



National American Indian & Alaska Native

**ATTC**

Addiction Technology Transfer Center Network  
Funded by Substance Abuse and Mental Health Services Administration

**IOWA**

**SAMHSA**  
Substance Abuse and Mental Health  
Services Administration

# **ESAS: Adolescent Brain Maturation and Health: Intersections on the Developmental Highway (Re-broadcast)**

September 14, 2022

Speaker:

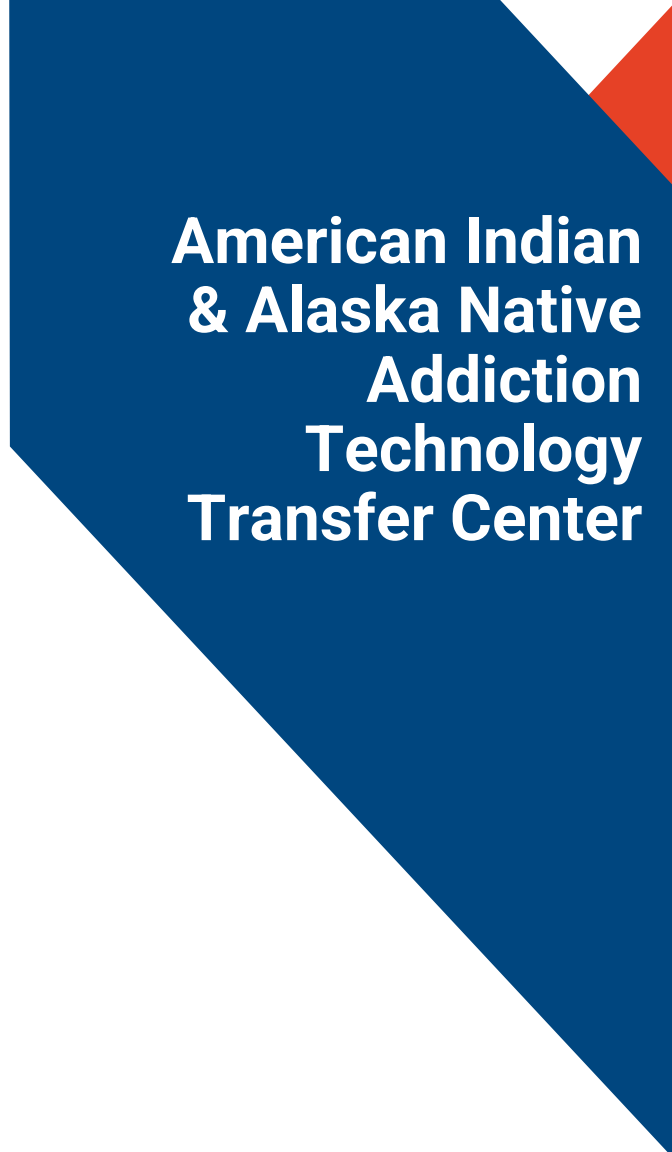
Ken Winters PhD



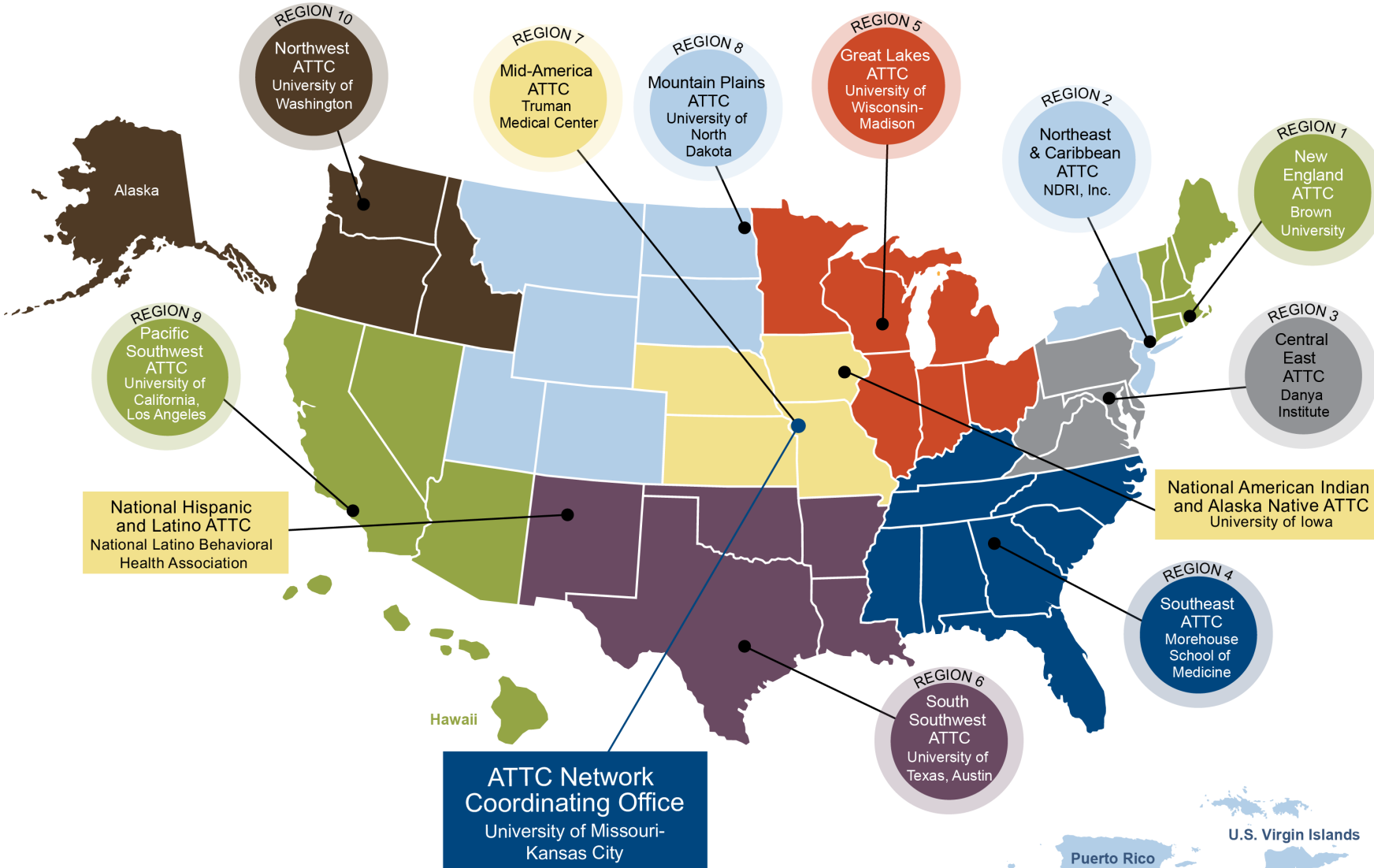
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## U.S.-based ATTC Network



# American Indian & Alaska Native Addiction Technology Transfer Center



# ***SAMHSA***

Substance Abuse and Mental Health  
Services Administration

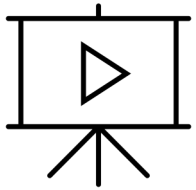
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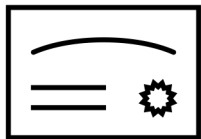


# Follow-up

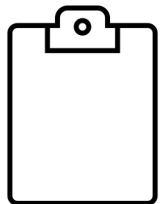
Following today's event, you will receive a follow up email, which will include:



Links to the presentation slides and recording, if applicable



Information about how to request and receive CEUs



Link to our evaluation survey (GPRA)



# Land Acknowledgement

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We would like to take this time to acknowledge the land and pay respect to the Indigenous Nations whose homelands were forcibly taken over and inhabited.

Past and present, we want to honor the land itself and the people who have stewarded it throughout the generations.

This calls us to commit to forever learn how to be better stewards of these lands through action, advocacy, support, and education.

We acknowledge the painful history of genocide and forced occupation of Native American territories, and we respect the many diverse indigenous people connected to this land on which we gather from time immemorial.

While injustices are still being committed against Indigenous people on Turtle Island, today we say thank you to those that stand with Indigenous peoples and acknowledge that land reparations must be made to allow healing for our Indigenous peoples and to mother earth, herself.

Dekibaota, Elleh Driscoll, Meskwaki and Winnebago Nations

Ttakimaweakwe, Keely Driscoll, Meskwaki and Winnebago Nations

Ki-o-kuk, Sean A. Bear, 1<sup>st</sup>. Meskwaki





## Today's Speaker

Ken Winters, Ph.D. has been a consultant to the National American Indian Alaska Native Technology Transfer Center for several years. He is a Senior Scientist at the Oregon Research Institute (MN location). Previously he was a Professor, Department of Psychiatry at the University of Minnesota, where he founded and directed the Center for Adolescent Substance Abuse Research for 25 years. His primary research interests are adolescent health, with a focus of substance abuse and co-existing mental and behavioral disorders.



**ESAS:  
Adolescent Brain Maturation and Health:  
Intersections on the Developmental Highway**

**Ken Winters, Ph.D.  
winte001@umn.edu**

**September 7, 2022  
*Essential Substance Abuse Skills: A Guide for  
Professionals*  
National American Indian & Alaska Native  
Technology Transfer Center**

# **Professional Disclosure/Conflicts of Interest**

- **None**



## **Personal Disclosure**

**I hope to avoid the concern once voiced by the famous Italian-American physicist, Enrico Fermi, who had this reaction after he attended a seminar:**

**“Before I came here, I was confused about this subject. Having listened to your lecture, I am still confused -- but on a higher level.”**

*The National  
Academies of*

SCIENCES  
ENGINEERING  
MEDICINE

THE NATIONAL ACADEMIES PRESS

This PDF is available at <http://nap.edu/25388>

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# Get Out of My Life,

*but First Could You Drive Me and Cheryl to the Mall?*



A PARENT'S GUIDE TO THE NEW TEENAGER

**Anthony E. Wolf, Ph.D.**

Copyright © 2002

# **YouTube Video** (from a “research” expert)

***<https://youtu.be/6zVS8HIPUng>***  
**Sarah-Jayne Blakemore’s Ted Talk:**  
***The mysterious workings of the***  
***adolescent brain***



# YouTube Video (from “real experts”)

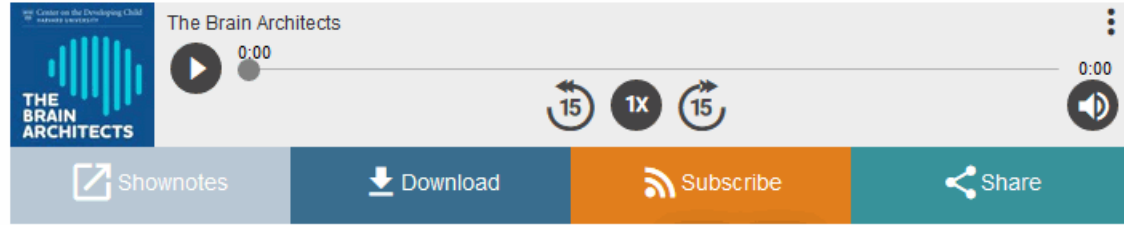
<https://www.youtube.com/watch?v=t5sJyq59y5I>



Native American Teens: Who We Are

# Podcast Series

- Harvard's Center on the Developing Child new podcast series, *The Brain Architects*



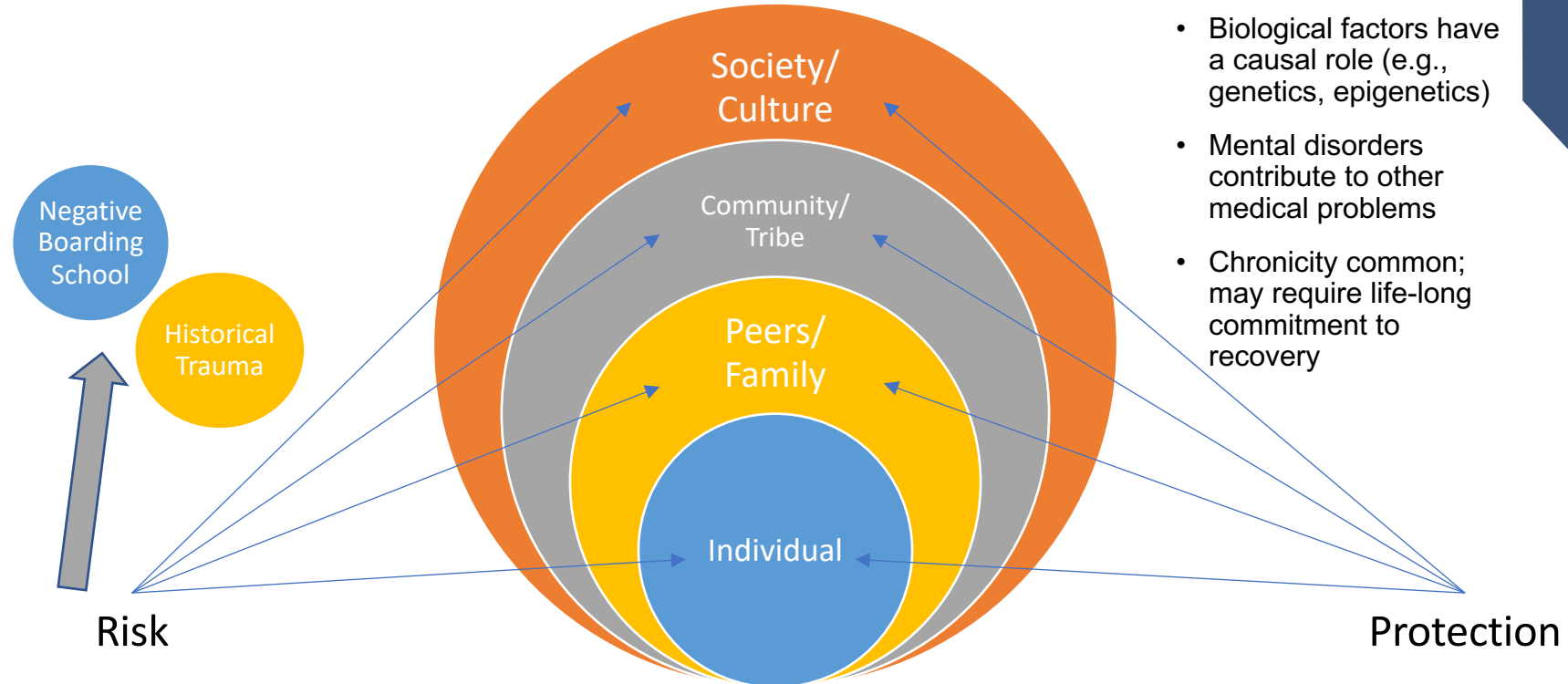
- “Learn the science behind how brains are built and what it means how to build a strong brain.”
- <https://developingchild.harvard.edu/science/key-concepts/brain-architecture/>

## **Cautionary Note #1**



- **My spotlight on brain development and its impact on adolescent behavior and health does not diminish the impact of environment and social determinants on adolescent behavior.**
- **Of course, the role of non-biological influences on youth behavior is significant.**

# A Native Ecological Model: Multiple Domains Influence Behavioral Health



adapted from Bronfenbrenner, 1979 and McGregor et al., 2003



## Cautionary Note #2



- The science of adolescent brain development is still in its relative infancy
- Studies typically do not have large samples and not diverse in terms of ethnicity/race

### Adolescent Brain Cognitive Development National Longitudinal Study

U.S. longitudinal study of 13,000 children enrolled at age 9-10 years to assess effects of drugs on individual brain development trajectories



Slide courtesy of Maureen Boyle, PhD

# Teen Brain Development Quiz



1. Two health indices that suggest teenagers are taking less risk than in years past are the decline in teenage pregnancy and the very low rate of cigarette smoking. T or F?
2. The brain development of Native adolescents follows the same principles as with non-Native adolescents. T or F?
3. Which is more harmful to the developing brain?
  - a. Regular use of high potency cannabis
  - b. Regular binge drinking
  - c. Regular vaping of nicotine

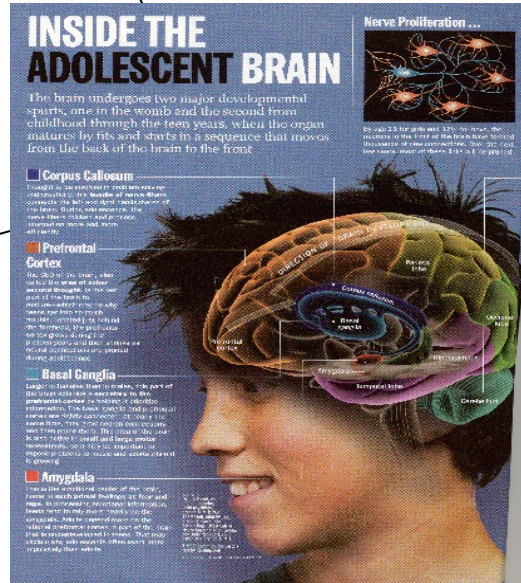


# I. Relevance of Brain Development Science

## II. Overview of Adolescent Brain Development

- impact of drug use, mental health, early experiences and social media

## III. Summary



# Major Points from My Talk



- 1. Service providers can leverage teen brain science when working with adolescents and parents.**
- 2. The maturation of the adolescent brain likely contributes to behaviors that are characteristic of this developmental period.**
- 3. This maturation also informs our understanding of risk for substance use disorders and other behavioral disorders.**

# I. Relevance of Brain Development Science

## INSIDE THE ADOLESCENT BRAIN

The brain undergoes two major developmental spurts: one in the womb and the second from childhood through the teen years, when the organ matures by fits and starts in a sequence that moves from the back of the brain to the front.

