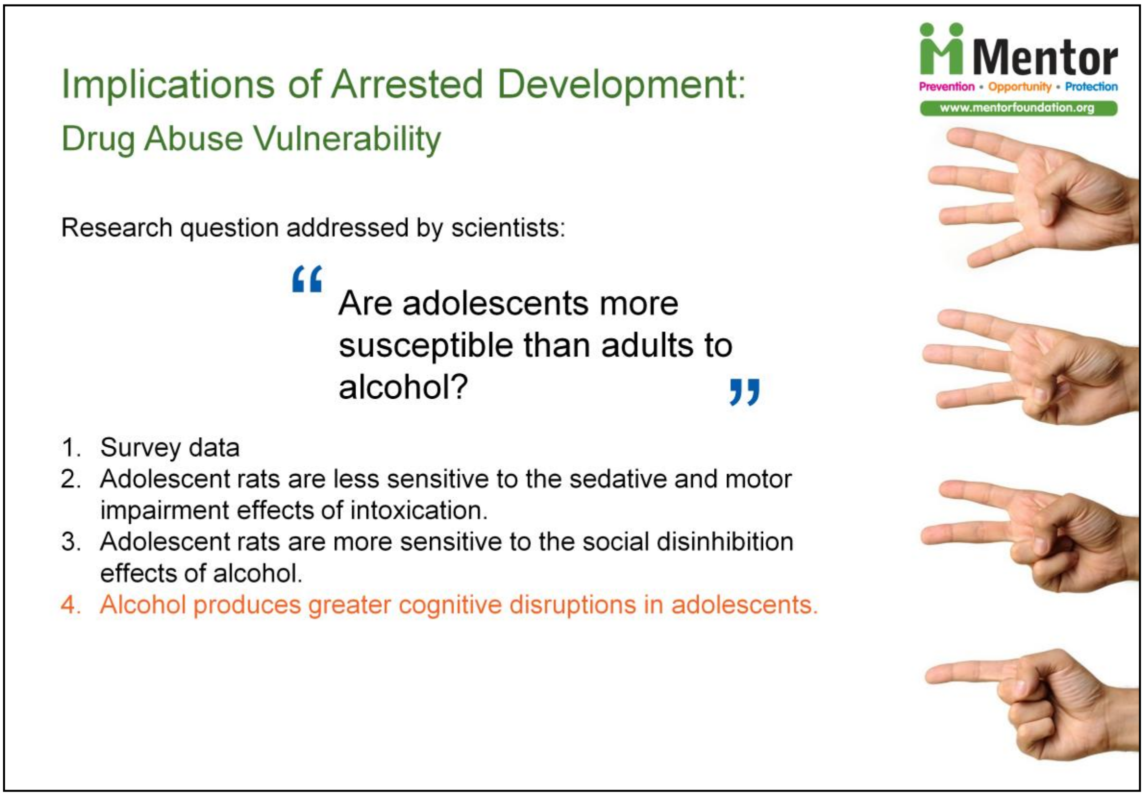
These studies suggest that adolescent rats derive greater "social comfort" from intoxication than adult rats.

