This is Your Brain on Adolescence

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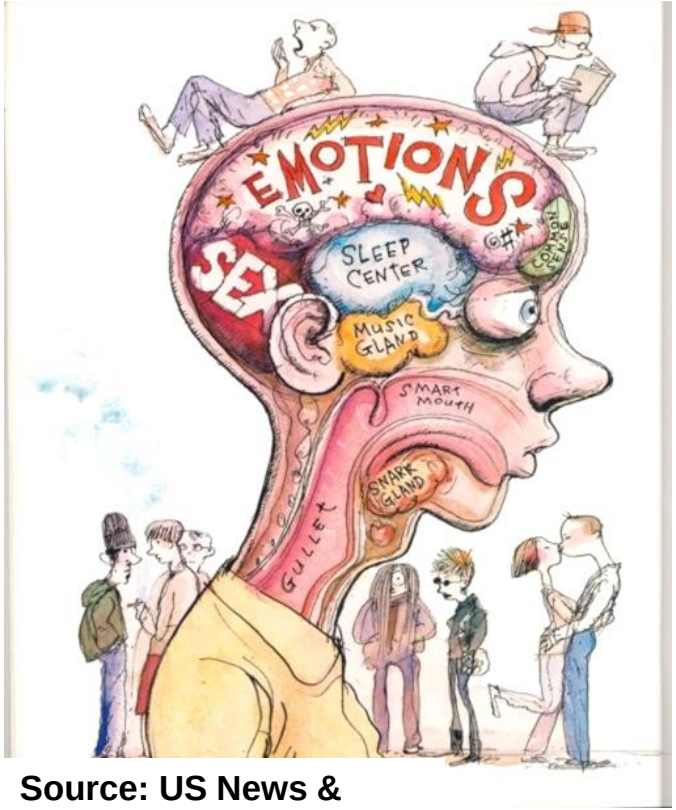
International Society of Substance Use Professionals

Webinar, February 20, 2020



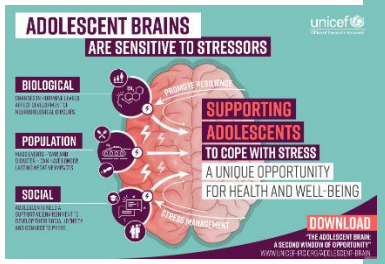
Source: US News & World Report, 2005

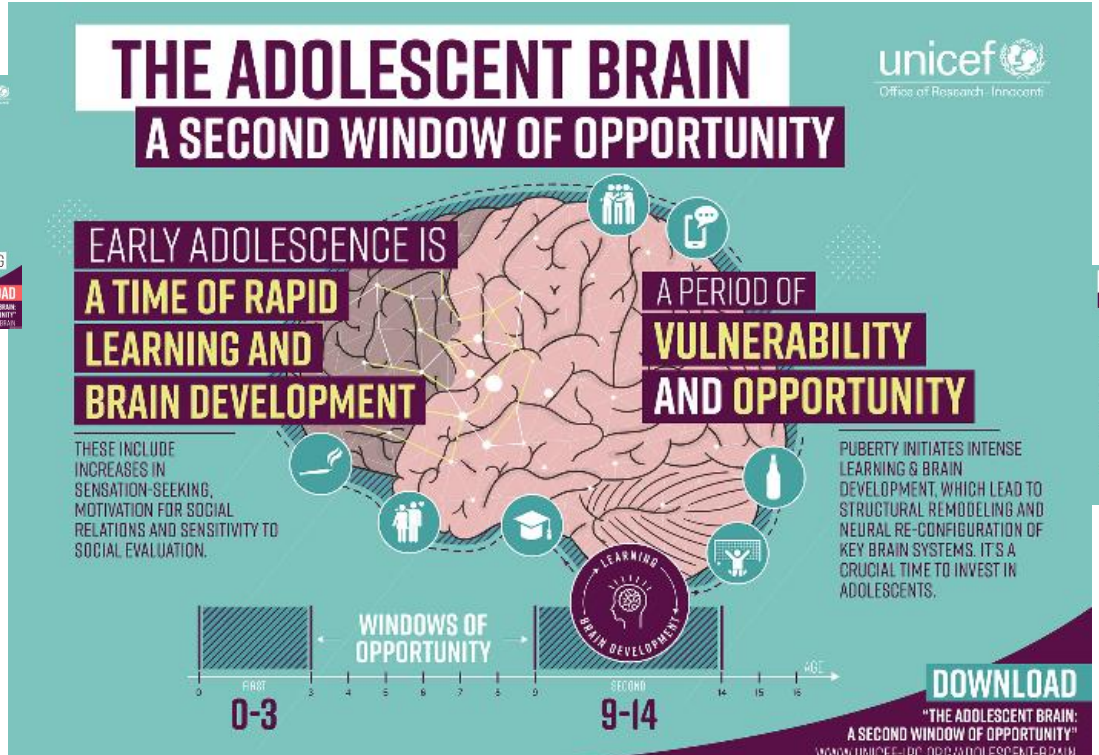
Professional Disclosures

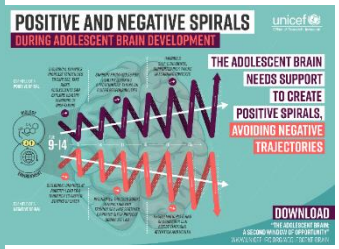
None to report

Website

- https://www.unicef-irc.org/adolescent-brain

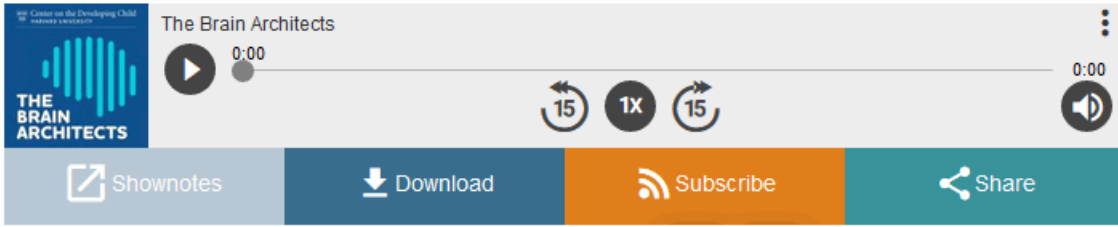






Podcast Series

- **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/**

YouTube Video

https://youtu.be/6zVS8HlPUng

Sarah-Jayne Blakemore's Ted Talk:
The mysterious workings of the adolescent brain

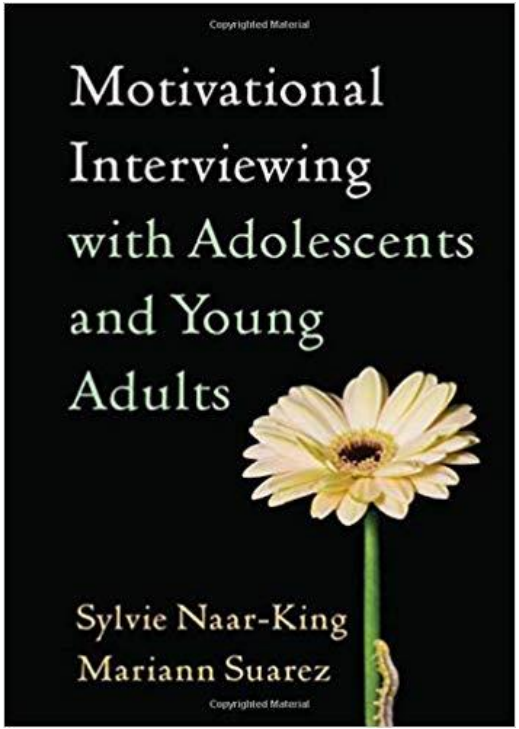
Publication on the Intersection of Brain Development and Treatment

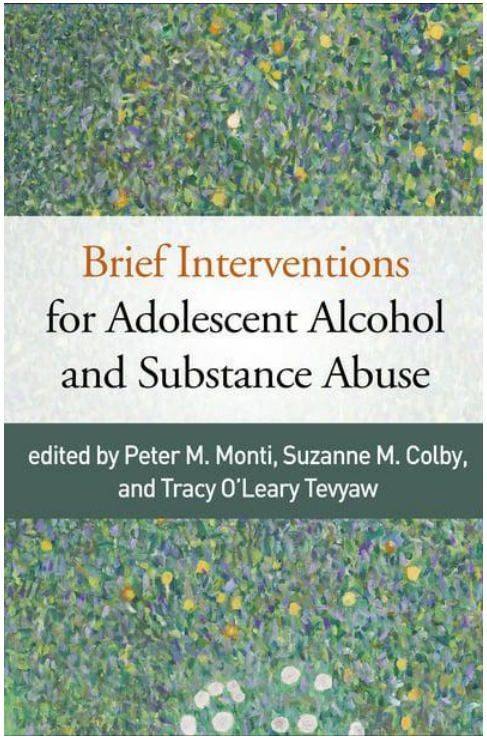
Wetherill, R., & Tapert, S. F. (2013). Adolescent brain development, substance use, and psychotherapeutic change. *Psychology of Addictive Behaviors, 27*(2), 393–402.

https://doi.org/10.1037/a0029111

Recent "Treatment" Publications

(that integrate teen brain development)





Teen Brain Development Quiz

1. There are several health indices suggesting that teenagers take less risk than in years past. T or F ?

2. What lifestyle choices during adolescence promote good brain development?

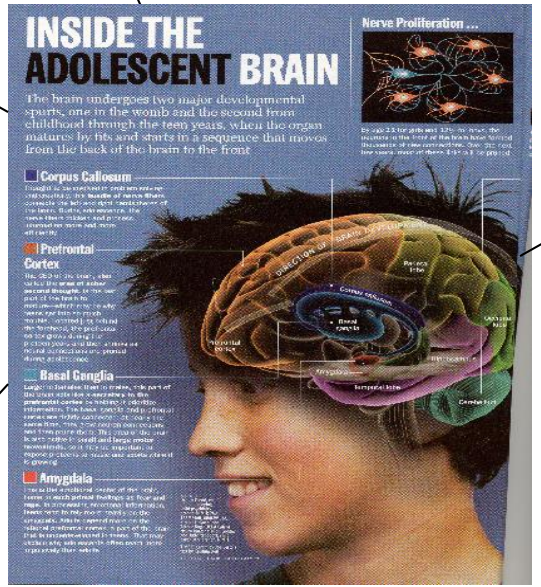
3. Which is more harmful to the developing brain?
   a. Chronic, heavy use of marijuana?
   b. Chronic, heavy drinking?

I. Overview of brain development

II. Developing brain: drug use, mental health, early experiences

III. Youth Serving Workers

IV. Summary



Possible Sources of Confounds when Interpreting Studies on Brain Development and Health

1. Confirmation bias
2. Small sample sizes
3. Too small a time window
4. Community-level vs. individual-level data
5. Direct links between brain functions and structures and human behavior are problematic

Possible Sources of Confounds when Interpreting Studies on Brain Development and Health

- One more introductory note about this talk: 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.