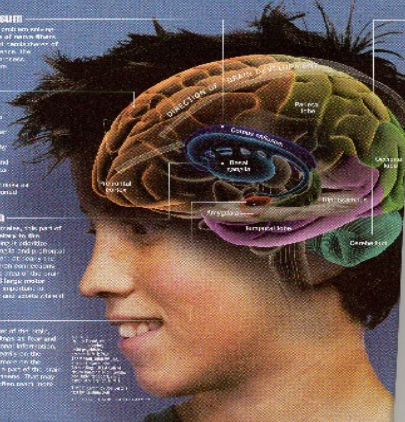
**Nerve Proliferation ...**  
By age 25, the brain will have 100 billion neurons in the front of the brain, but 100 billion neurons in the back of the brain. See: "The New Science of the Teen Brain" by David Greenberg, 8-10-11, p. 100.

**Corpus Callosum**  
Found in the brain's white matter, the corpus callosum is a thick band of nerve fibers that connects the left and right hemispheres of the brain. It is essential for the transfer of information between the two sides of the brain.

**Prefrontal Cortex**  
The part of the brain that is responsible for executive functions such as planning, decision-making, and impulse control. It is the last part of the brain to mature, and its development continues into the late 20s.

**Basal Ganglia**  
A group of structures in the brain that are involved in movement, learning, and emotion. They are located in the center of the brain, below the cerebral cortex.

**Amgyala**  
The seat of emotion and the center of the brain's limbic system. It is involved in processing information about the environment and is essential for the formation of memories.



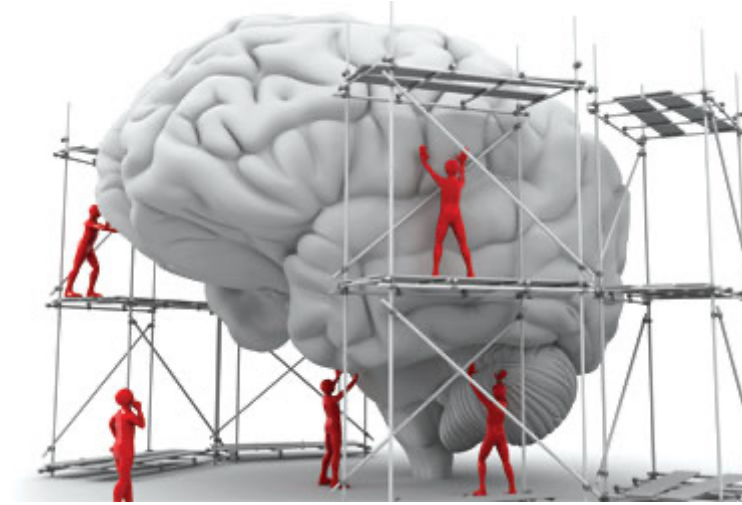
## II. Overview of Adolescent Brain Development

- impact of drug use, mental health, early experiences and social media

## III. Summary

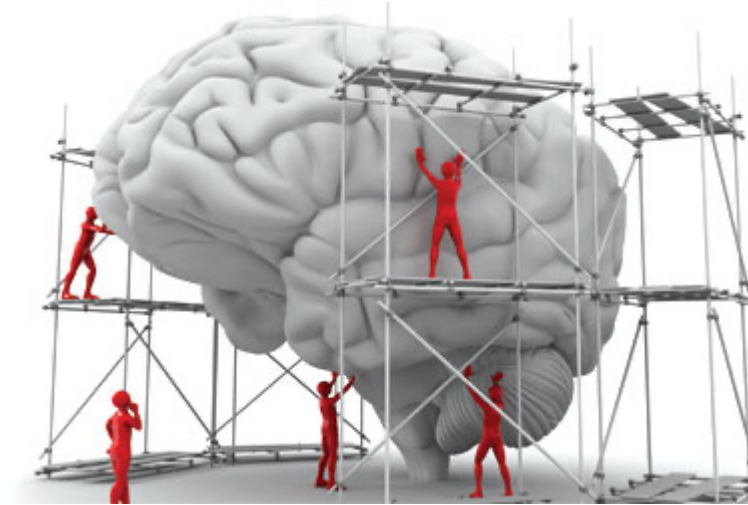
# Brain Development: Implications for Youth Serving Workers & Educators

- 1. Teach youth about brain development and its importance to health and personal growth**



# Brain Development: Implications for Youth Serving Workers & Educators

- **Teach “adaptive” decision making**
  - **taking risks that promote “personal-growth”**
  - **“on second thought” skills**
  - **how to avoid peer pressure to engage in delinquency**

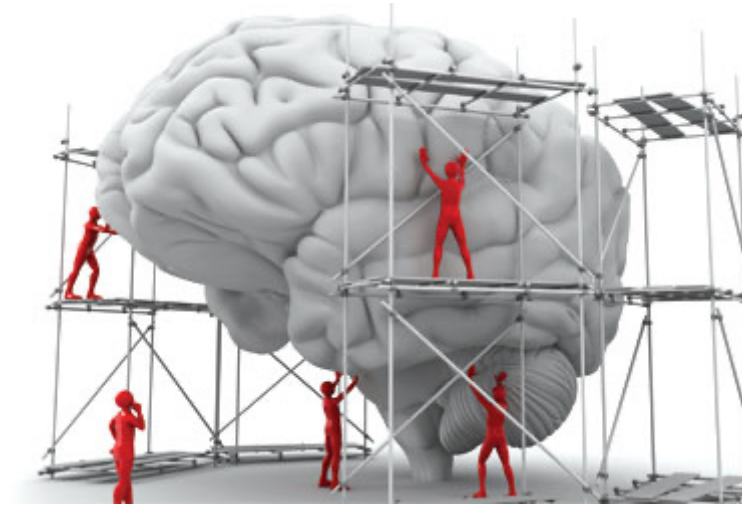


# Brain Development: Implications for Youth Serving Workers & Educators

- Interested in a “teen brain” resource to help teach youth about brain development?

send me an e-mail:

[winte001@umn.edu](mailto:winte001@umn.edu)

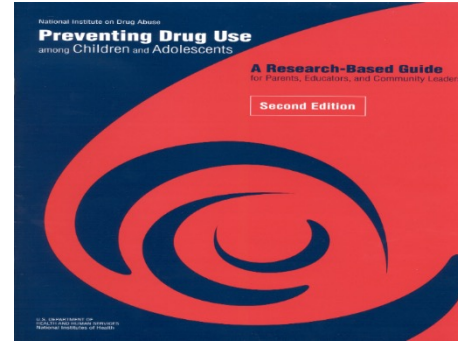




# Brain Development: Implications for Youth Serving Workers & Educators

## 2. Use evidenced-based *prevention* programs

- Keys to effective prevention are in the research literature
  1. National Institute on Drug Abuse  
<https://www.drugabuse.gov>
  2. Cochran literature review  
<https://www.cochranelibrary.com/cdsr/about-cdsr>
  3. ISSUP's prevention curriculum  
<https://www.issup.net/training/universal-prevention-curriculum>



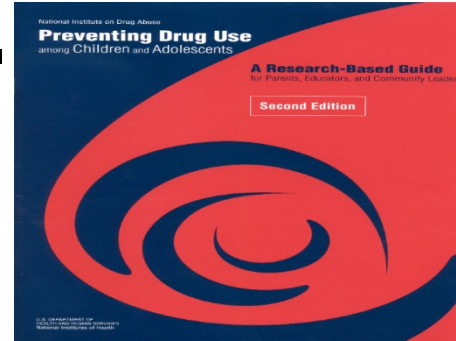
Trusted evidence.  
Informed decisions.  
Better health.



# Brain Development: Implications for Youth Serving Workers & Educators

## 2. These best programs ....

- developmentally adjusted
- address all substances
- focus on skills
- focus on building assets
- often have parent component

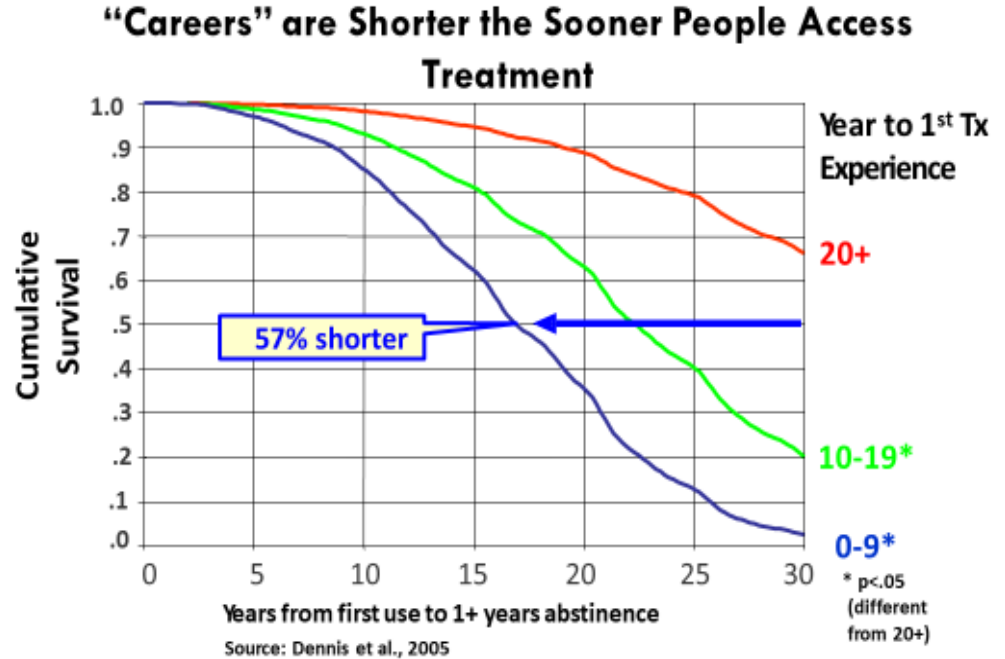


Trusted evidence.  
Informed decisions.  
Better health.



# Brain Development: Implications for Service Providers

## 3. Earlier the *treatment*, the better



# Brain Development: Implications for Service Providers

## 4. Use evidenced-based *treatment*

Treatment: Recent literature summary and meta-analysis (Hogue et al., 2018; **NIDA, 2014**; Tanner-Smith et al., 2012)

Treatment “as usual” is no better than prevention education only or no treatment.

A wide range of more recent evidenced-based treatment do significantly better.

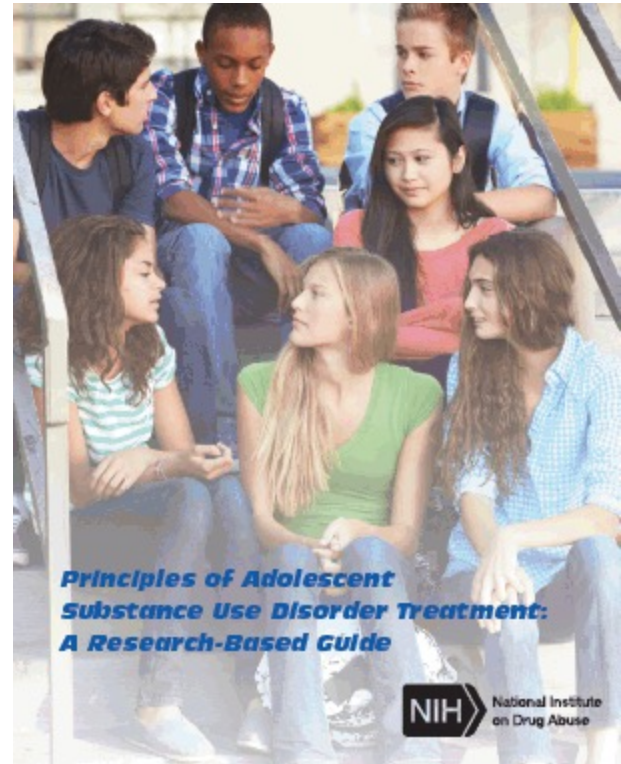
**MET, CBT and family therapy**



# Evidenced-Based Treatment

NIDA (2014): *Principles of Adolescent Substance Use Disorder Treatment: A Research-Based Guide*

- **Motivational Interviewing**
- **Cognitive – Behavioral Therapy (CBT)**
- **Family Treatment**



# **CBT and MI Are Helpful for Teaching and Supporting Self-Regulation**

- **impulse control**
- **“second” thought processes**
- **social decision making**
- **dealing with risk situations**
- **taking healthy risks**



# Use of “Westernized” Treatment for AI/AN Youth

- **Preferable to culturally adapt EBTs in order to optimize treatment effectiveness**
  - 1. culture-based interventions enhance pride in native traditions and promote recovery**
  - 2. supports traditional healing practices and beliefs**
  - 3. there is no one right way of doing things; many paths to healing exist**



# Use of “Westernized” Treatment for AI/AN Youth

- **When selecting culturally adapted approaches for AI/AN youth, consider them in light of.....**
  - **cultural identity**
  - **use of traditional healing practices**
  - **relevance to presenting problems and needs of the adolescent client and the community**
  - **emphasis on strengths and asset-building**
  - **capability for home-based implementation (to address rural nature of many tribes)**