Source: Spear, 2002

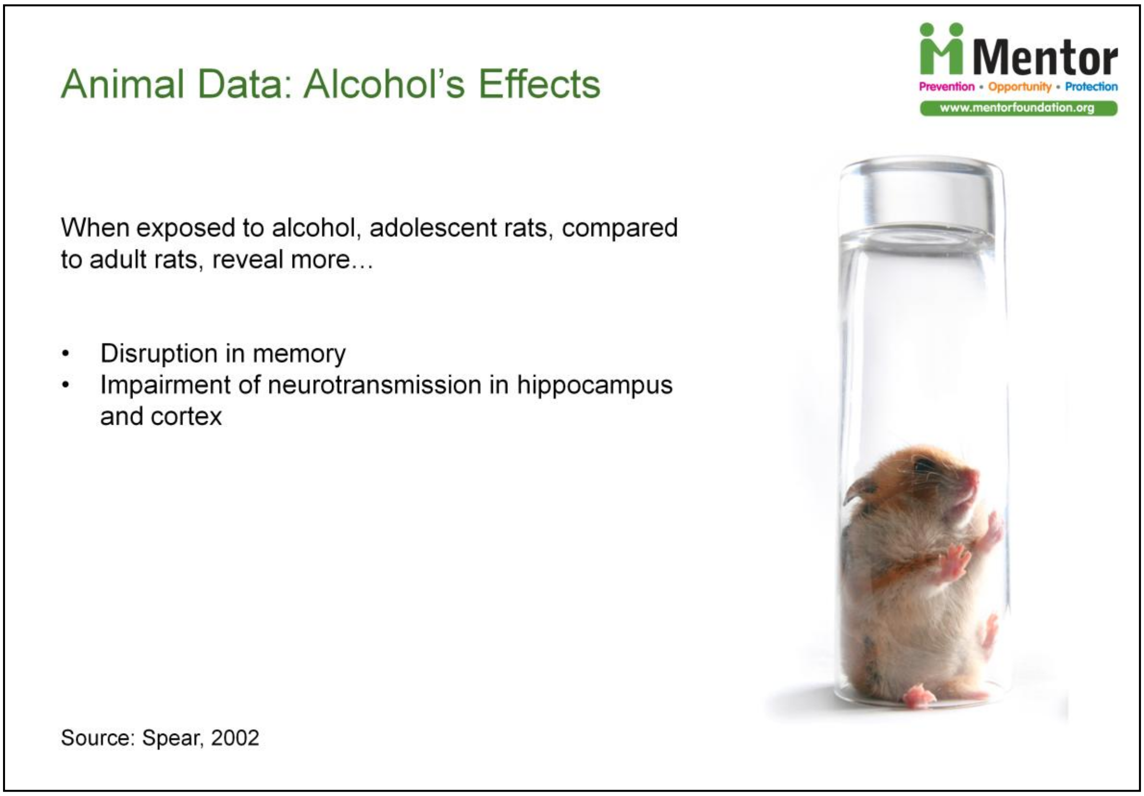
In another series of studies by Dr. Spear and colleagues, adolescent rats demonstrate a <u>greater</u> sensitivity to the social disinhibition that occurs while drinking. That is, compared to adult rats, adolescent rats show behavior consistent with the notion that they experience "greater social benefit" from the effects of intoxication. For example, intoxicated adolescent rats are more inclined to congregate with other rates compared to intoxicated adult rats who show less of this social behavior.



These two general findings from the animal studies by Professor Spear suggest that adolescence is a developmental period during which time alcohol is experienced quite differently compared to how adults handle alcohol. The tendency for youth to have a diminished sensitivity to the negative effects of drinking and yet to have an enhanced sensitivity to the positive effects of alcohol suggests a “recipe” for binge drinking.



There now is some scientific evidence suggesting that the developing brain is prone to the deleterious effects of alcohol.