- I will be integrating into today's discussion the important role of non-biological influences.

Major Points from My Talk

1. The maturation of the adolescent brain likely contributes to behaviors that are characteristic of this developmental period.

2. This maturation also informs our understanding of risk for substance use disorders and other behavioral disorders.

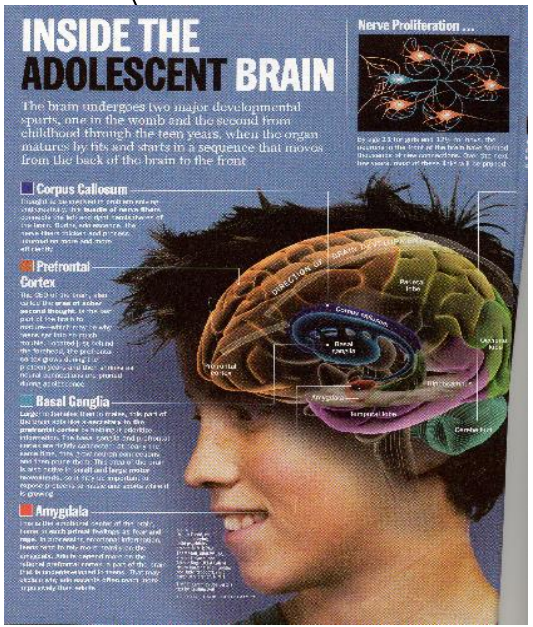
3. Youth serving workers & educators can leverage teen brain science when working with adolescents and parents.

Major Points from My Talk

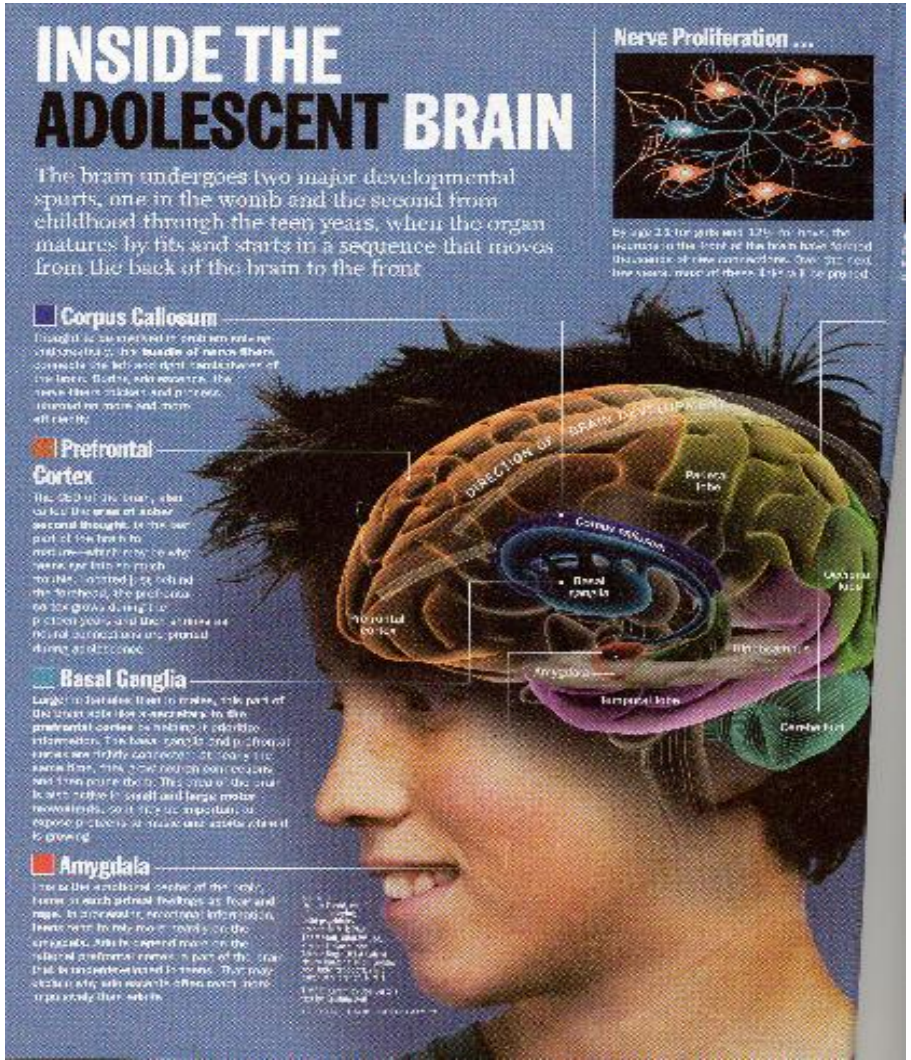
1. The maturation of the adolescent brain likely contributes to behaviors that are characteristic of this developmental period.
2. This maturation also informs our understanding of risk for substance use disorders and other behavioral disorders.

3. **Youth serving workers & educators can leverage teen brain science when working with adolescents and parents.**
   - i. **teaching youth about brain development**
   - ii. **use evidenced-based prevention programs**
   - iii. **treat teen behavioral disorders as early as possible**
   - iv. **use evidence-based treatment programs**
   - v. **increase youth "cannabis and vaping IQ"**
   - vi. **educate parents**

I. Overview of brain development



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



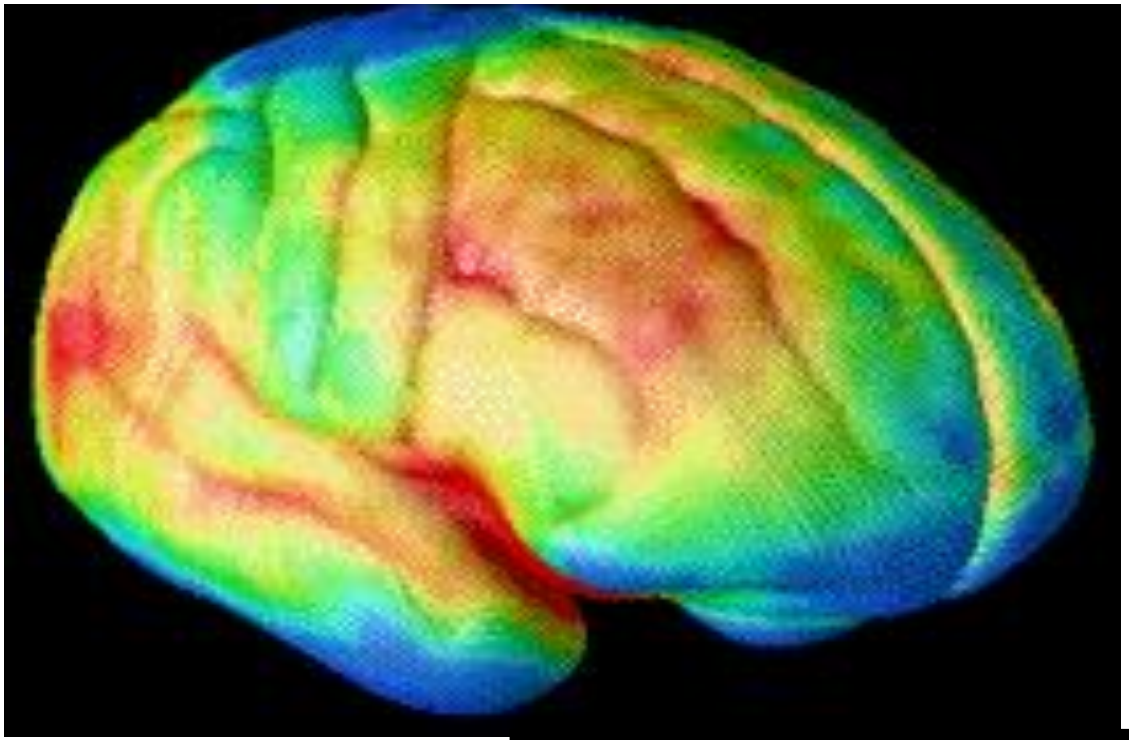
A Developing Brain =
Less Brakes on the "Go" System

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

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

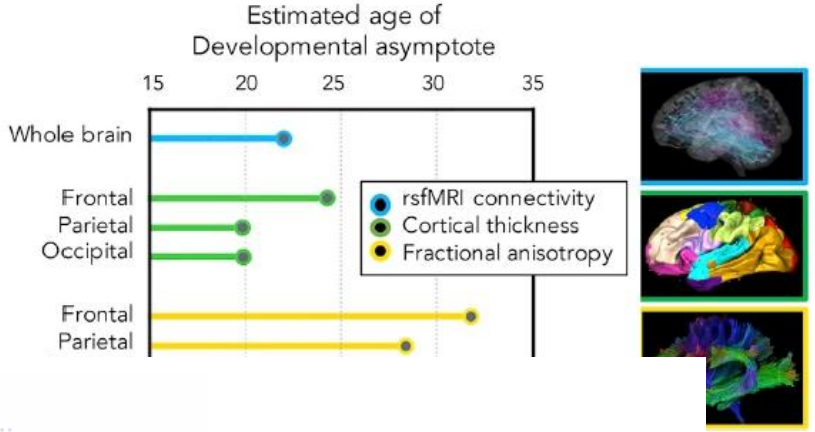
Frontal: later (judgment)

Limbic: earlier (emotion, motivation)

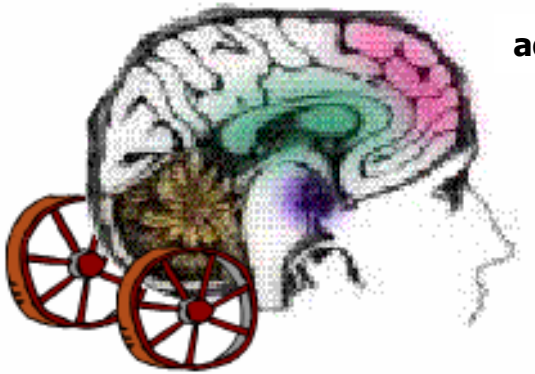


Blue represents maturing of brain areas

Source: PHAS USA 2004 May 25; 101(21): 8174-8179. Epub 2004 May 17.



- **During adolescent brain development, the brain is not functioning at full and optimal capacity.**



adapted from Somerville, 2016

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**

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Contributors for unhealthy or unwise risk?