# Brain Development: Implications for Youth Serving Workers & Educators

## 5. Increase the “cannabis and vaping IQ” of adolescents



- **Sources of exercises and quizzes**

- **Cannabis:**

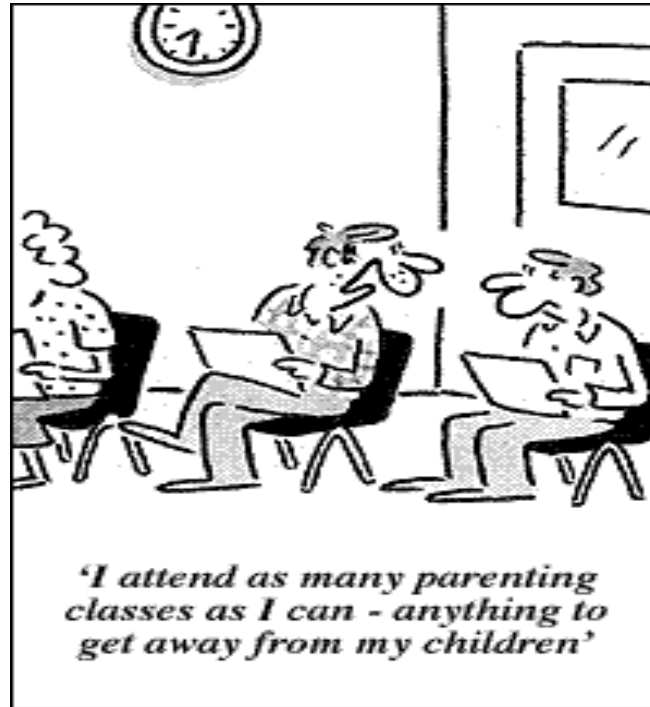
- **[www.dfaf.org](http://www.dfaf.org) (*Busting the Top Ten Myths of Marijuana*)**

- **Vaping:**

- **Google “CDC educating kids on vaping”**  
**<https://www.cdc.gov/tobacco/features/back-to-school/e-cigarettes-talk-to-youth-about-risks/index.html>**

# Brain Development: Implications for Service Providers

## 6. Teach parents about brain development



# Brain Development: Implications for Service Providers

## 6. Teach parents about brain development

**P** = Promote activities that capitalize on the strengths of the developing brain.

**A** = Assist children with challenges that require planning.

**R** = Reinforce their seeking advice from adults; teach decision making.

**E** = Encourage a lifestyle that promotes good brain development.

**N** = Never underestimate the impact of a parent being a good role model.

**T** = Tolerate the “oops” behaviors due to an immature brain.

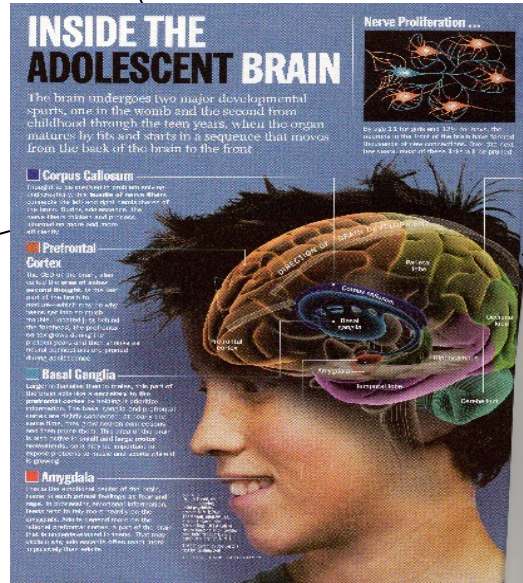


# Parent Resources

[https://www.youtube.com/watch?v=\\_SstSiZ\\_0rw](https://www.youtube.com/watch?v=_SstSiZ_0rw)



# I. Relevance of Brain Development Science

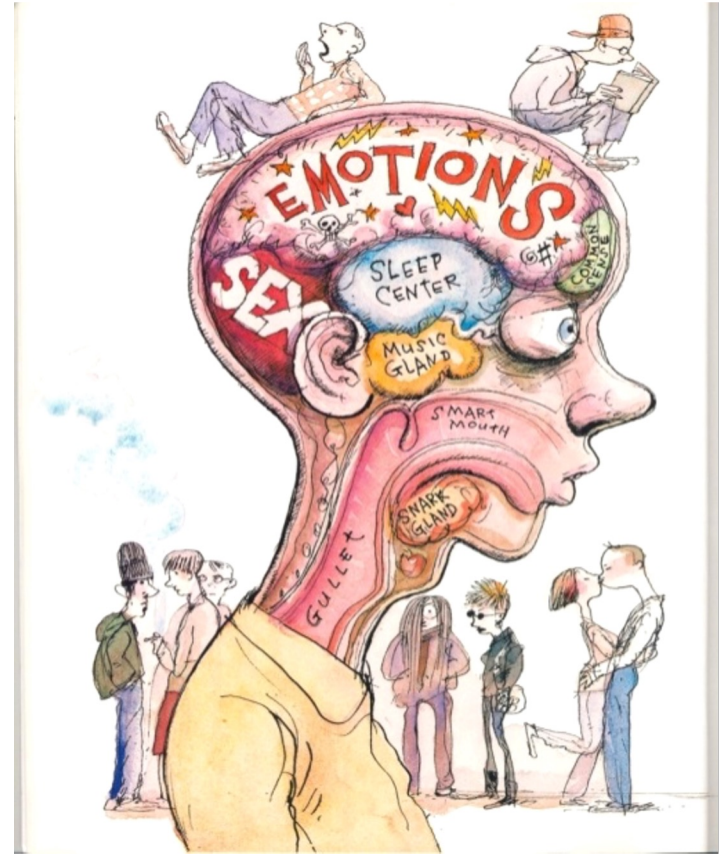


## II. Overview of Adolescent Brain Development

- impact of drug use, mental health, early experiences and social media

## III. Summary

- **Based on research by neuroscientists, brain maturation continues through adolescence, until approx. age 25**



Source: US News &  
World Report, 2005

# **An Immature Brain = Less Brakes on the “Go” System**

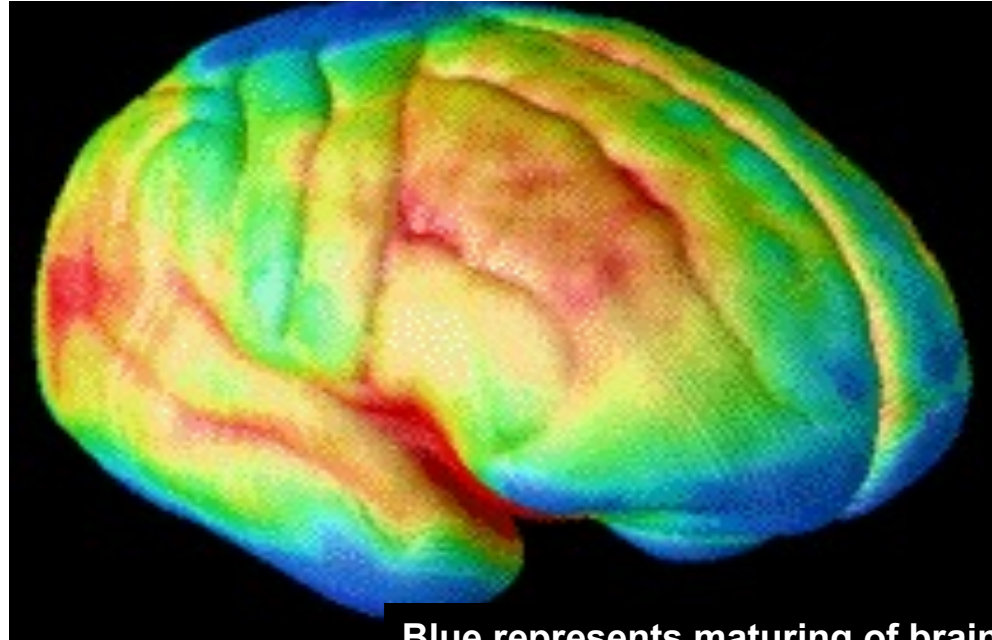


# Maturation Occurs from Back to Front of the Brain and Inside to Outside

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

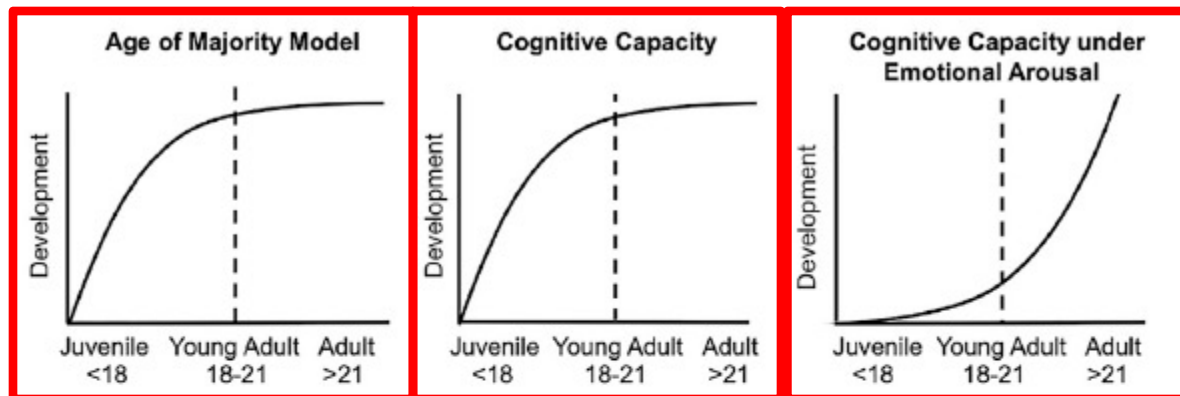
**Earlier: Limbic**  
**Motor Coordination**  
**Emotion**  
**Motivation**

**Later: Frontal**  
**Judgment**



Blue represents maturing of brain areas





**Figure 1. Legal, Psychological, and Brain-Based Accounts of When an Adolescent Is an Adult**

Adapted from [Cohen et al. \(2016b\)](#) and [Icenogle et al. \(2019\)](#).

# Implications of Brain Development for Adolescent Behavior



- **Preference for ....**
  - 1. physical activity**
  - 2. high excitement and rewarding activities**
  - 3. activities with peers that trigger high intensity/arousal**
  - 4. novelty**
- **Less than optimal..**
  - 5. control of emotions**
  - 6. consideration of negative consequences**
- **Greater tendency to...**
  - 7. be attentive to social information**
  - 8. take risks and show poor self-control**

# Implications of Brain Development for Adolescent Behavior

(Winters et al., 1995)



- **Preference for ....**

1. **physical activity**
2. **high excitement and rewarding activities**
3. **activities with peers that trigger high intensity/arousal**
4. **novelty**

- **Less than optimal..**

5. **control of emotions**
6. **consideration of negative consequences**

- **Greater tendency to...**

7. **be overly attentive to social information**
8. **take risks**

**Contributors for healthy  
or personal growth?**

# Implications of Brain Development for Adolescent Behavior

(Winters et al., 1995)



- **Preference for ....**

1. **physical activity**
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- **Greater tendency to...**

7. **be overly attentive to social information**
8. **take risks**

**Contributors for  
unhealthy or unwise risk?**

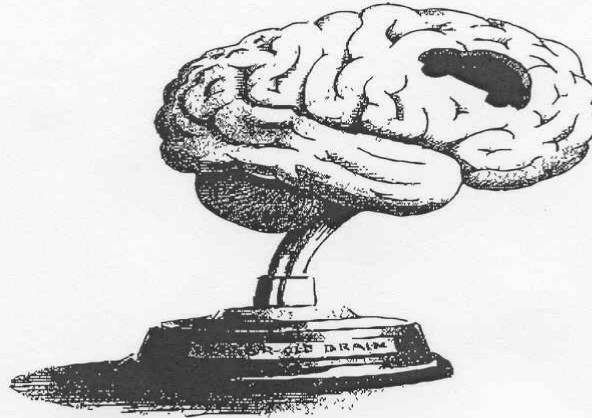
# **Risk-Taking & Self Control**

- **Based on science of brain development, a modern view of risk taking in adolescence is...**
  - **evolutionarily adaptive**
  - **normative; important to development**
  - **significant individual differences**
  - **is due primarily to emotional and contextual, not cognitive, factors**

# Why do most 16-year-olds drive like they're *missing a part of their brain?*



BECAUSE THEY ARE.



EVEN BRIGHT, MATURE TEENAGERS SOMETIMES DO THINGS THAT ARE "STUPID."

But when that happens, it's not really their fault. It's because their brain hasn't finished developing. The underdeveloped area is called the dorsal lateral prefrontal cortex. It plays a critical role in decision making, problem solving and understanding future consequences of today's actions. Problem is, it won't be fully mature until they're into their 20s.

It's one reason 16-year-old drivers have crash rates three times higher than 17-year-olds and five times higher

crashes. These laws restrict the more dangerous kinds of driving teens do, such as nighttime driving and driving with teen passengers. Since North Carolina implemented one of the most comprehensive GDL laws in the country, it has seen a 25% decline in crashes involving 16-year-olds.

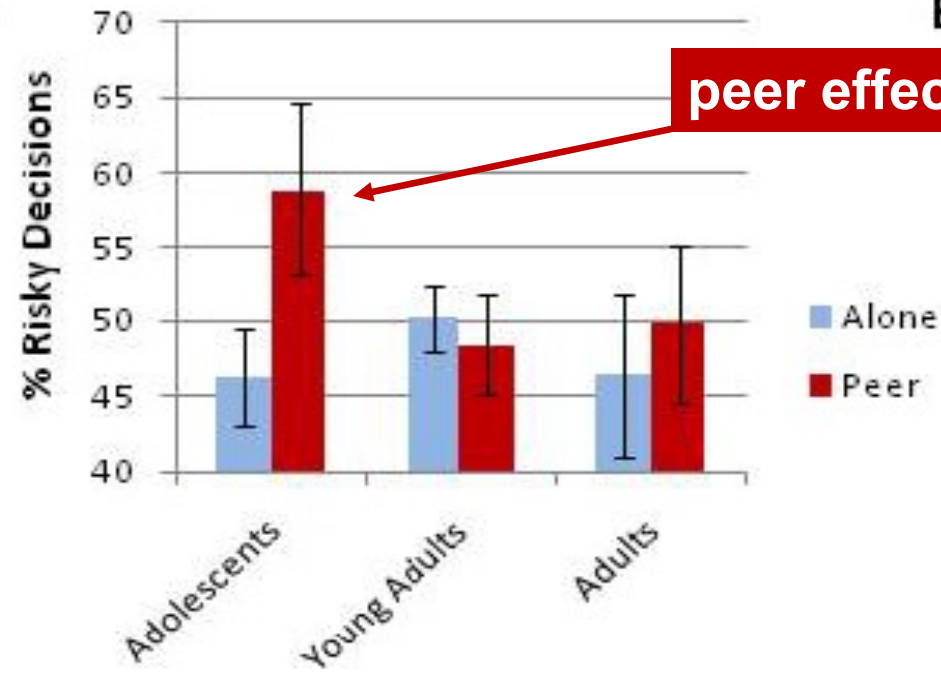
**To find out what the GDL laws are in your state, visit [Allstate.com/teen](http://Allstate.com/teen). Help enforce them—and if they aren't strong enough, ask your legislator to strengthen them.**

Let's help our teenagers not miss out on tomorrow just

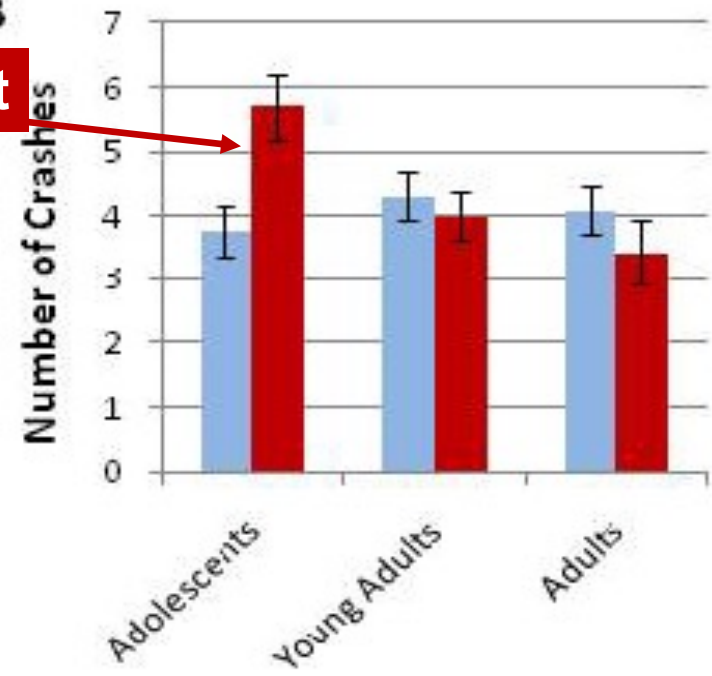
**Allstate ad, *NY Times*,  
May, 2007**

# Impact of Peer Presence on Risky Driving in Simulated Context

A



B



# 1. Developing brain and drugs

## INSIDE THE ADOLESCENT BRAIN

The brain undergoes two major developmental spurts, one in the womb and the second from childhood through the teen years, when the organ matures by fits and starts in a sequence that moves from the back of the brain to the front.