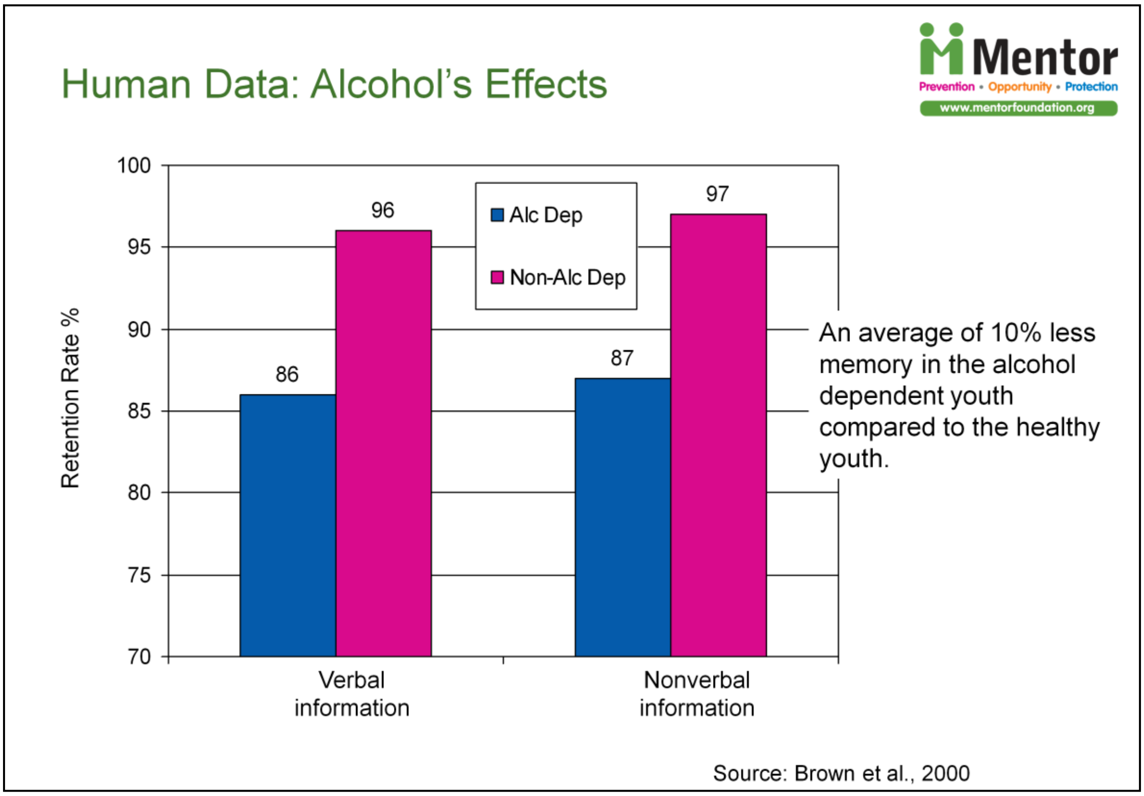


The work from Professor Spear's laboratory suggests that the memory region of the brain – the hippocampus - is particularly sensitive to alcohol, especially during adolescence. Adolescent rats exposed to various amounts of alcohol have significantly more brain damage in their frontal cortex than their adult counterparts. They also show greater damage to their working memory. With long-term use, adolescent rats have shown massive neuronal loss in other regions of the brain - the cerebellum, basal forebrain, and neocortex.

Human Data: Alcohol's Effects

Adolescents with a history of an alcohol use disorder may show deficits in short-term memory.

There are some human data that have confirmed the findings from the animal literature.