Implications of Brain Development for Adolescent Behavior

(Winters et al., 1995)

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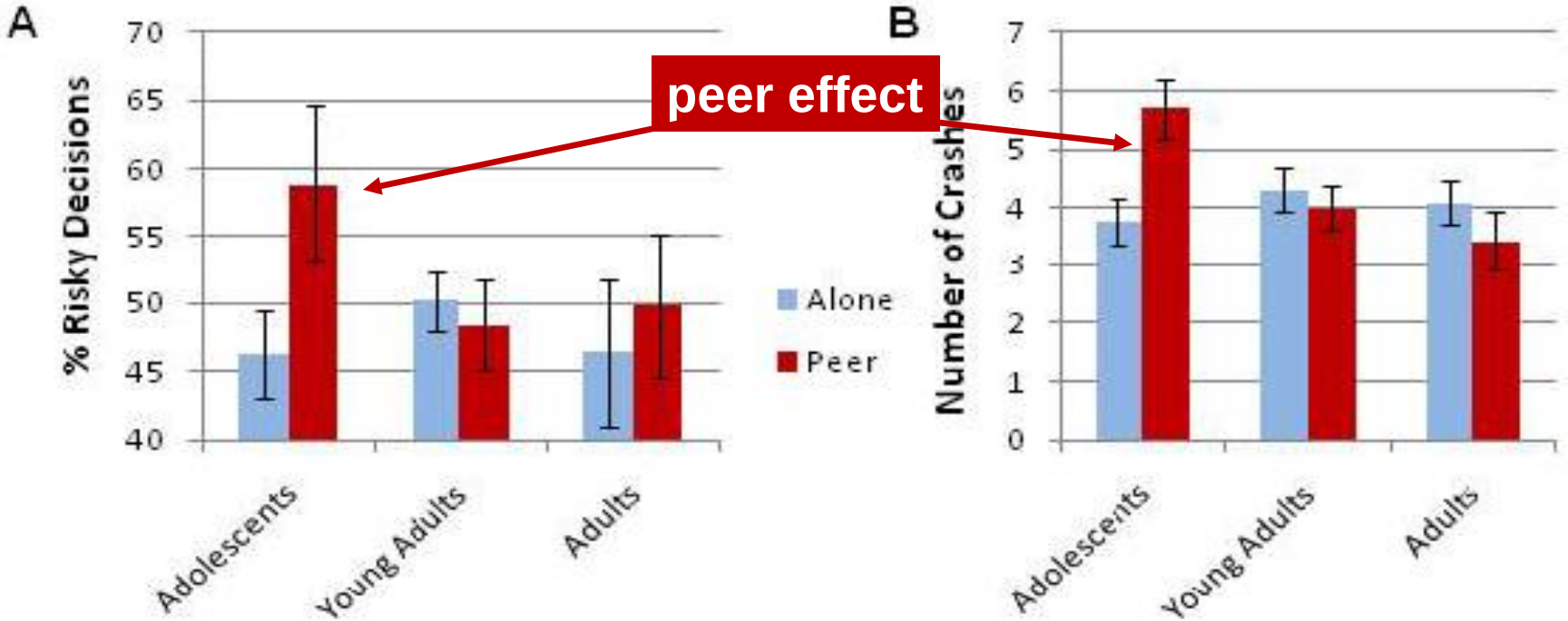
Contributors for healthy or personal growth?

Risk-Taking – Context Matters!

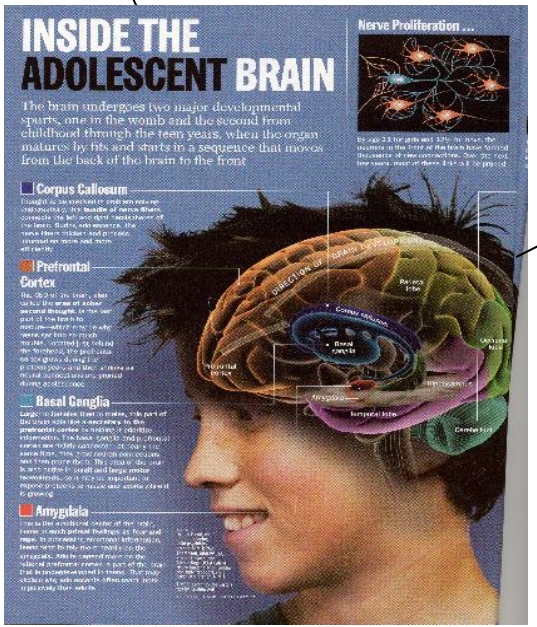
- **Based on science of brain development, a modern view of risk taking in adolescence is…**
  - **evolutionarily adaptive**
  - **normative; important to development**
  - **significant individual differences**
  - **is due primarily to <u>emotional and contextual</u>, not cognitive, factors**

Impact of Peer Presence on Risky Driving in Simulated Context



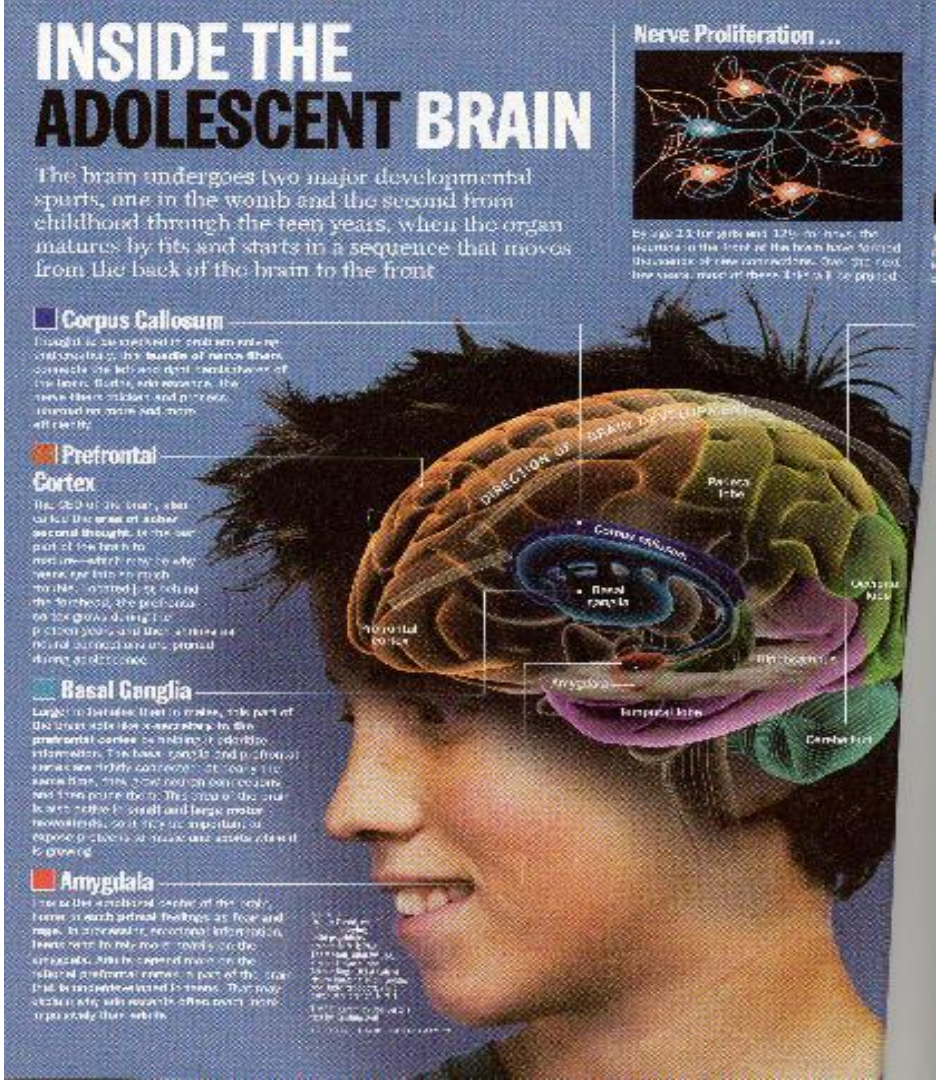
Chein et al., in press

I. Brain development



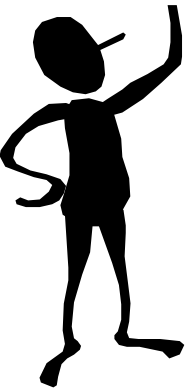
II. Developing brain: drug use, mental health, early experiences

i. Developing brain and drugs



Implications of Brain Development for Drug Abuse Vulnerability

Are adolescents more susceptible than adults to drugs?