### Corpus Callosum

Thought to be involved in emotion and memory, the corpus callosum is a bundle of nerve fibers connecting the left and right hemispheres of the brain. It is the largest white matter tract in the brain and is made up of myelinated axons and nerve fibers.

### Prefrontal Cortex

The prefrontal cortex is the area of the brain that is the seat of the brain's executive functions. It is the part of the brain that is most involved in planning, decision-making, and impulse control. It is the part of the brain that is most affected by drugs.

### Basal Ganglia

Larger in females than in males, this part of the brain is involved in motor control, learning, and emotion. It is the part of the brain that is most affected by drugs.

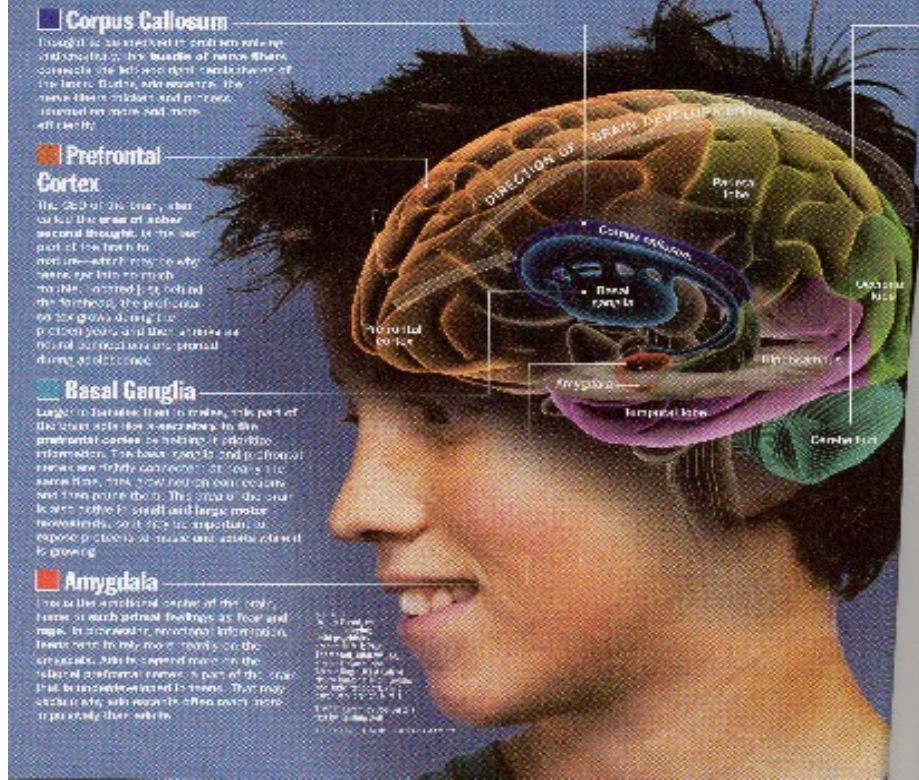
### Amygdala

One of the emotional centers of the brain, the amygdala is involved in processing information about fear and anger. It is the part of the brain that is most affected by drugs.

### Nerve Proliferation ...



By age 13, for girls and 15% for boys, the neurons in the front of the brain have formed thousands of new connections. One-third of these connections will be pruned.



Source: National Institute of Mental Health, National Institute on Drug Abuse, National Institute on Alcohol Abuse and Alcoholism, National Institute on Drug Abuse, National Institute on Alcohol Abuse and Alcoholism, National Institute on Drug Abuse, National Institute on Alcohol Abuse and Alcoholism.

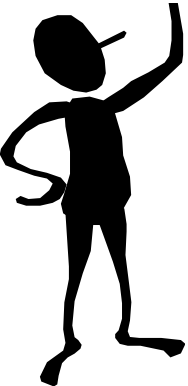


# **Implications of Brain Development for Drug Abuse Vulnerability**

**Are adolescents more susceptible than adults to drugs?**

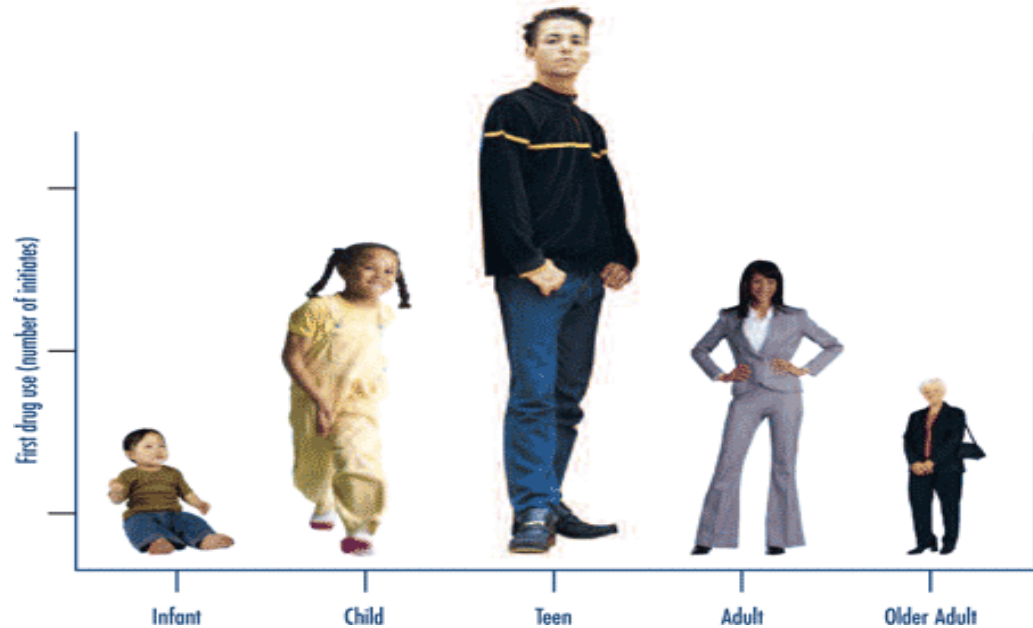
**Several lines of evidence  
(acknowledgement to Linda Spear, Ph.D.)**

**Unethical to give human adolescents alcohol in the laboratory;  
much of the best evidence comes from adolescent rat studies.**

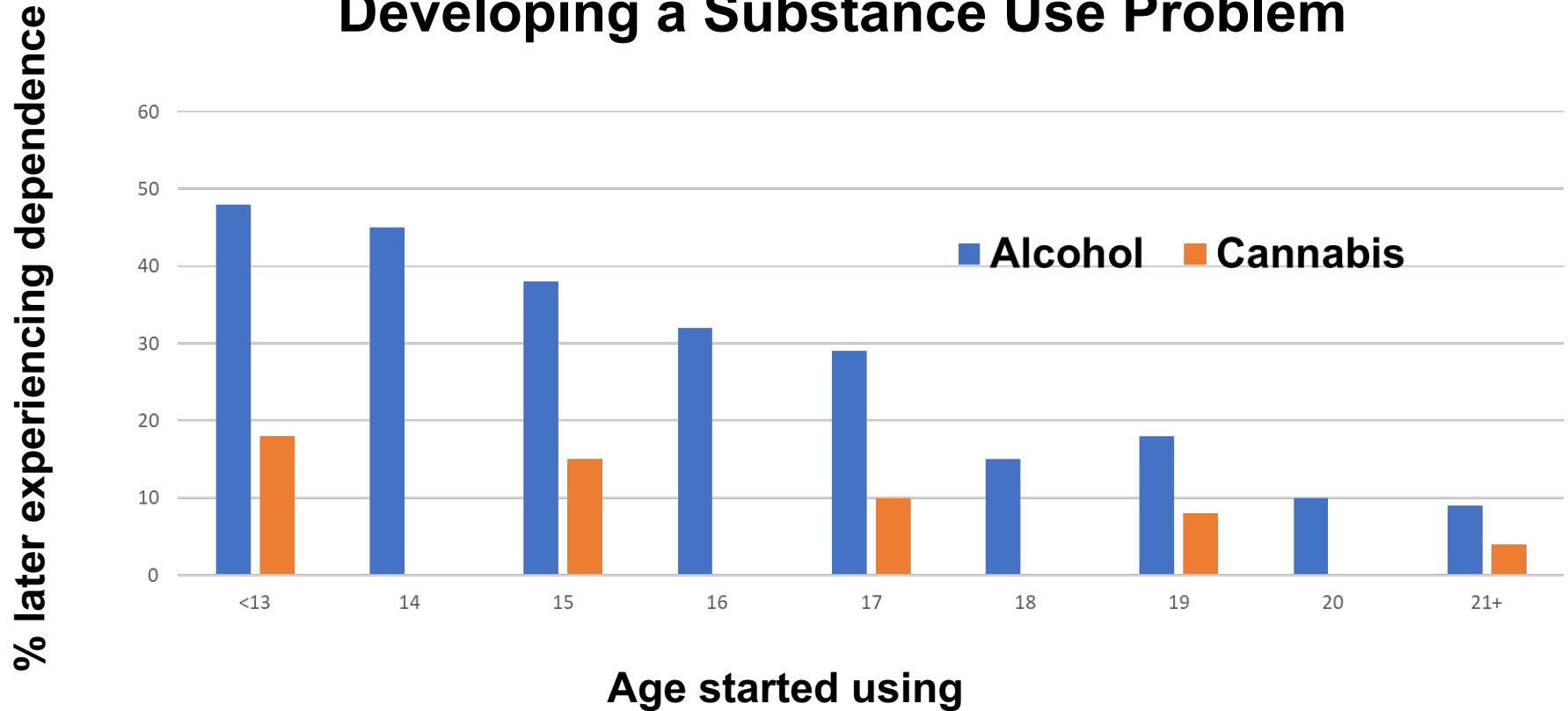


# Evidence from epidemiological studies

Drug use starts early and peaks in the teen years



# Relationship of Age of Onset of Use and Later Developing a Substance Use Problem

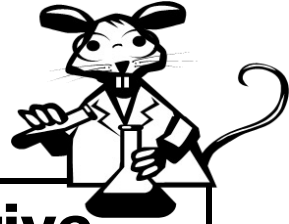


# Implications of Brain Development for Drug Abuse Vulnerability

# Alcohol



# Are adolescents more susceptible to alcohol than adults?



- 1. Adolescent rats are less sensitive to the sedative and motor impairment effects of intoxication.**
- 2. Adolescent rats are more sensitive to the social disinhibition effects of alcohol.**



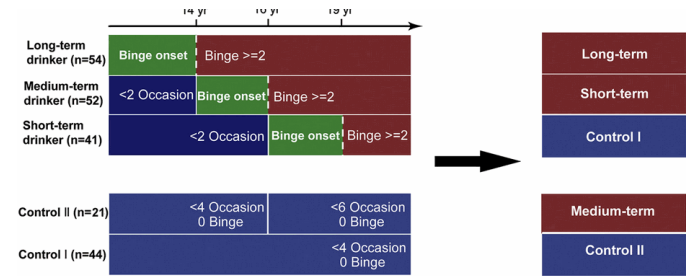
# Impact of Binge Drinking

Adolescent binge drinking disrupts normal trajectories of brain functional organization and personality maturation

Ruan et al., 2019



- Longitudinal design; assessed at ages 14, 16 and 19
- Accumulating effect of binge drinking....
  - Neuroimaging data: disruption in the maturation of frontal connectivity (caution: small sample with neuroimaging data at baseline)
  - Personality data: slower developmental improvement of impulse control



# Impact of Alcohol

SYSTEMATIC REVIEW

OPEN

 Check for updates

Age-related differences in the effect of chronic alcohol on cognition and the brain: a systematic review

Lauren Kuhns<sup>1,2,5</sup>, Emese Kroon<sup>1,2</sup>, Heidi Lesscher<sup>2</sup>, Gabry Mies<sup>1</sup> and Janna Cousijn<sup>1,2,4</sup>

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- **“Human evidence is largely missing, but animal research provides limited but consistent evidence of heightened adolescent sensitivity to chronic alcohol’s effects on several outcomes, including conditioned aversion, dopaminergic transmission in reward-related regions, neurodegeneration, and neurogenesis.”**