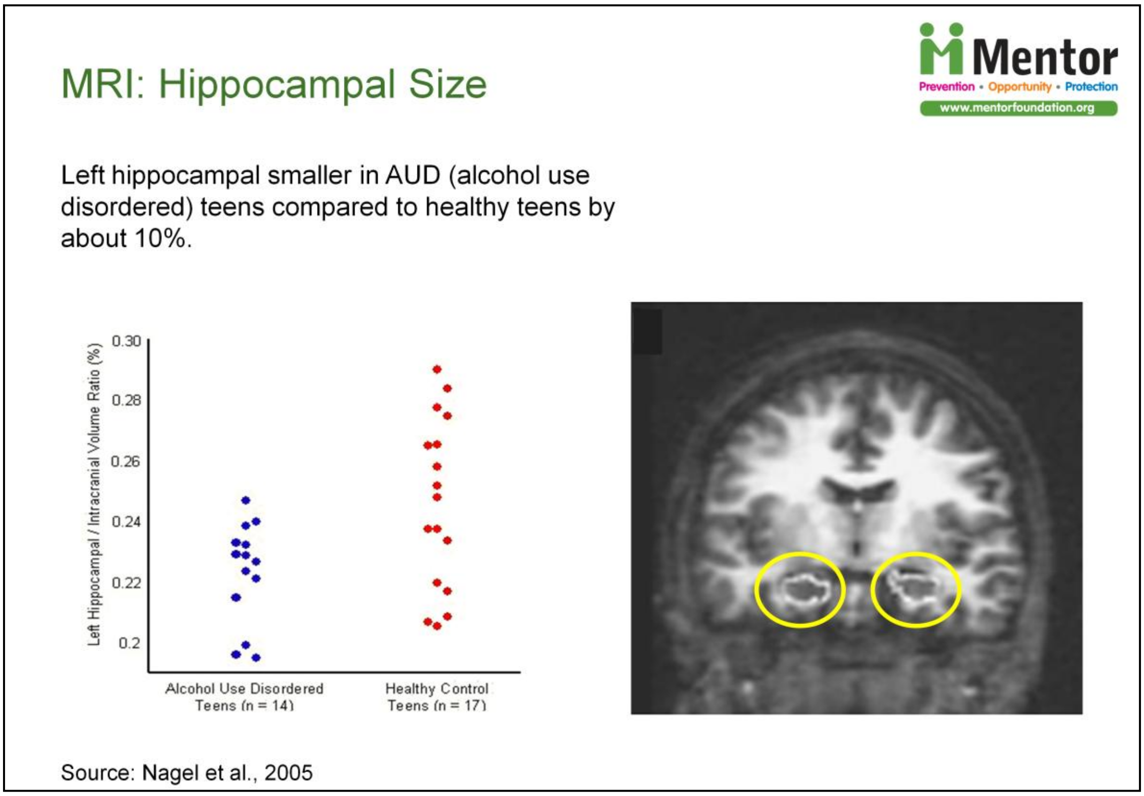


There are indications that alcohol can negatively impact memory. Dr. Brown and colleagues found that adolescents with a history of alcohol dependence showed an average of 10% less memory on short term verbal and non-verbal tasks compared to a healthy comparison group.

Human Data: Alcohol's Effects

The hippocampus encodes new information into memory.

Adolescents with a history of abusing alcohol may have a smaller hippocampus volume.



Professor Susan Tapert and her colleagues studied 14 adolescents (ages 15-17) with a history of alcohol abuse and 17 healthy comparison teenagers. Those with the histories of health drinking had a smaller left hippocampus volume.

Here is the scatter plot of these data. The blue data points represent the left hippocampal size of the adolescents with a prior alcohol use disorder and the red data points are associated with the health comparisons. On average, the left hippocampal size is smaller in the alcohol use disordered group.

Summary

1. Expect impulsivity, poor judgment, emotionality
- "On second thought…" *not* in the repertoire
- Parents must use *their* judgment to protect teens
- Parents must anticipate - teens need help with this
- Less than optimal planning and judgment

2. Drugs, particularly alcohol, have different and more significant effects on teenagers
- Drug experimentation is normal
- *But*… can be dangerous

Lets review the implications of this range of information presented here.

A normal and healthy adolescent can be expected to exhibit some risk-taking, show less than optimal judgment, and have difficulty managing emotions. Adolescents may make decisions that are too often based on how he or she feels rather than on careful and reasoned thinking. Adults play an important role by using their judgment to protect teenagers.

And do not minimize the potential for young people to fall victim to drugs, particularly alcohol. Drug use can be dangerous!

Take Home for Parents

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Promote activities that capitalize on the strengths of the developing brain

Assist your child with challenges that require planning

Reinforce their seeking advice from you and other adults

Educate about risk taking and negative consequences

Never underestimate drug effects on developing brain

Tolerate "oops" behaviors common during the teens

Here are six summary points of this material organized by the mnemonic, PARENT.