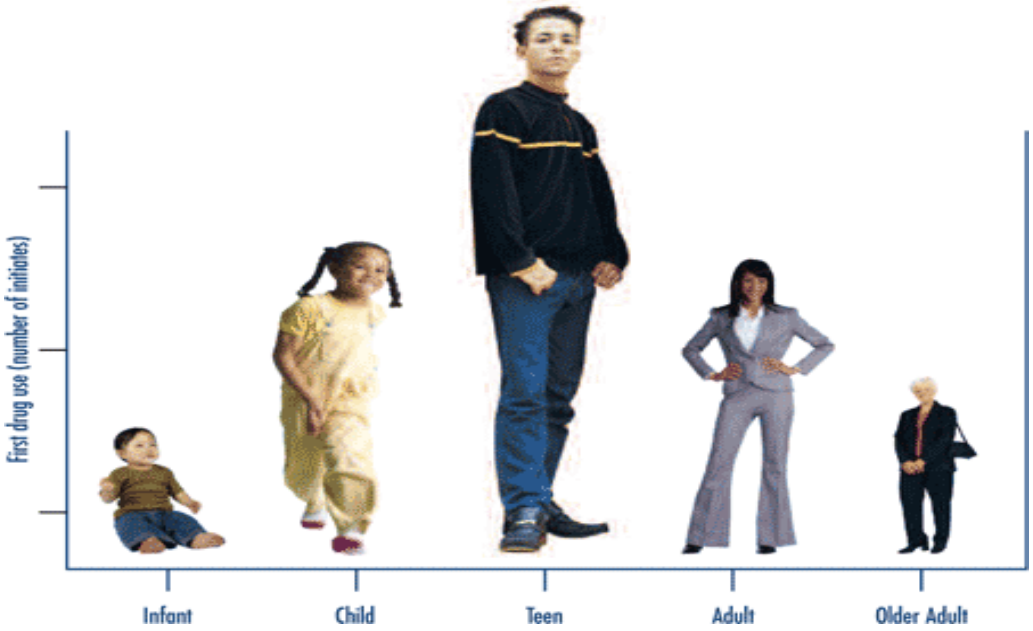
Several lines of evidence

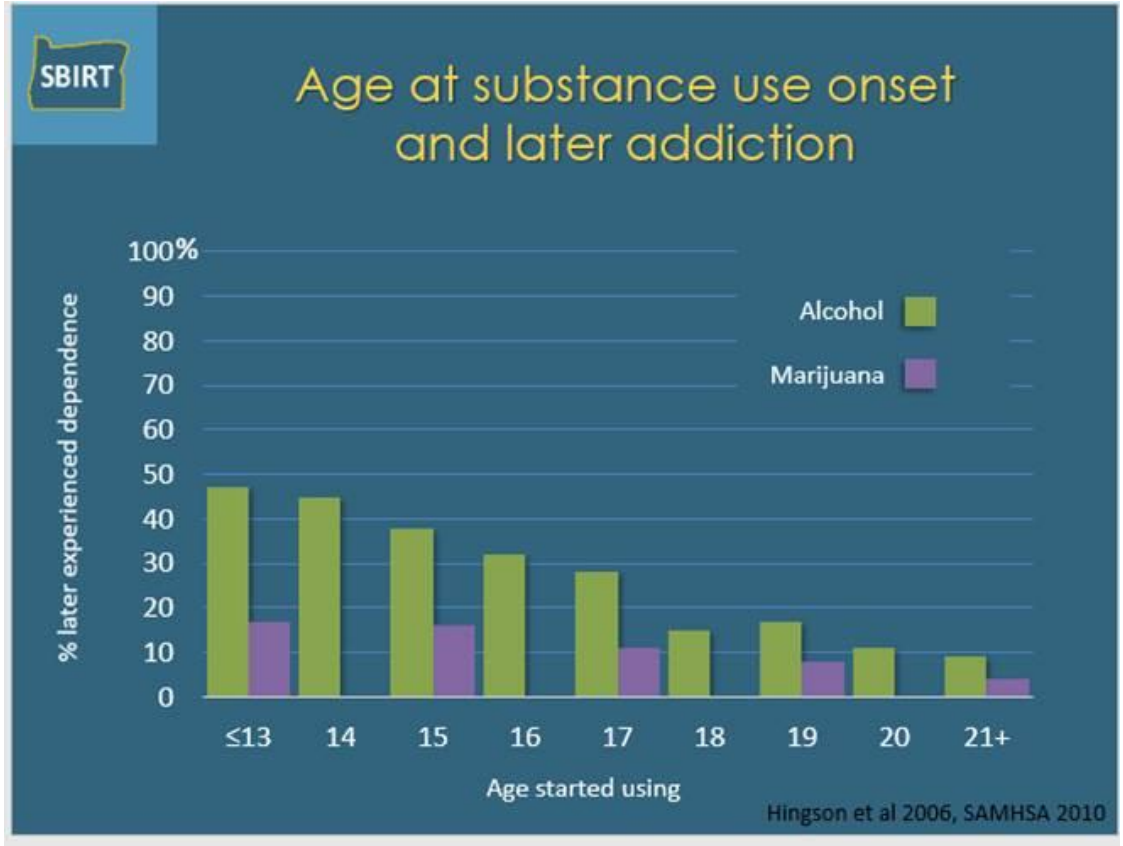
(acknowledgement to Linda Spear, Ph.D.)

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

Evidence from <u>epidemiological studies</u>

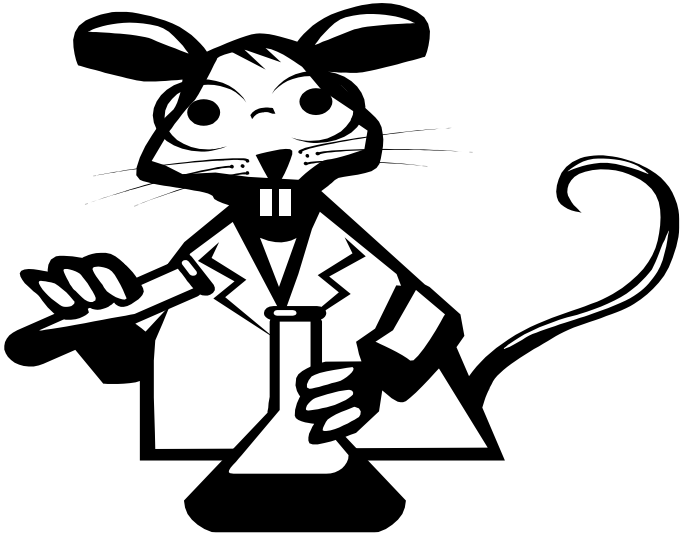
Drug use starts early and peaks in the teen years




SBIRT
Age at substance use onset and later addiction
100%
90
80
70
60
50
40
30
20
10
0
% later experienced dependence
Alcohol
Marijuana
≤13
14
15
16
17
18
19
20
21+
Age started using
Hingson et al 2006, SAMHSA 2010

Implications of Brain Development for Drug Abuse Vulnerability

Alcohol

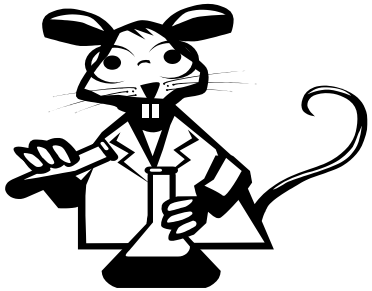


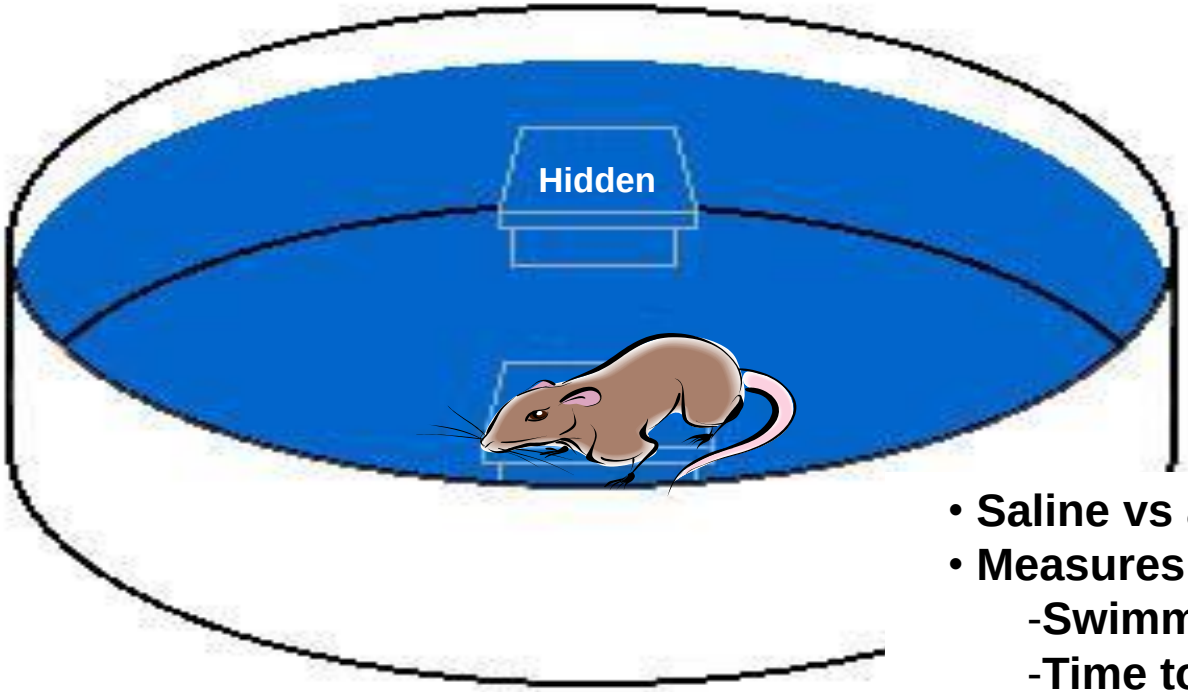
Are adolescents more susceptible to alcohol than adults?

1. Adolescent mice 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.

The Water Maze Test





- Saline vs alcohol
- Measures
  - -Swimming speed
  - -Time to find platform

Slide courtesy
Sion Kim Harris, Ph.D.

Are adolescents more susceptible to alcohol than adults?

1. Adolescent mice are less sensitive to the sedative and motor impairment effects of intoxication.

2. **Adolescent mice are more sensitive to the social disinhibition effects of alcohol.**

#2 and #3 : May contribute to binge drinking and increased risk to alcohol dependence.

Wanna look for some cheese with me?

Sure!

Impact of Binge Drinking

NeuroImage: Clinical 22 (2019) 101804

Contents lists available at ScienceDirect

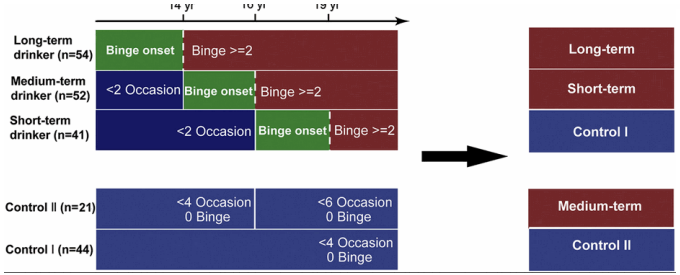
NeuroImage: Clinical

journal homepage: www.elsevier.com/locate/ynicl

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**



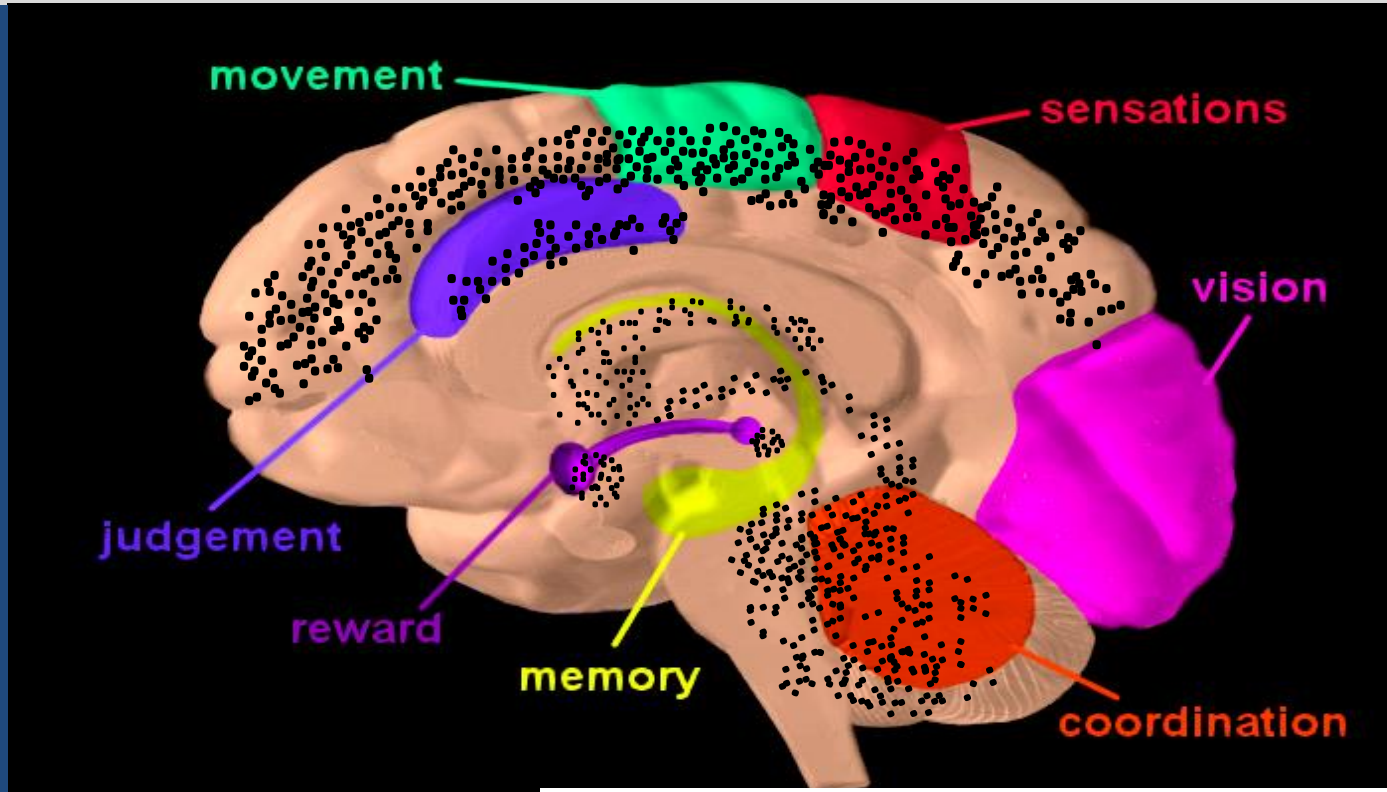
Implications of Brain Development for Drug Abuse Vulnerability