**Implications of Brain Development for Drug Abuse Vulnerability**

# Marijuana

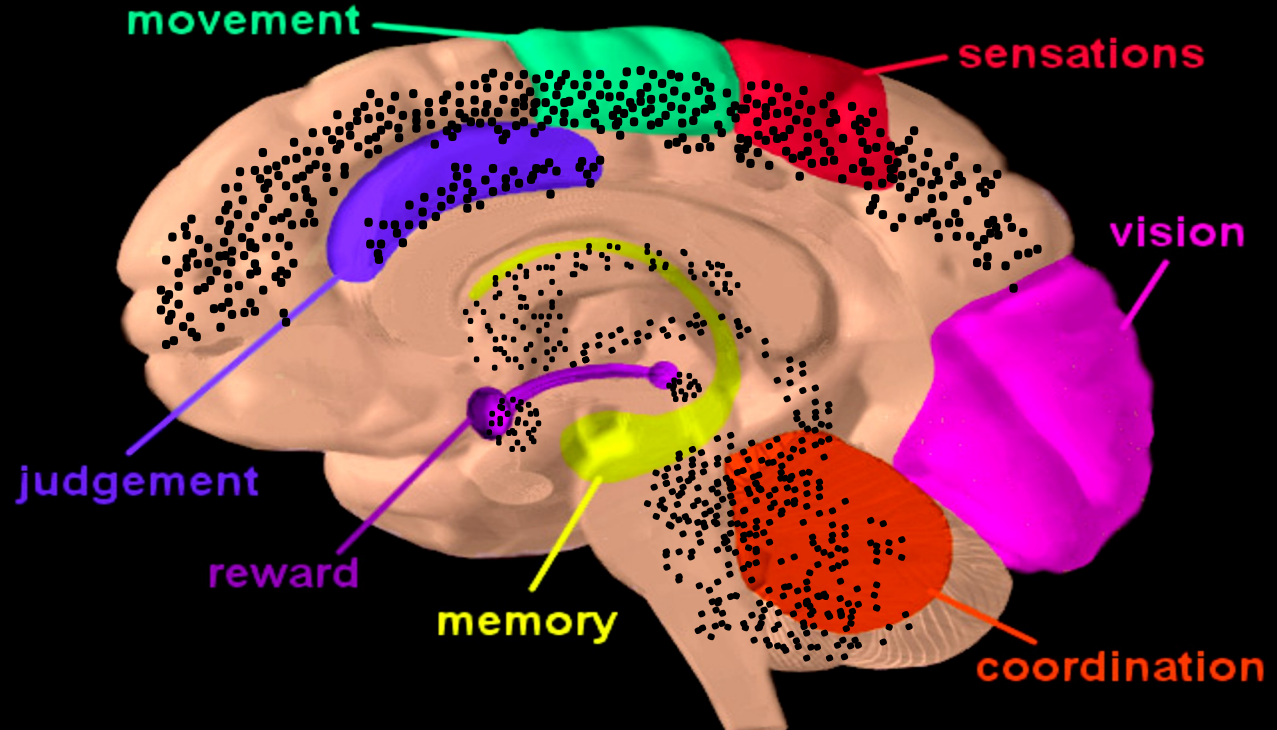




# Marijuana Binds Cannabinoid Receptors Located Throughout the Brain

(source NIDA)

- Brain Development
- Memory & Cognition
- Motivational Systems & Reward
- Appetite
- Immunological Function
- Reproduction
- Movement Coordination
- Pain Regulation & Analgesia



Slide courtesy of Maureen Boyle, PhD

# THC Binds to Cannabinoid Receptors That are Located Throughout the Brain

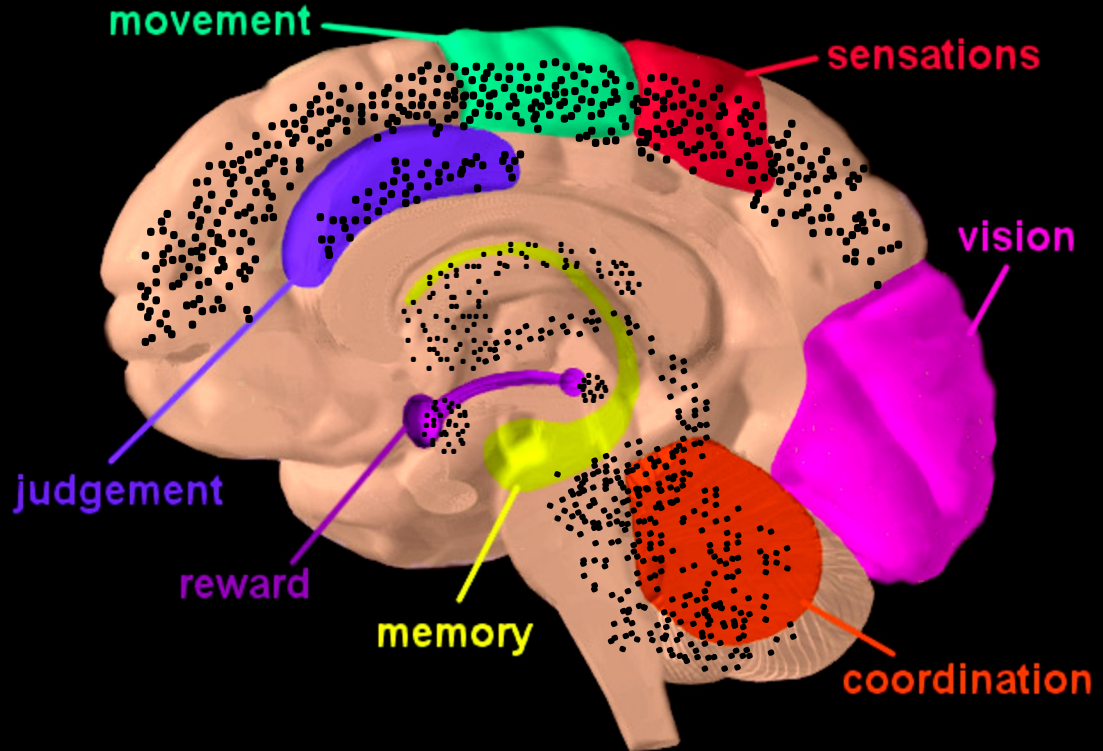
(source NIDA)

Exposure to cannabis during adolescence ...

...can affect neurobehavioral functions, especially cognition, emotional functioning, the risk of psychosis, and addiction.

...is thought to interfere with the normal trajectories and mechanisms underlying brain maturation.

Sources: Rubino and Parolaro, 2014; Bossong and Niesink, 2010; Renard et al., 2016).



Slide courtesy of Maureen Boyle PhD

# **Eight Adverse Health Effects of Chronic Marijuana Use (Volkow et al., 2014)**

## **“Low Level of Confidence”**

- Lung cancer

## **“Medium Level of Confidence”**

- Altered brain development
- Progression to use of other drugs
- Increased risk of schizophrenia, depression and anxiety disorders (in persons with a predisposition to such disorders)

## **“High Level of Confidence”**

- Addiction
- Motor vehicle accidents
- Diminished life achievement (including cognitive impairment and poor educational outcome)
- Symptoms of chronic bronchitis



## The Health Effects Strongly Associated with Initial Cannabis Use Early in Adolescence (Volkow et al., 2014)

### “Low Level of Confidence”

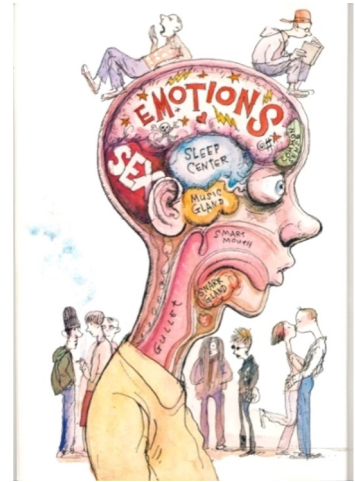
- Lung cancer

### “Medium Level of Confidence”

- Altered brain development
- Progression to use of other drugs
- Increased risk of chronic psychosis disorders (including schizophrenia and depression) in persons with a predisposition to such disorders

### “High Level of Confidence”

- Addiction
- Motor vehicle accidents
- Diminished life satisfaction and achievement (including cognitive impairment and poor educational outcome)
- Symptoms of chronic bronchitis



Source: US News &  
World Report, 2005

# The Dunedin Study (New Zealand) (N=1,037)



**13 yrs**  
(Pre-initiation)

1



**18 yrs**

2

**21 yrs**

3



**32 yrs**

4

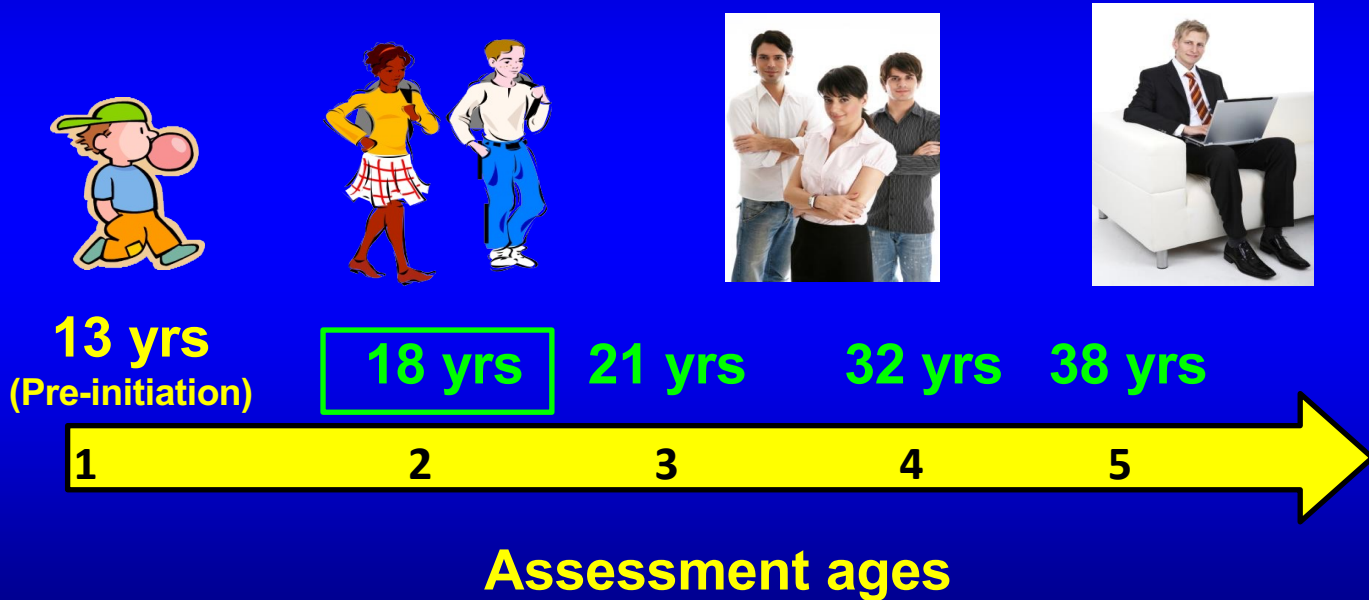


**38 yrs**

5

**Assessment ages**

# The Dunedin Study (New Zealand) (N=1,037)

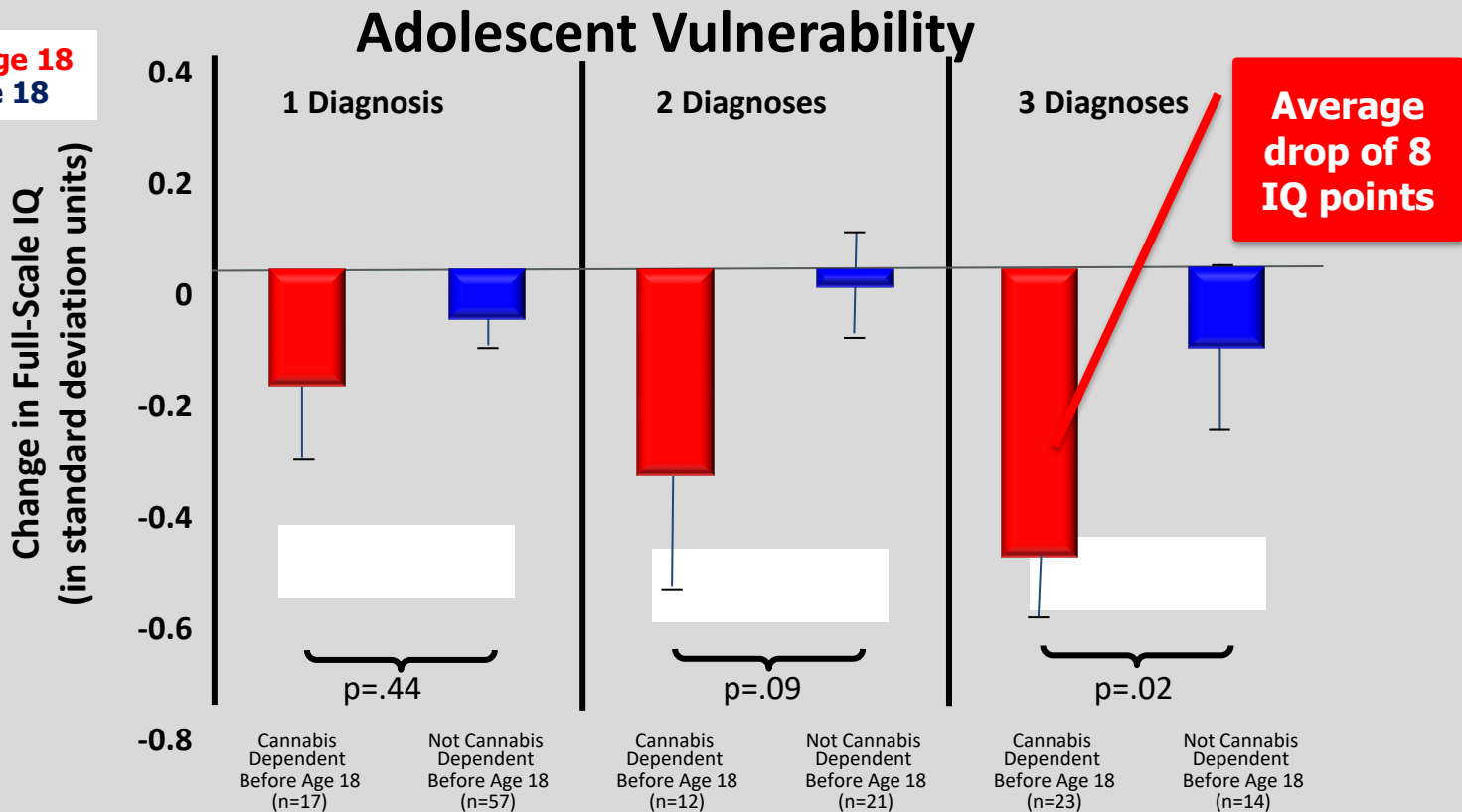




Major New Study Shows Heavy Marijuana Use Lowers IQ

# Marijuana and Cognitive Development

Red = use onset before age 18  
Blue = use onset after age 18



Source: Meier MH et al., PNAS Early Edition 2012.