(READ EACH LETTER AND SUMMARY STATEMENT)

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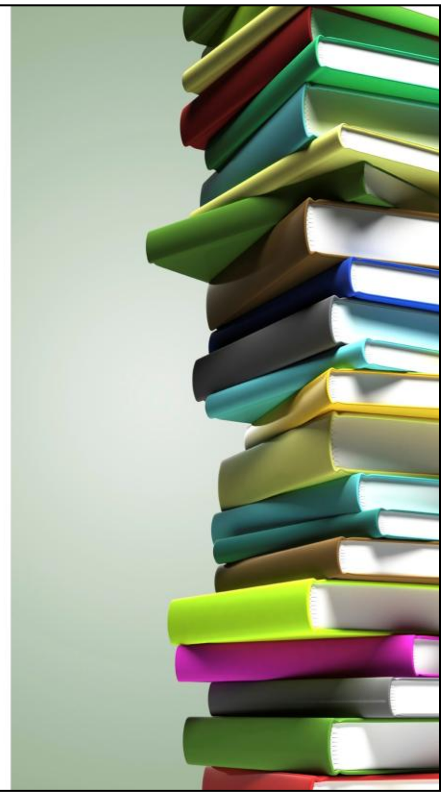

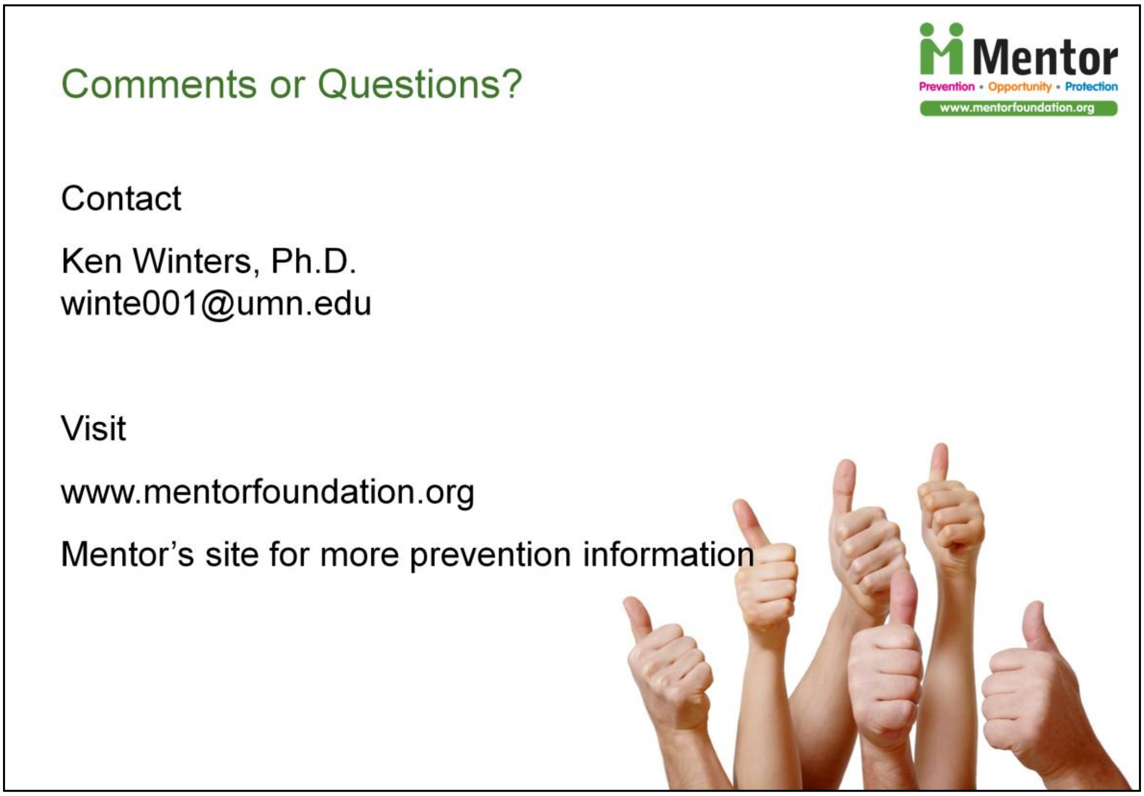

Send comments and questions to Dr. Ken Winters, at winte011@umn.edu.

And visit the website of the Mentor Foundation for more drug prevention resources – www.mentorfoundation.org .