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

Eight Adverse Health Effects of Chronic Cannabis 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

Some Adverse Health Effects of Chronic Cannabis Use More Pronounced with Youth Onset (Volkow et al., 2014)

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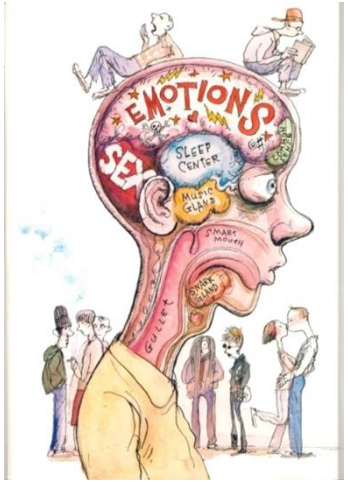

Source: US News & World Report, 2005

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

13 yrs (Pre-initiation) 18 yrs 21 yrs 32 yrs 38 yrs

1 2 3 4 5

Assessment ages

Slide courtesy of Sion Kim, MD; Source: Meier et al. PNAS, 2012

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13 yrs
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18 yrs **21 yrs** **32 yrs** **38 yrs**

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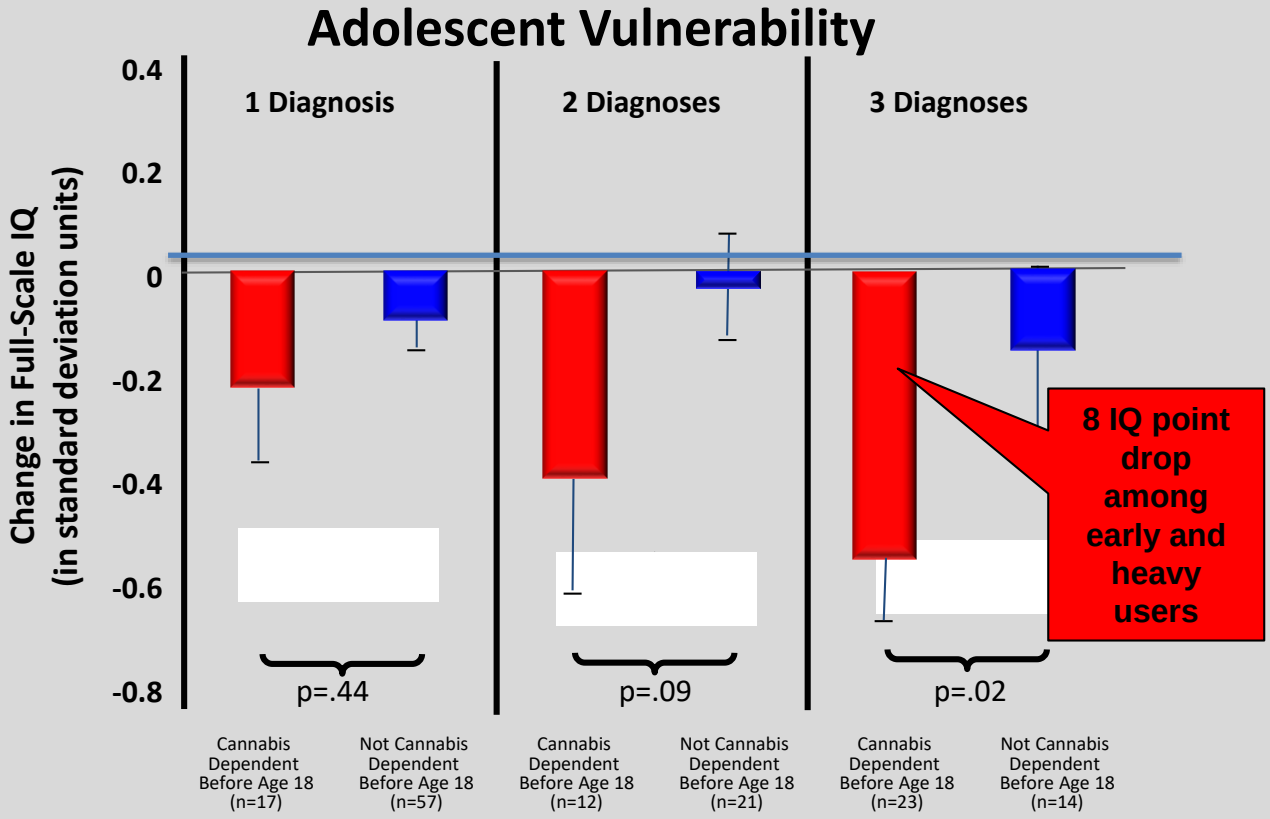
Assessment ages

Slide courtesy of Sion Kim, MD; Source: Meier et al. PNAS, 2012

Marijuana and Cognitive Development

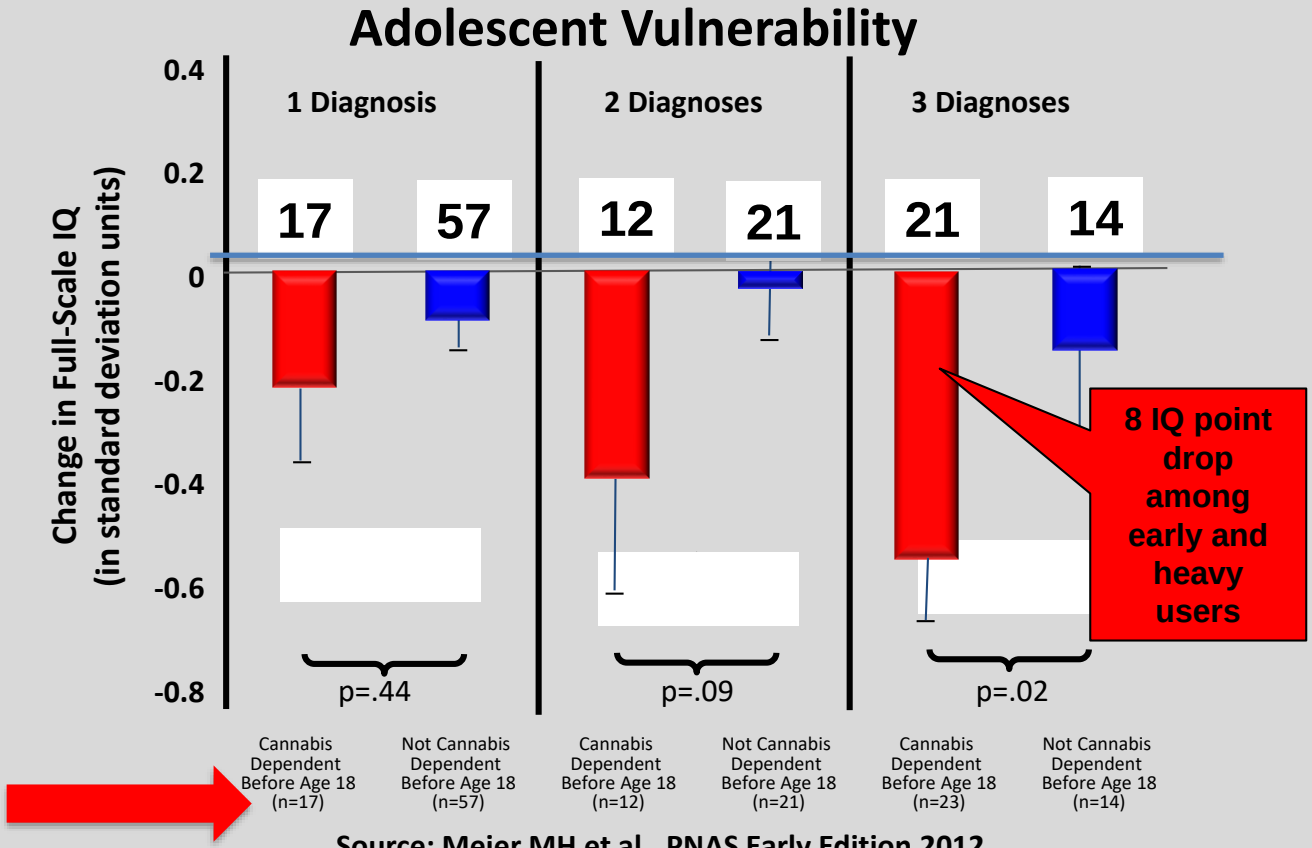


Source: Meier MH et al., PNAS Early Edition 2012

National Institute on Drug Abuse

NIH

Sample Sizes Far from Ideal!!



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

National Institute on Drug Abuse

NIH

WHY?

1. Could there be inherent risk factors of brain development that contribute to drug use?

- **Preference for ….**
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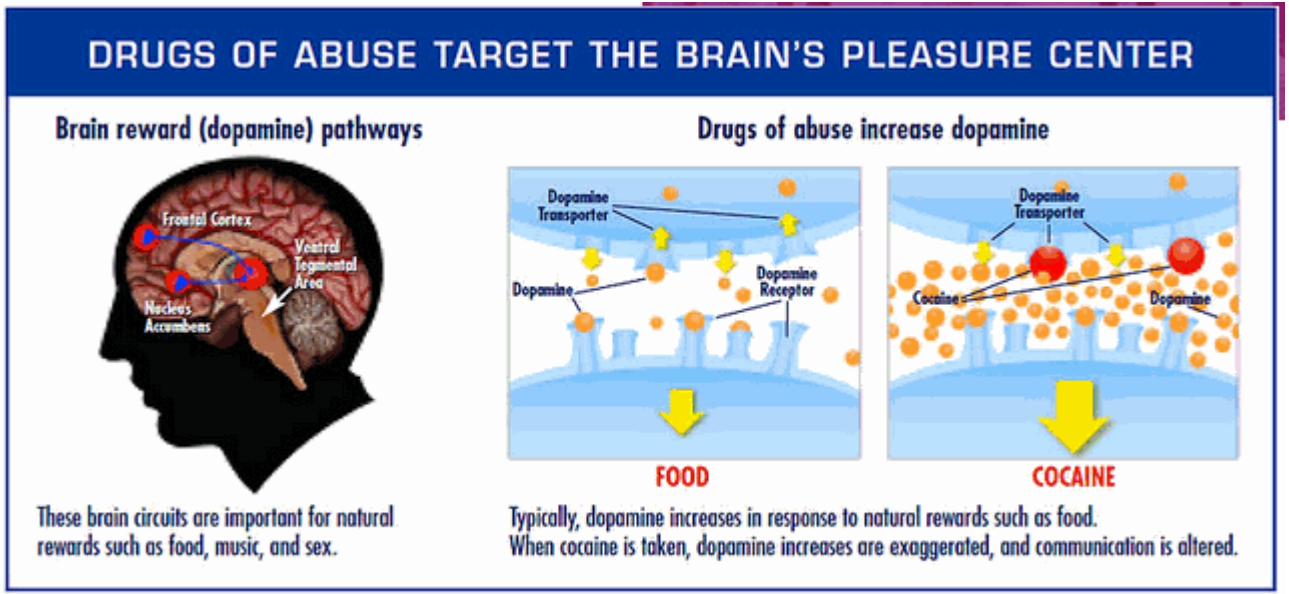
2. Adolescent pleasure centers in the brain may be more sensitive to the acute effects of drugs than pleasure centers in the adult brain.