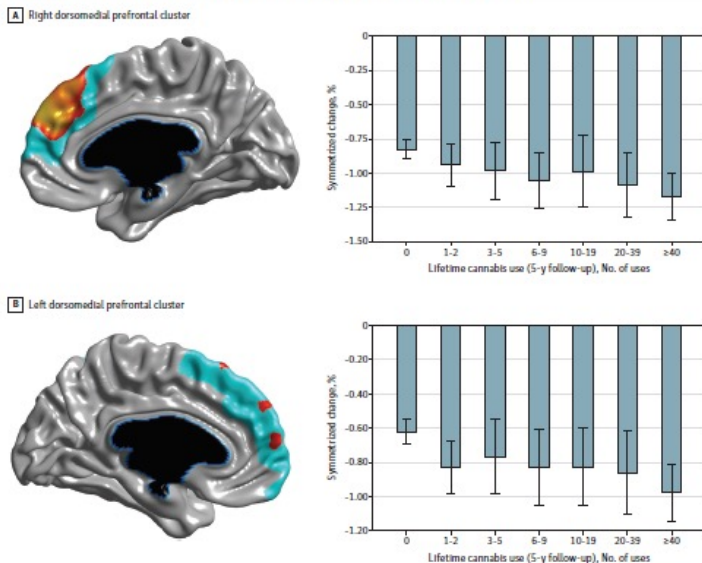
# Developing Brain's Vulnerability to Cannabis Exposure

Research

JAMA Psychiatry | Original Investigation  
Association of Cannabis Use During Adolescence With Neurodevelopment

Matthew D. Abaugh, PhD, Jonathan Demers-Gosselin, PhD, Amanda Skewell, BS, Claude Lesage, PhD, Anthony Juliano, PhD, Max M. Owens, PhD, Bader Chahar, PhD, Philip Speciner, PhD, Nicholas Fontaine, BS, Pierre Rioux, MSc, Lindsay Lewis, PhD, Sean Jeon, PhD, Alan Evans, PhD, Doreen D'Souza, MD, Rajiv Radhakrishnan, MD, Tobias Banaschewski, MD, PhD, Arun L. W. Bokde, PhD, Eric Barker-Quarnan, PhD, Patricia Connod, PhD, Sylvaine Desrochers, PhD, Herta Flor, PhD, Antonio Gallego, PhD, Henry Gowland, PhD, Andreas Heinz, MD, PhD, Bernd Mannens, PhD, Jean-Luc Martinot, MD, PhD, Marie-Laure Palliere Martinot, MD, PhD, Frauke Nees, PhD, Dimitri Papadopoulos Orfanos, PhD, Tomoki Pasi, MD, PhD, Lise Poustka, MD, Gabriela Milleret, PhD, Juliane H. Frohner, MSc, Michael N. Smolka, MD, Henrik Walter, MD, PhD, Robert Whelan, PhD, Gunnar Schumann, MD, Alexandra Potkin, PhD, Hugh Garavan, PhD, for the IMAGEN Consortium

Figure 3. Magnetic Resonance Imaging–Assessed Cortical Thinning at Varying Levels of Lifetime Cannabis Use



- longitudinal brain imaging data on 799 teens at two time points: baseline (no use yet) and 5 years later (many had initiated cannabis use)
- cannabis use during adolescence was associated with altered neurodevelopment, particularly in the regions of the brain that are rich with cannabinoid receptors
- a dose-dependent relationship was found: the heavier the cannabis use, the greater the altered neurodevelopment



# Trends in Youth Cannabis Use and Legalization Status in U.S. States

- Survey studies included respondents as adolescents or young adults (18-26 years old). Search identified 33 research reports
- **Adolescents (23)**: ten studies reported no change in prevalence use associated with legalization, six reported a decrease, and seven reported an increase.
- **Young adults (13)**: eight studies showed an increase in at least one prevalence measure, four showed no change, and one showed a decrease.
- **Cannabis Use Disorder (3)**: the two adolescent studies showed an increase, and the one young adult showed no change.
- **Caveats:**
  - legalization date used rather than dispensary opening date; some intervals significant
  - survey data not examined as a function of number of years since legalization; prior work shows that trends not observed very soon after legalization



Fig. 1 Map of United States by state and recreational legalization status (year) of cannabis use

# Longitudinal Study of Youth Who are Frequent Cannabis Users

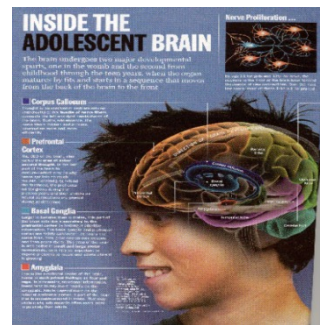


- Researchers reviewed ~ 1500 records from a longitudinal sample of urban youth (ages 13 to 20) who were assessed from 2004 to 2018
- Almost one in five participants used marijuana frequently (weekly or daily) between ages 13 and 17
- Frequent use was significantly associated with problematic substance use and deficits in functional well-being at age 20, compared to those who did not use the drug or used it only occasionally
- “Our results suggest that frequent cannabis is by no means a harmless phenomenon. The findings should give pause to proponents of cannabis legalization policies that effectively facilitate adolescents’ access to cannabis.”

**WHY?**

# 1. Normal brain development may contribute to initiating and maintaining drug use

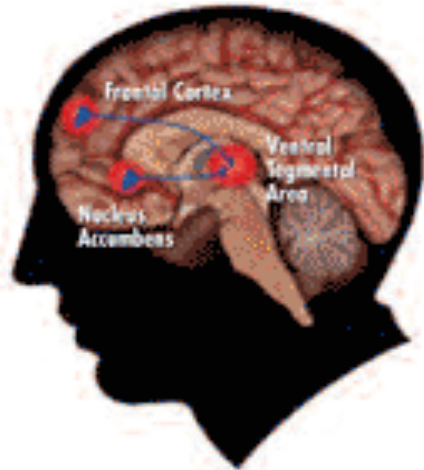
- Preference for ....
  1. physical activity
  2. high excitement and rewarding activities
  3. activities with peers that trigger high intensity/arousal
  4. novelty
- Less than optimal..
  5. control of emotions
  6. consideration of negative conseq.
- Greater tendency to...
  7. be attentive to social information
  8. take risks and show less self control



## 2. Adolescent pleasure centers in the brain may be more sensitive to the acute effects of drugs than pleasure centers in the adult brain

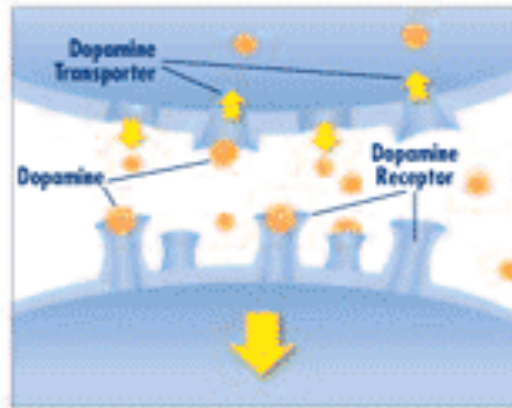
### ALL DRUGS OF ABUSE TARGET THE BRAIN'S PLEASURE CENTER

#### Brain reward (dopamine) pathways



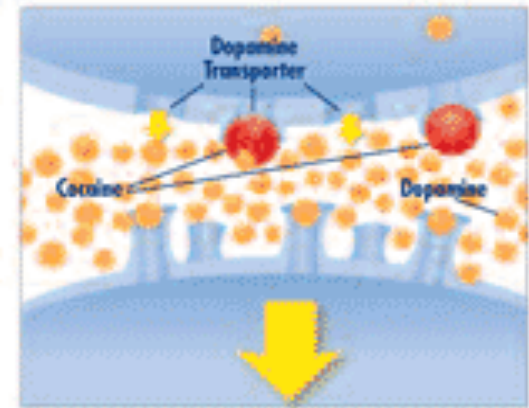
These brain circuits are important for natural rewards such as food, music, and art.

#### All drugs of abuse increase dopamine



**FOOD**

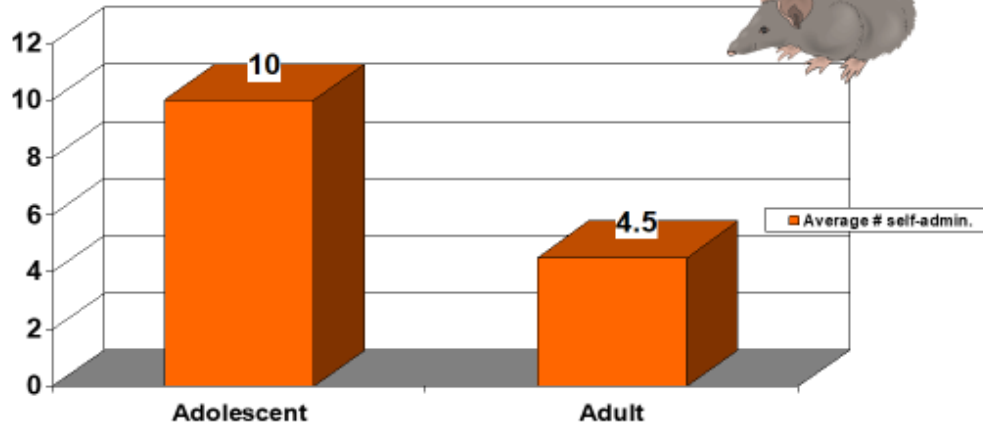
Typically, dopamine increases in response to natural rewards such as food. When cocaine is taken, dopamine increases are exaggerated, and communication is altered.



**COCAINE**

## C. Early use may create a biological priming or “gateway effect”

### Average Number of Self-Administered Doses of Nicotine When Rats Were Adults (Levin et al., 2003)



Age of Rates When First Exposed to Nicotine. All Data Collected When Rats were Adults.

### Nicotine Gateway Effects on Adolescent Substance Use

Michelle Ren, MS\*  
Shahrdad Lotfipour, PhD†

\*University of California, Irvine, Department of Pharmaceutical Sciences, Irvine, California  
†University of California, Irvine, Department of Emergency Medicine and Pharmaceutical Sciences, Irvine, California

Section Editor: Tony Zitek MD

- Literature suggests: “Disruption of nicotinic acetylcholine receptors (nAChR) development with early nicotine use may alter the release of reward-related neurotransmitters, and thus increase the likelihood of future drug seeking behaviors, including drugs other than nicotine.”
- There is a “large collection of clinical and preclinical evidence that adolescent nicotine exposure influences long-term molecular, biochemical, and functional changes in the brain that encourage subsequent drug abuse.”

## 2. Brain development and behavioral disorders

# INSIDE THE ADOLESCENT BRAIN

The brain undergoes two major developmental spurts, one in the womb and the second from childhood through the teen years, when the organ matures by fits and starts in a sequence that moves from the back of the brain to the front.

### Corpus Callosum

Thought to be involved in emotion and eye coordination, this bundle of nerve fibers connects the left and right hemispheres of the brain. During adolescence, the nerve fibers mature and myelinate, allowing for more rapid communication.

### Prefrontal Cortex

The CEO of the brain, also called the area of higher thought, is the last part of the brain to mature. It's the area that helps you weigh the pros and cons of a decision, and it's the area that helps you resist temptation. It's the area that helps you think about the future and make plans. It's the area that helps you control your emotions and impulses.

### Basal Ganglia

Larger in females than in males, this part of the brain is involved in motor control, learning, and emotion. It's the area that helps you learn from your mistakes and adjust your behavior accordingly. It's the area that helps you control your movements and impulses.

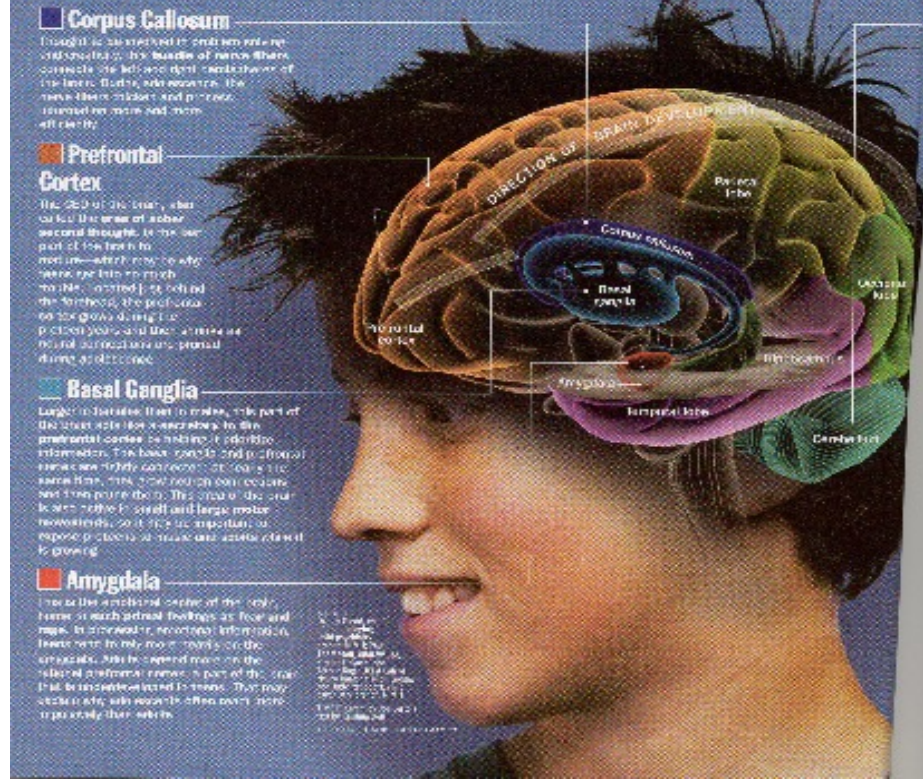
### Amygdala

Known as the emotional center of the brain, this is where you feel things like fear and rage. It's the area that helps you process information from your senses and make decisions based on that information. It's the area that helps you control your emotions and impulses.

### Nerve Proliferation ...



By age 13 for girls and 15 for boys, the neurons in the front of the brain have formed the basis of new connections. One-third of the new connections that will be pruned.