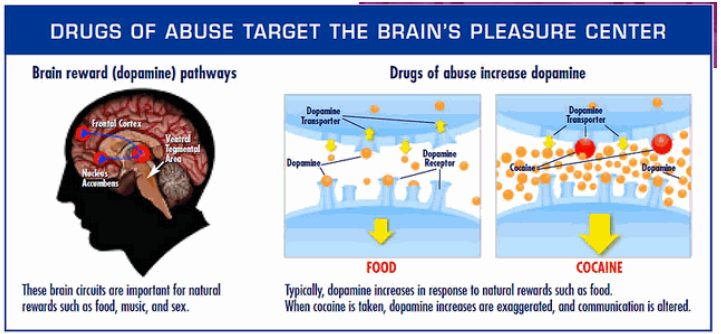


Courtesy National Institute on Drug Abuse, National Institute of Health

2. Adolescent pleasure centers in the brain may be more sensitive to the acute effects of drugs than pleasure centers in the adult brain. (Chambers, Taylor and Potenza, 2003)

- Evidence that dopamine activity is more "robust" during adolescence.

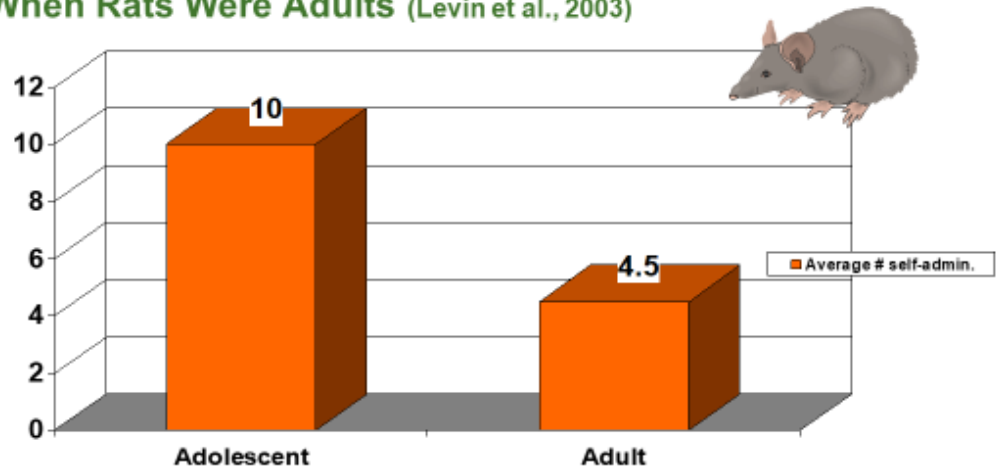
- If dopamine production is more pronounced or "robust" during adolescence, risk of drug abuse could be heightened
- > sensitivity to initial drug effects
- > motivation to continue use
- > difficulty to reduce use



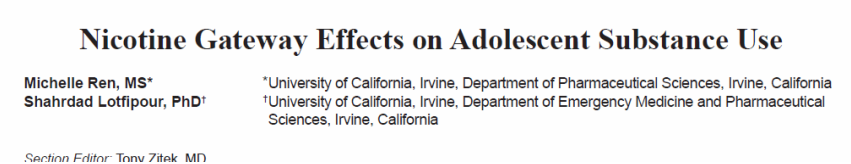
Courtesy National Institute on Drug Abuse, National Institute of Health

3. 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

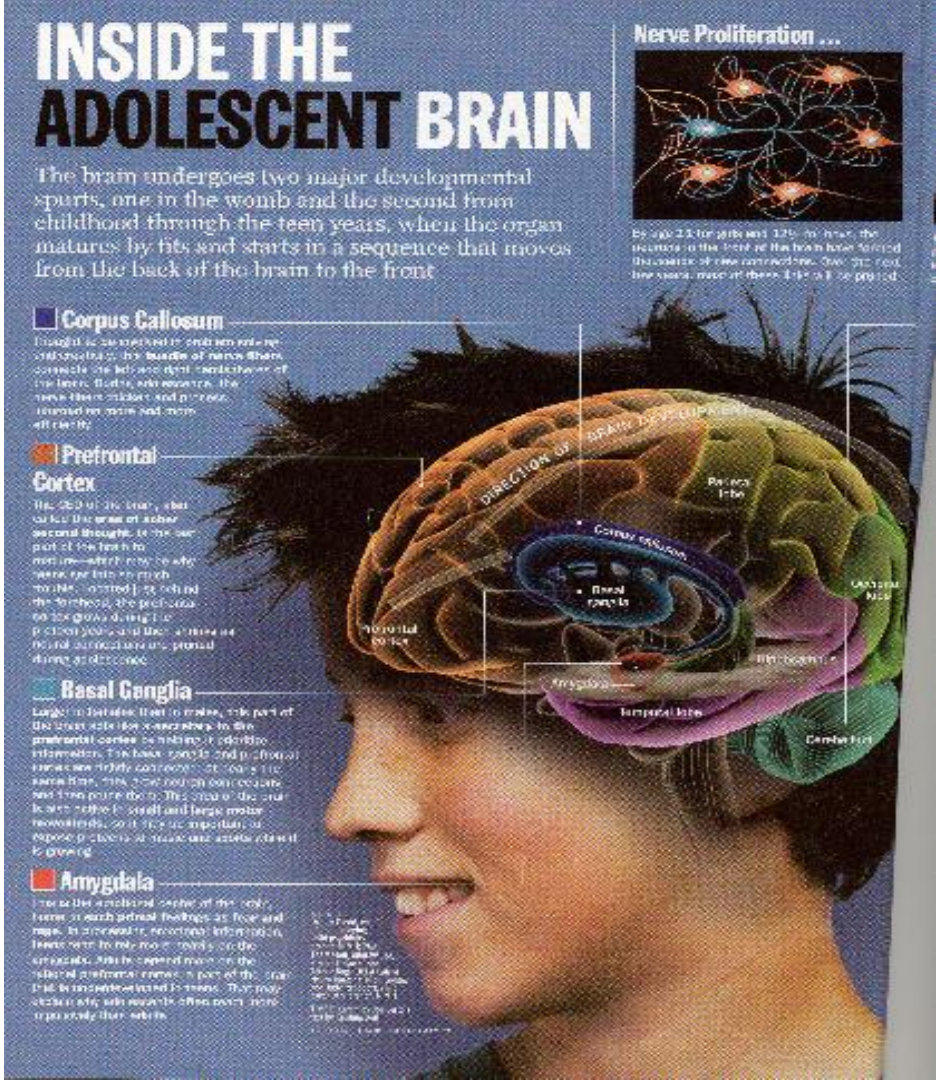
Michelle Ren, MS*
Shahrdad Lotfipour, PhD†

*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."**

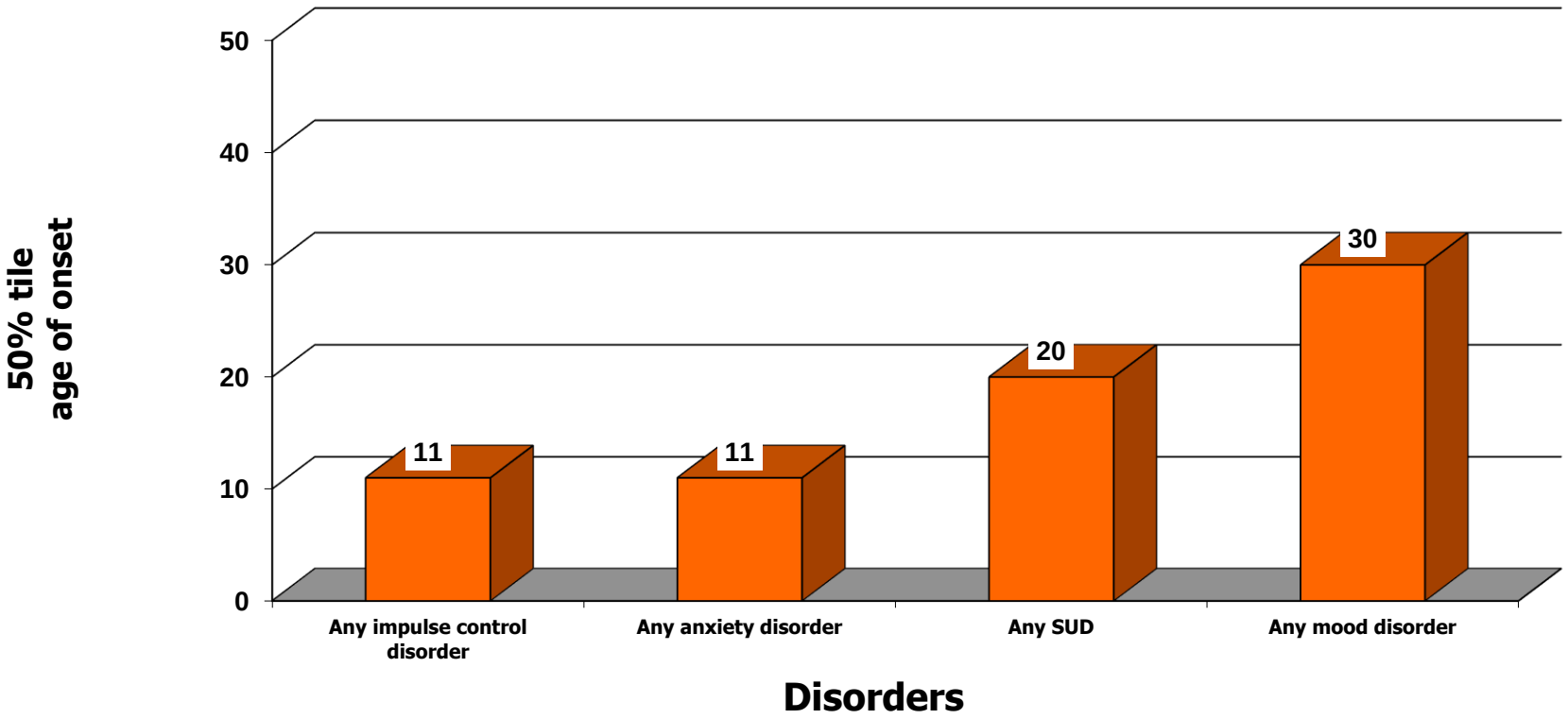
ii. Brain development and behavioral disorders



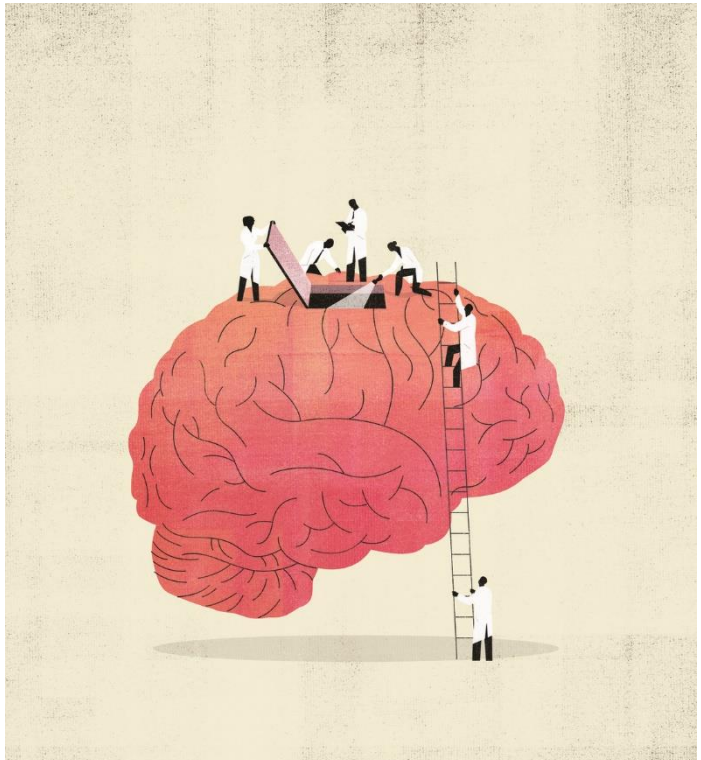
Adolescence and Behavioral Disorders

- 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 Marijuana and Mental Health Connection

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. (in press). The impact of marijuana on mental health. In K. Sabet & K.C. Winters, *Contemporary health issues on marijuana.* NY: Oxford 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 •

- **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)**

Source: Lancet Psychiatry, 2019

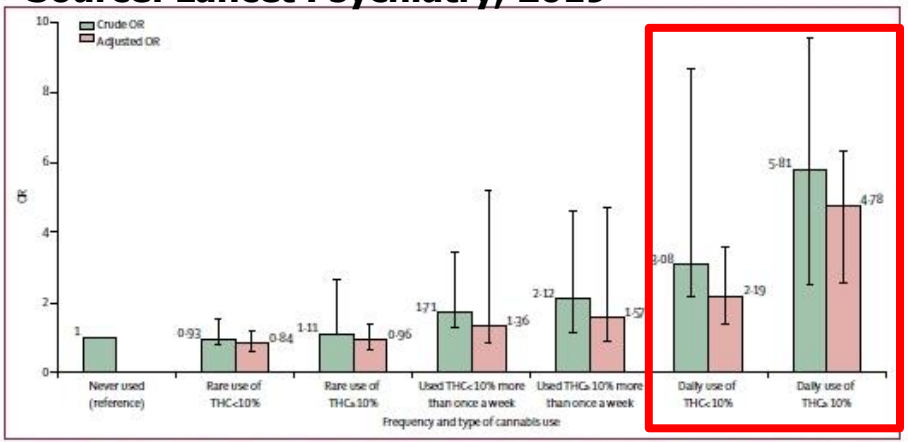


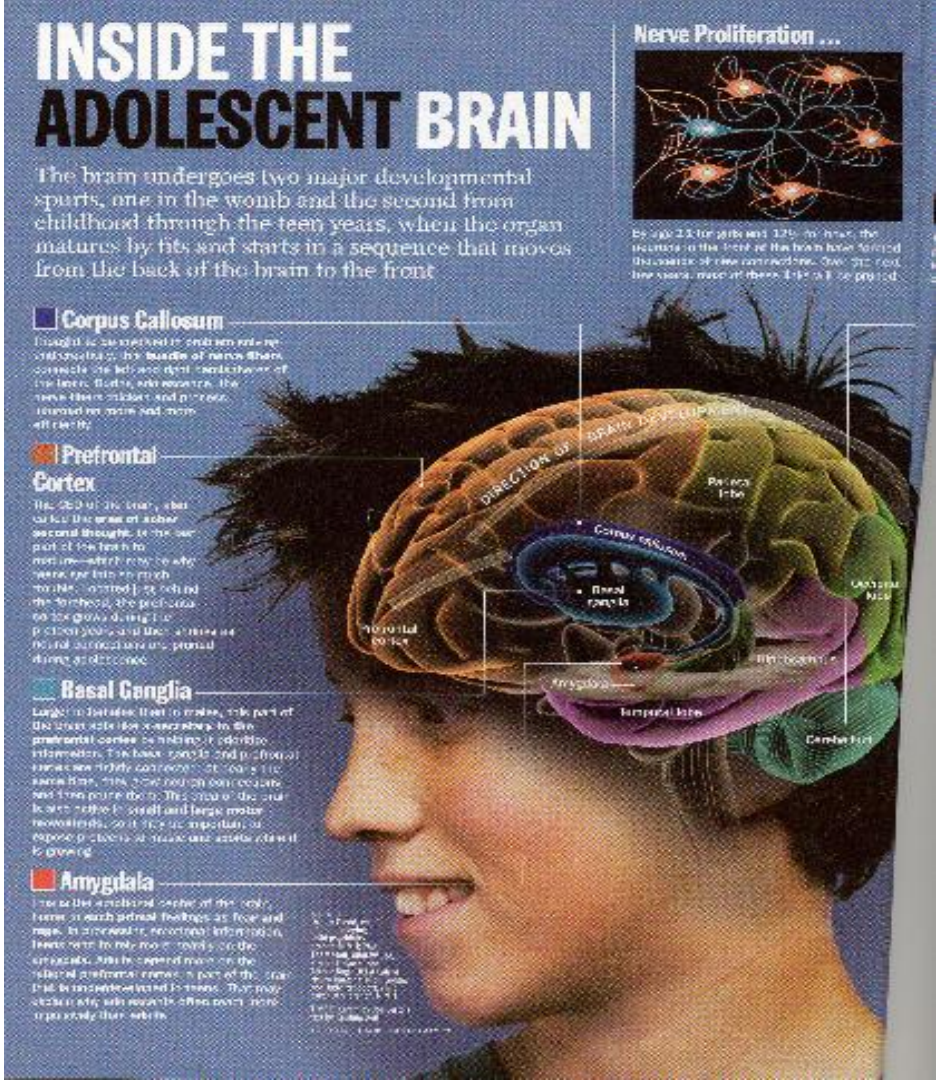
Figure 1: Crude and fully adjusted ORs of psychotic disorders for the combined measure of frequency plus type of cannabis use in the whole sample
Crude ORs are adjusted only for age, gender and ethnicity and fully adjusted ORs are additionally adjusted for level of education, employment status, and use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

Cautionary Notes

- **Reverse causation (self-medication).**

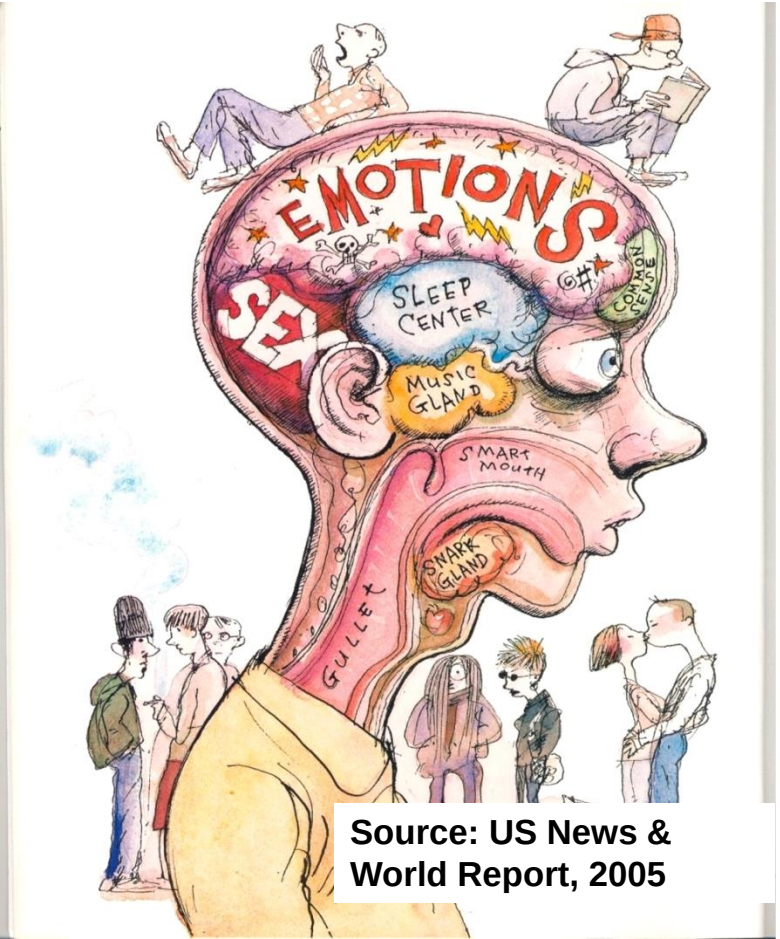
- **Early drug use may be a marker of underlying genetic risk and not causative, or only partially causative.**

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



A Developing Brain

> Impact from Environment?