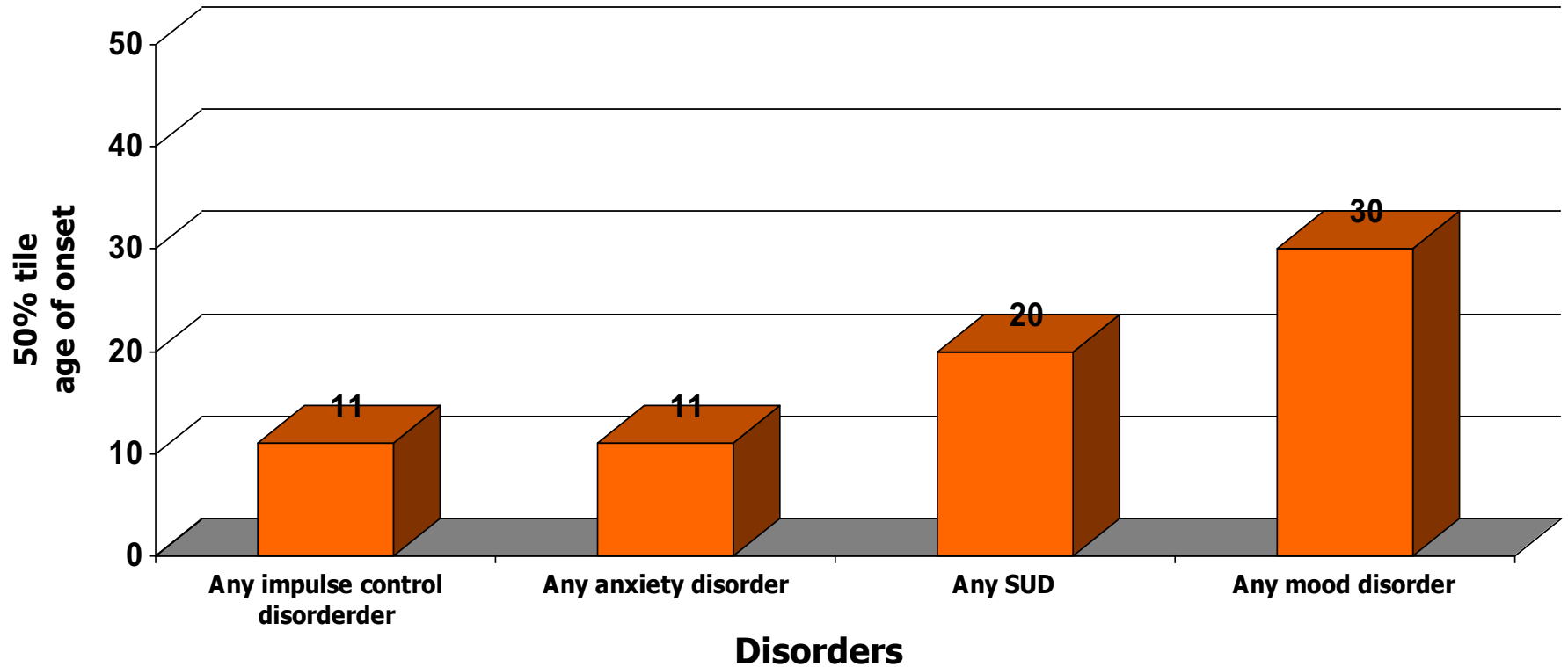


# **Adolescence and Behavioral Disorders**

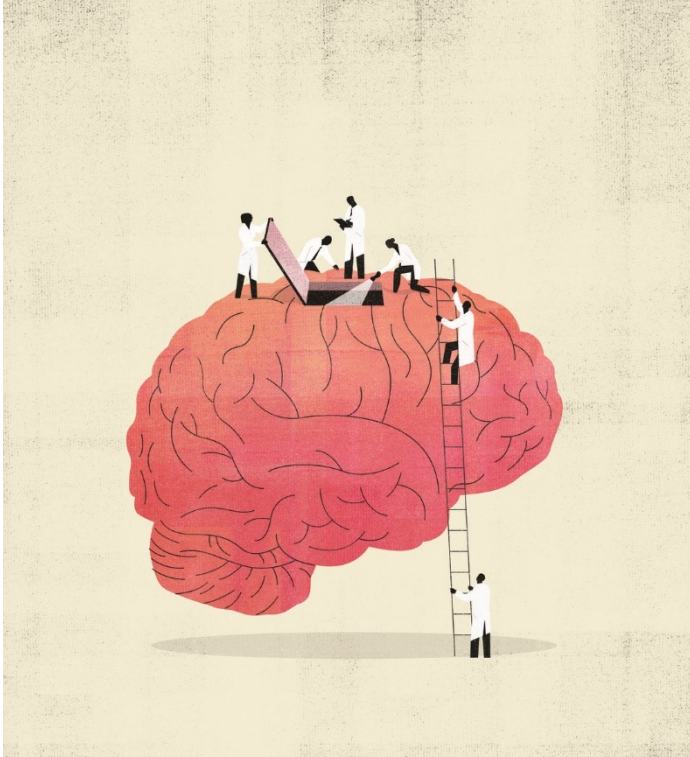
- **Alterations in neurodevelopment have been linked to several adolescent-onset mental and behavioral disorders (Charney et al., 2013):**
  - **ADHD**
  - **Affective Disorders**
  - **Anxiety Disorders**
  - **Autism**
  - **Obsessive-Compulsive Disorders**
  - **PTSD**
  - **Schizophrenia**



# Ages at the 50 Percentile of the Age-at-Onset Distribution for Major Disorders (Kessler et al., 2005)



# Adolescent Use of *Marijuana* and Behavioral Disorders



## Miller's Review of the Cannabis Use and Mental Illness

Disorder	Cross-Sectional Data	Longitudinal Data
Schizophrenia	++	++
Bipolar	+	
Anxiety Disorders	+	+
Depressive Disorders	+	+
Risk of Suicide	+	

Key: ++ = several studies; + a few studies

Yellow box = risk greater when MJ use onset during youth.

Miller, C. L. (2018). The impact of marijuana on mental health. In K. Sabet & K.C. Winters, *Contemporary health issues on marijuana*. NY: Oxford University Press.

# The contribution of cannabis use to variation in the incidence of psychotic disorder across Europe (EU-GEI): a multicentre case-control study

Marta Di Forti, PhD • Diego Quattrone, MD • Tom P Freeman, PhD • Giada Tripoli, MSc •  
Charlotte Gayer-Anderson, PhD • Harriet Quigley, MD • et al. [Show all authors](#)

Source: Lancet Psychiatry, 2019

- 901 patients with first episode psychosis across 11 clinic sites in Europe
- Compared 1237 population controls from those same sites
- Cannabis use was associated with increased odds of psychotic disorder compared with never users
  - Daily use of low potency cannabis = adjusted odds ratio, 3.2 (95% CI 2.2 – 4.1)**
  - Daily use of high potency cannabis = adjusted odds ratio, 4.8 (95% CI 2.5 – 6.3)**

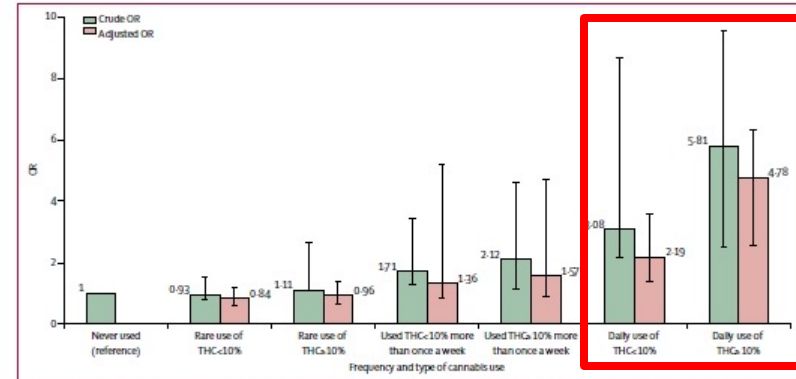
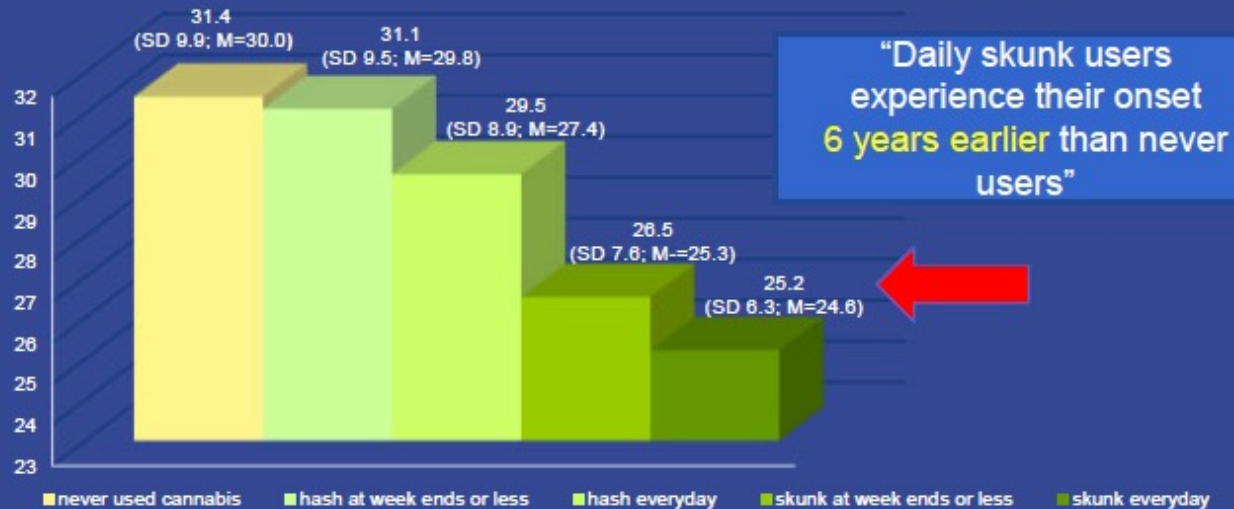


Figure 1: Crude and fully adjusted ORs of psychotic disorders for the combined measure of frequency plus type of cannabis use in the whole sample. Crude ORs are adjusted only for age, gender and ethnicity and fully adjusted ORs are additionally adjusted for level of education, employment status, and use of tobacco, stimulants, ketamine, legal highs, and hallucinogenics. Error bars represent 95% CIs. OR=odds ratio.

# Psychosis: Age of Onset and Cannabis Exposure

Mean age (yrs) of onset of psychosis by degree of exposure to cannabis



## Cautionary Notes

- **Reverse causation (self-medication).**
- **Early drug use may be a marker of underlying genetic risk and not causative, or only partially causative.**



### 3. Impact of early experiences on the developing brain and subsequent health and well-being

## INSIDE THE ADOLESCENT BRAIN

The brain undergoes two major developmental spurts, one in the womb and the second from childhood through the teen years, when the organ matures by fits and starts in a sequence that moves from the back of the brain to the front.

### ■ Corpus Callosum

Thought to be involved in emotion and eye coordination, this bundle of nerve fibers connects the left and right hemispheres of the brain. It also acts as a highway, linking the brain's motor and sensory systems to one another.

### ■ Prefrontal Cortex

The CEO of the brain, also called the area of higher thought, is the last part of the brain to mature. It's responsible for the ability to think, plan, and make decisions. It's also the part of the brain that's most vulnerable to drug and alcohol use.

### ■ Basal Ganglia

Larger in females than in males, this part of the brain acts like a switchboard, relaying information. The basal ganglia and thalamus are closely connected. It's also the part of the brain that's most vulnerable to drug and alcohol use.

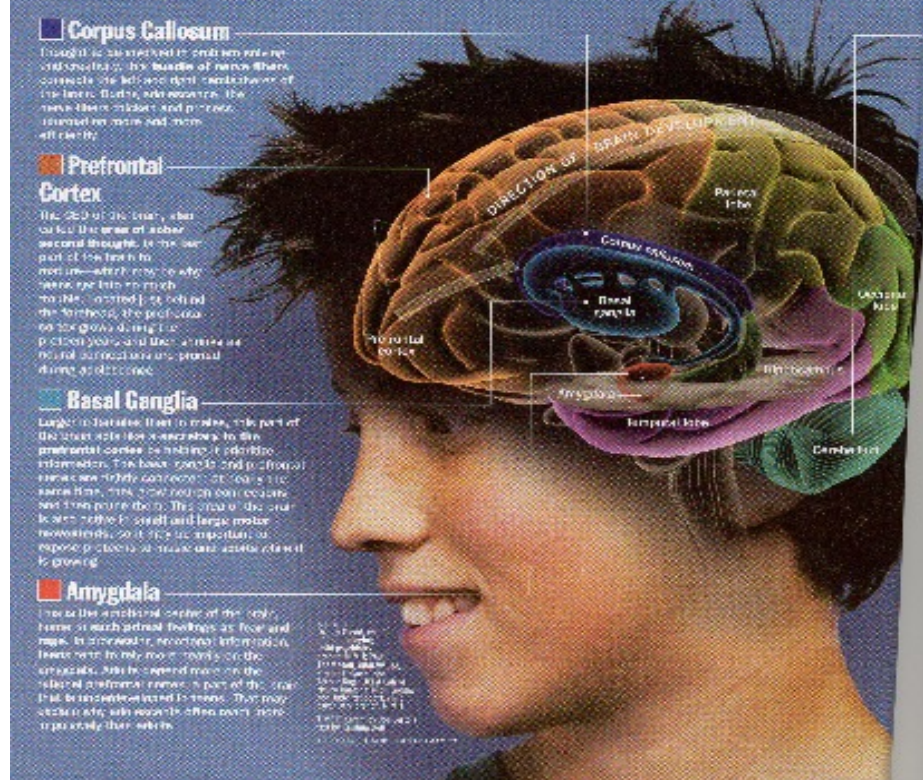
### ■ Amygdala

It's the emotional center of the brain, home to such primal feelings as fear and rage. It also acts as a switchboard, relaying information. The amygdala is also the part of the brain that's most vulnerable to drug and alcohol use.

### Nerve Proliferation ...



By age 13, for girls and 15% for boys, the neurons in the front of the brain have formed thousands of new connections. One-third of these connections will be pruned.



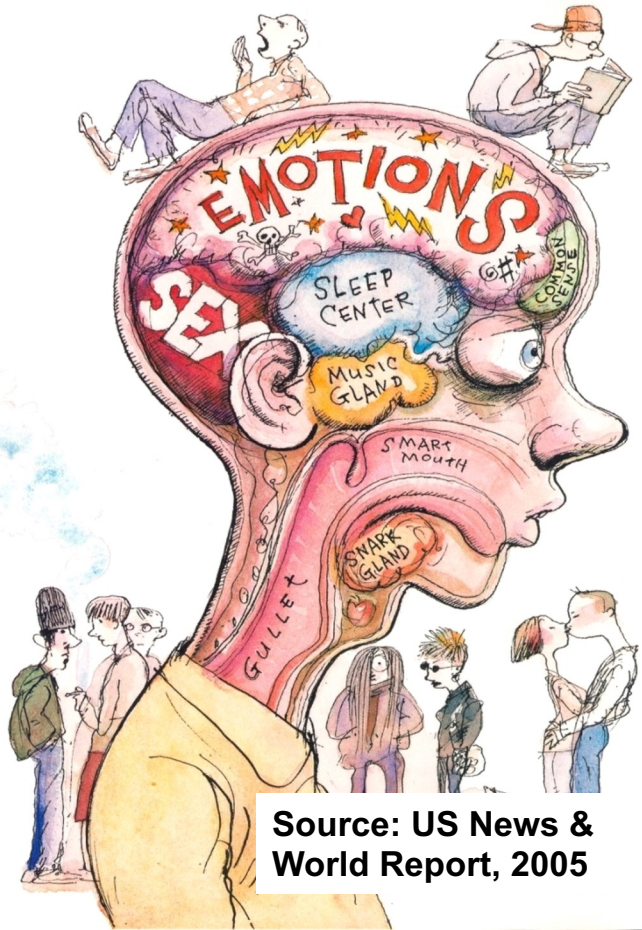
Source: National Institute of Mental Health, National Institute on Drug Abuse, National Institute on Alcohol Abuse and Alcoholism, National Institute on Drug Abuse, National Institute on Alcohol Abuse and Alcoholism, National Institute on Drug Abuse, National Institute on Alcohol Abuse and Alcoholism.

# A Developing Brain

## > Impact from Environment?

- “Exposure to both positive and negative elements before adolescence can imprint on the final adult topography in a manner that differs from exposure to the same elements after adolescence.”

(Anderson, 2003, *Neuroscience & Biobehavioral Reviews*)



Source: US News & World Report, 2005



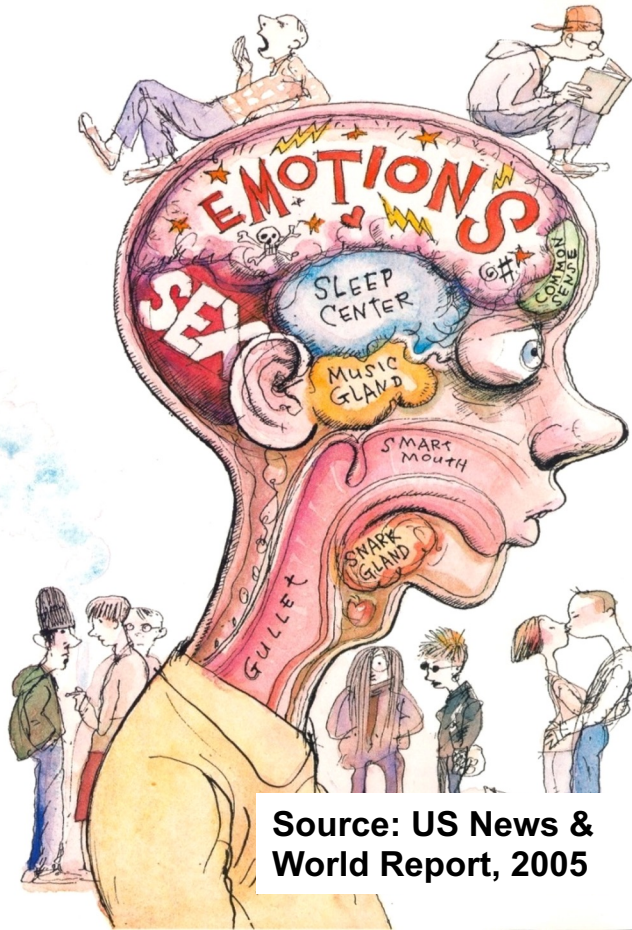
# A Developing Brain

## > Impact from Environment?

<https://developingchild.harvard.edu/science/deep-dives/mental-health/>

 Center on the Developing Child  
HARVARD UNIVERSITY

- “The interaction between genetic predispositions and sustained, stress-inducing experiences early in life can lay an unstable foundation for mental health that endures well into the adult years.”

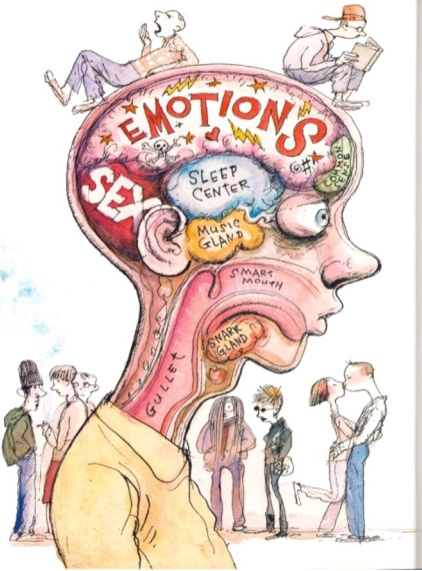


Source: US News &  
World Report, 2005



# Trauma

- **Adverse childhood experiences (ACEs)** refer to abuse and other kinds of adversity faced by children in the home environment



1. *Acute trauma* refers to a single, traumatic incident that happens. The event is specific and defined with a beginning, middle, and end (e.g., witnessing or victim of a violent event, sexual assault, serious injury, natural disaster).
2. *Chronic trauma* typically results from ongoing abuse or persistent exposure to a dangerous situation (e.g., bullying, intimate partner violence, ongoing sexual, physical or emotional abuse).
3. *Historical trauma* may also be relevant to adolescents as they are impacted early in life of “cumulative emotional and psychological wounding” resulting from massive group trauma.

# A Developing Brain

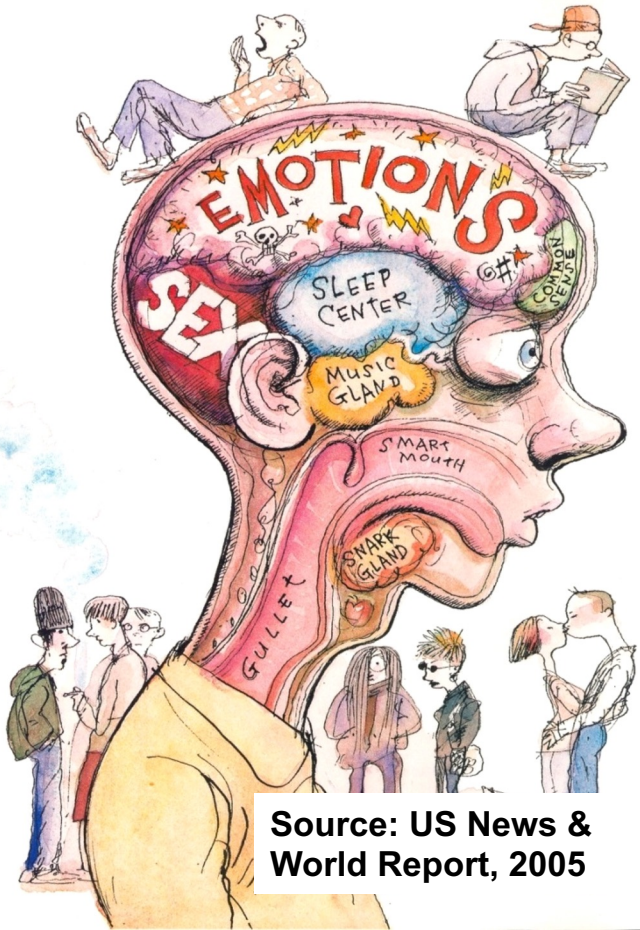
## > Impact from Environment?

<https://developingchild.harvard.edu/science/deep-dives/mental-health/>

 Center on the Developing Child  
HARVARD UNIVERSITY

## Rays of Hope!

- “Some individuals demonstrate remarkable capacities to overcome the severe challenges of early, persistent maltreatment, trauma, and emotional harm.”
- “Most potential mental health problems will not become mental health problems if we respond to them early.”



Source: US News &  
World Report, 2005

# Early experiences can alter brain development in positive ways



Centers for Disease Control and Prevention  
CDC 24/7: Saving Lives, Protecting People™

**“Nurturing and responsive care for the child’s body and mind is the key to supporting healthy brain development.”**



**Early experiences can alter brain development in positive ways.**



## Preschool is a sensitive period for the influence of maternal support on the trajectory of hippocampal development

Joan L. Luby<sup>a,1</sup>, Andy Belden<sup>a</sup>, Michael P. Harms<sup>a</sup>, Rebecca Tillman<sup>a</sup>, and Deanna M. Barch<sup>a,b,c</sup>

<sup>a</sup>Department of Psychiatry, Washington University in St. Louis, St. Louis, MO 63110; <sup>b</sup>Department of Psychological & Brain Sciences, Washington University in St. Louis, St. Louis, MO 63130; and <sup>c</sup>Department of Radiology, Washington University in St. Louis, St. Louis, MO 63110

**More parental support = more hippocampus volume**



Early experiences can alter brain development in negative ways

## WHAT ARE ACES?

AND HOW DO THEY RELATE TO TOXIC STRESS?

**SAMHSA**  
Substance Abuse and Mental Health  
Services Administration



**The impact of child traumatic stress can have near-term impacts and last well beyond childhood. Associated with...**

- Learning problems
- Substance abuse
- Increased use of health services, including mental health services



# Early experiences can alter brain development in negative ways

Development and Psychopathology

Article

Supplementary materials

Metrics

First View

**Mind and gut: Associations between mood and gastrointestinal distress in children exposed to adversity**

Bridget L. Callaghan <sup>(a1)</sup> <sup>(a2)</sup>, Andrea Fields <sup>(a1)</sup>, Dylan G. Gee <sup>(a3)</sup>, Laurel Gabard-Durnam <sup>(a4)</sup> ... <sup>(4)</sup>  
<https://doi.org/10.1017/S0954579419000087> Published online: 28 March 2019



- **Children deprived of parents early in life (orphans), compared to children with parents, revealed....**
  - **increased gastrointestinal symptoms**
  - **pattern of gut microbiomes linked to..**
    - **current and future anxiety**
    - **prefrontal cortex activation to emotional faces**



# 4. Developing brain and social media

## INSIDE THE ADOLESCENT BRAIN

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### Corpus Callosum

Thought to be involved in emotion and eye coordination, this bundle of nerve fibers connects the left and right hemispheres of the brain. During adolescence, the nerve fibers mature and myelination is more and more complete.

### Prefrontal Cortex

The CEO of the brain, also called the area of higher thought, is the last part of the brain to mature—often not until the late 20s. It's responsible for planning, problem-solving, and decision-making. It's also the area of the brain that's most affected by drugs and alcohol.

### Basal Ganglia

Larger in females than in males, this part of the brain is involved in motor control, learning, and decision-making. It's also the area of the brain that's most affected by drugs and alcohol. It's also the area of the brain that's most affected by stress.

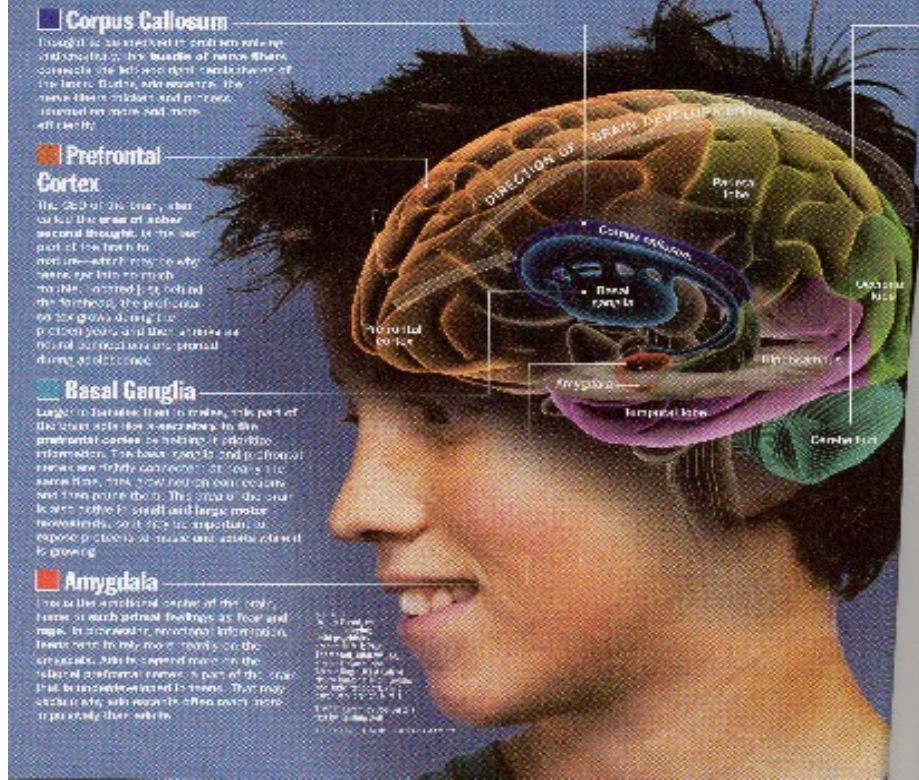
### Amygdala

Known as the emotional center of the brain, it's involved in processing information about fear and anger. It's also the area of the brain that's most affected by stress. It's also the area of the brain that's most affected by drugs and alcohol.

### Nerve Proliferation ...



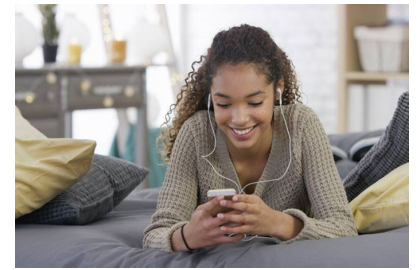
By age 13, for girls and 15% for boys, the neurons in the front of the brain have formed the same number of connections. The 50% of the neurons that are not formed will be pruned.





# Screenagers

- **The lure of modern technologies to the “teen brain”**
  - **immediacy**
  - **micro-rewards**
  - **social affirmation**
  - **missing out**
  - **salience**
  - **lure of reciprocity, peer influence**
  - **competition**
  - **management of self-presentation**



# Too Much Screen Time = Depression and Anxiety



- **National survey ( $N = 40,337$ )** (Twenge & Campbell, 2018)
  - **More than ave. 1+ hrs/day of screen time:**
    - < psychological well-being
    - < self-control, emotional stability
    - > difficulty to finish tasks
    - > difficulty making friends
  - **None users and low users generally equal on these health and wellness measures**

# Strategies



- 1. Set a time limit (limit to only 1 or 2 hours/day).**
- 2. Abstain from screen time for the last 2 hours of the day.**
- 3. If social media: only send positive messages and steer clear of negative ones.**
- 4. If game playing: avoid the violent ones.**
- 5. Recruit your friends to join in reducing screen time.**
- 6. Seek support from parents.**
- 7. Watch the documentary “The Social Dilemma” (Netflix).**

# I. Relevance of Brain Development Science

# II. Overview of Adolescent Brain Development

- impact of drug use, mental health, early experiences and social media

# III. Summary

## INSIDE THE ADOLESCENT BRAIN

The brain undergoes two major developmental spurts: one in the womb and the second from childhood through the teen years, when the organ matures by fits and starts in a sequence that moves from the back of the brain to the front.

**Nerve Proliferation ...**  
By age 25, the brain will have 100 billion neurons in the cortex of the brain, but 100 billion neurons in the cerebellum. See: "The New York Times" (March 8, 2014) by Gina Kolata

**Corpus Callosum**  
Thought to be involved in spatial reasoning and attention, the corpus callosum connects the left and right hemispheres of the brain. It is important for the transfer of information between the two sides of the brain.

**Prefrontal Cortex**  
The part of the brain that is responsible for decision-making, planning, and impulse control. It is the last part of the brain to mature, and it is still developing in the teenage years.

**Basal Ganglia**  
Large, dark-colored structures in the part of the brain that is responsible for movement, learning, and habit formation. The basal ganglia are involved in the control of voluntary movements and are also involved in the regulation of emotions and the reward system.

**Amgyala**  
The almond-shaped center of the brain, known as the seat of emotion. It is involved in the processing of social information and is also involved in the regulation of emotions and the reward system.

# Summary

- **Adolescence is an extended period of transition from reliance on adults to independence**
- **Normal adolescence is characterized by....**
  - **increase in conflicts with family members**
  - **desire to be with one's friends**
  - **resistance to messages from authority**
  - **irritability**
  - **risk taking**
  - **proclamations of sheer boredom**



# Summary

- **Normal adolescence vs. signs of mental illness can be difficult to distinguish**
- Consider the list below of various DSM-5 symptoms, each of which is included in at least one mental disorder in the DSM. Which “so-called” symptoms are often observed among teenagers who may be struggling yet behaving well within what is normative for those turmoil years?
  1. Tendency to act unexpectedly and without consideration of the consequence.
  2. Unstable and chaotic interpersonal relationship.
  3. Distorted self-image.
  4. Interrupts or intrudes on others, for example in conversations, games, or activities.
  5. Avoids/dislikes tasks that require sustained mental effort (e.g., schoolwork or home chores).
  6. Bullies, threatens or intimidates others.
  7. Breaks rules.
  8. Lies to adults.
  9. Expresses ideas that are unusual or likely false.



# Summary

**reward incentives >  
perception of  
consequences**



# Summary

- **Several lines of evidence suggesting that adolescence is a period of vulnerability to the effects of drugs, and a period linked to the onset of some mental disorders.**





# Summary

- **Employ teen-brain friendly and evidence-based prevention and treatment**
  - **Prevention: decrease risk, increase protective factors**
  - **Treatment: employ these techniques**
    - **Motivational interviewing**
    - **CBT**
    - **Family therapy**
  - **Teach parents about brain development**



# Summary

## Teens Can Promote Their Brain Development

1. Participate in organized sports
2. Be involved with music
3. Active social life
4. Drug free
5. Healthy diet
6. Limit screen time (cell phone, video gaming)
7. Plenty of sleep



# Teen Brain Development Quiz



1. Two health indices that suggest teenagers are taking less risk than in years past are the decline in teenage pregnancy and the very low rate of cigarette smoking.

**True**

2. The brain development of Native adolescents follows the same basic principles as with non-Native adolescents.

**True**

3. Which is more harmful to the developing brain?
  - a. Regular use of high potency cannabis
  - b. Regular binge drinking
  - c. Regular vaping of nicotine

**Good question!!**



# THANK YOU

winte001@umn.edu

## Questions and Discussion