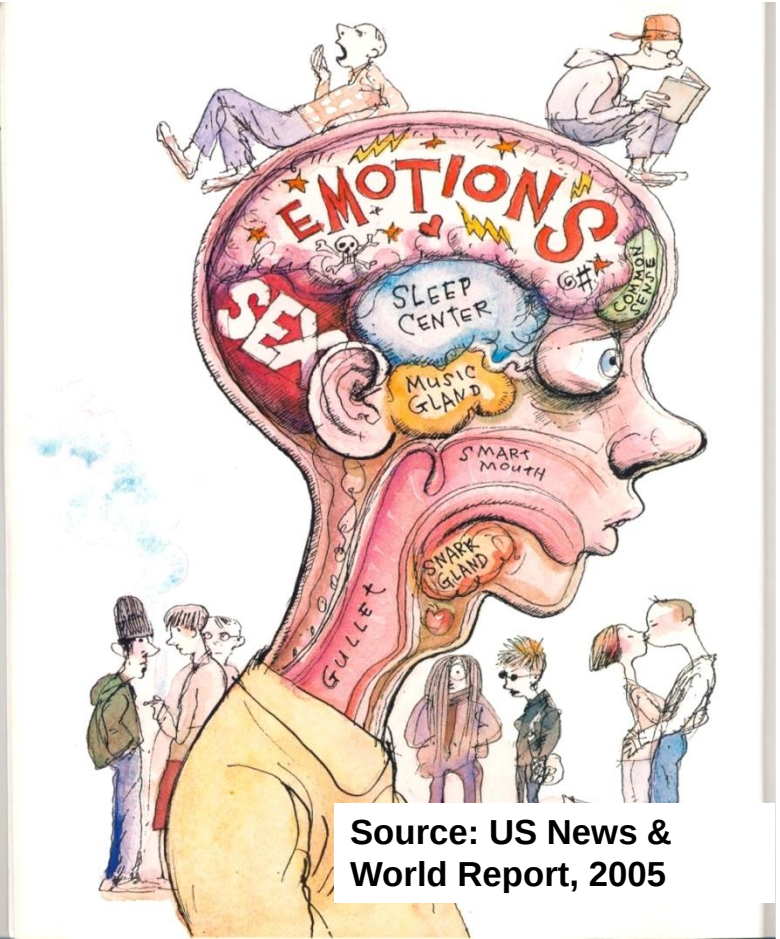
Source: US News & World Report, 2005

- **"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*)

A Developing Brain

> Impact from Environment?



Source: US News & World Report, 2005

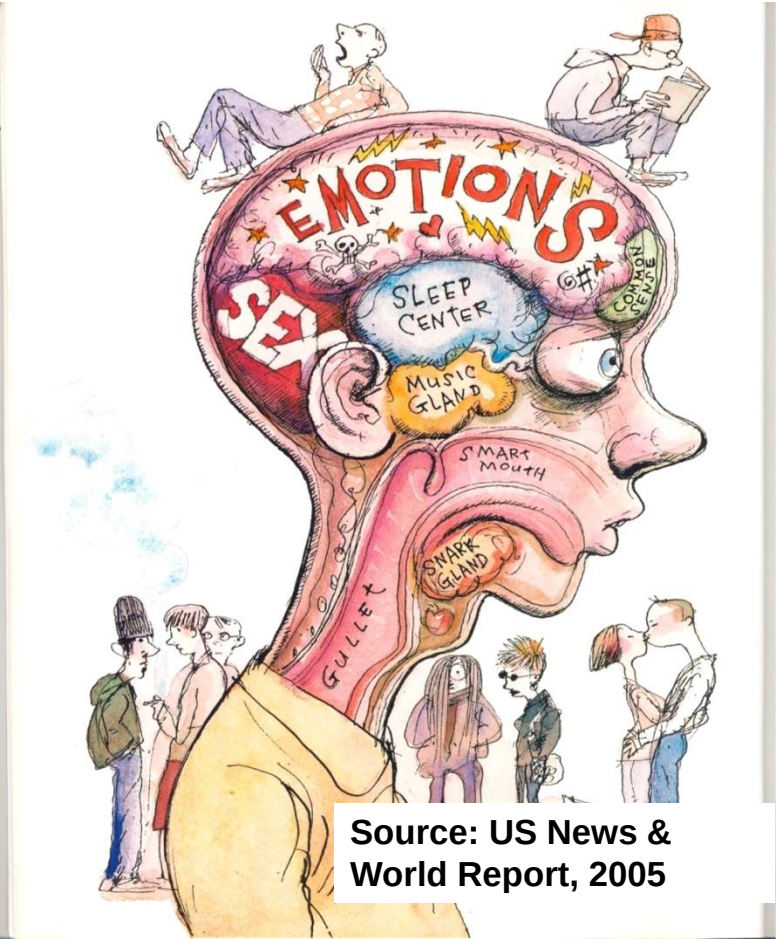
https://developingchild.harvard.edu/science/deep-dives/mental-health/

- **"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."**

A Developing Brain

> Impact from Environment?

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



Source: US News & World Report, 2005

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."

Early experiences can alter brain development in positive ways

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

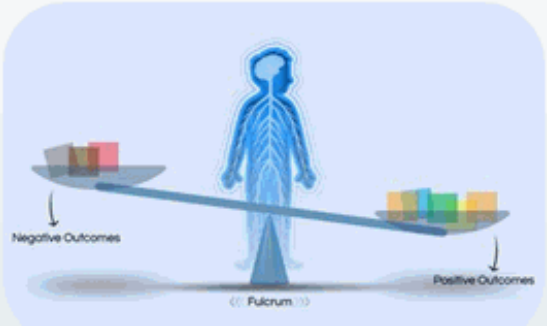
https://www.cdc.gov/ncbddd/childdevelopment/early-brain-development.html

"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

Center on the Developing Child
HARVARD UNIVERSITY

https://developingchild.harvard.edu/



The science of early childhood is a source of new ideas that could be used to develop more effective policies & services focused on the early years of life.

Browse Key Concepts | Browse Deep Dives

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[a,1], Andy Belden[a], Michael P. Harms[a], Rebecca Tillman[a], and Deanna M. Barch[a,b,c]

[a]Department of Psychiatry, Washington University in St. Louis, St. Louis, MO 63110; [b]Department of Psychological & Brain Sciences, Washington University in St. Louis, St. Louis, MO 63130; and [c]Department of Radiology, Washington University in St. Louis, St. Louis, MO 63110

More parental support = more hippocampus volume

More hippocampus volume = better memory & emotional regulation

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 last well beyond childhood. Associated with…**
  - **learning problems**
  - **mental illness; diminished level of functioning**
  - **increased use of a health services, including mental health services**

Early experiences can alter brain development in negative ways

Infant Stress Affects Teen Brain

(Davidson et al., 2012; *Nature Neuroscience*)

- **For *some* girls, stressful experiences in the first year of life was associated with…..**

  1. **altered hormonal changes; and**
  2. **abnormal development of connections between regions of the brain that control fear and stress responses**

Early experiences can alter brain development in negative ways


Development and Psychopathology

Article Supplementary materials Metrics

First View

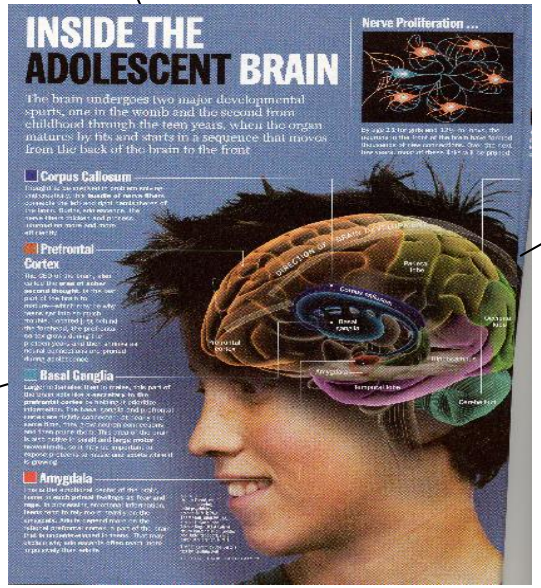
Mind and gut: Associations between mood and gastrointestinal distress in children exposed to adversity

Bridget L. Callaghan [a1] [a2], Andrea Fields [a1], Dylan G. Gee [a3], Laurel Gabard-Durnam [a4] ...

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..
    - concurrent and future anxiety
    - prefrontal cortex activation to emotional faces

I. Brain development



II. Developing brain, drug use and mental health

III. Youth Serving Workers

Brain Development: Implications for Youth Serving Workers & Educators

i. Teach youth about brain development and its importance to health and personal growth

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

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

i. **Interested in a "teen brain" resource to help teach youth about brain development?**

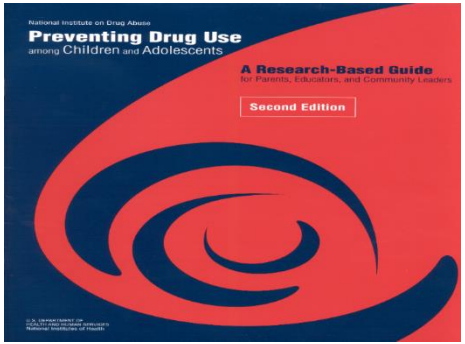
send me an e-mail:

winte001@umn.edu

Brain Development: Implications for Youth Serving Workers & Educators

ii. 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

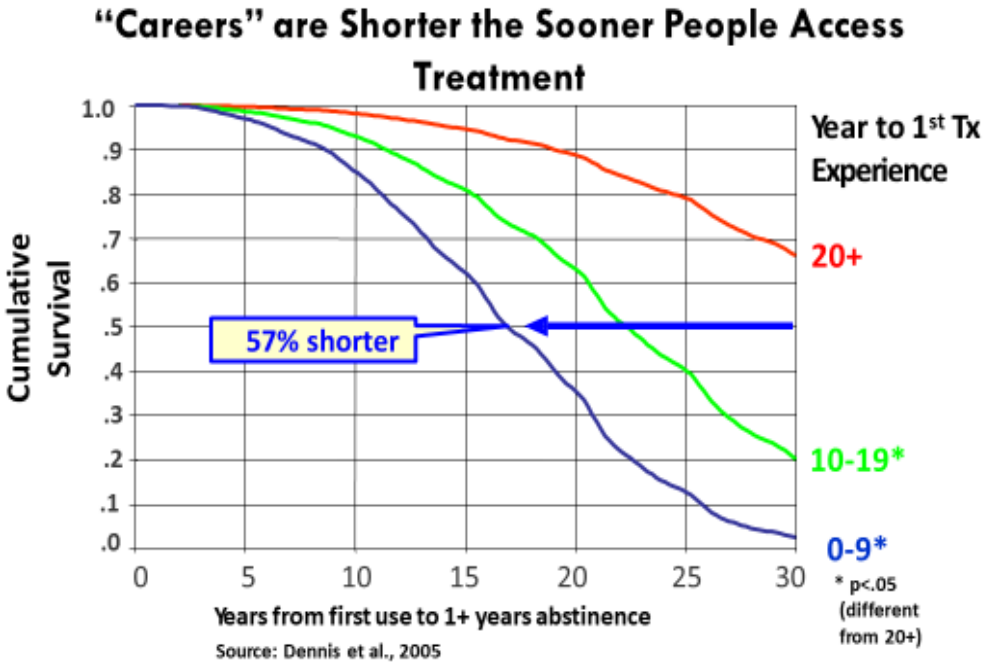


Cochrane
Trusted evidence.
Informed decisions.
Better health.

ISSUP INTERNATIONAL SOCIETY OF SUBSTANCE USE PROFESSIONALS

Brain Development: Implications for Service Providers

iii. **Earlier the *treatment*, the better**



Brain Development: Implications for Service Providers

iv. 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

Brain Development: Implications for Youth Serving Workers & Educators

v. Increase the "cannabis and vaping IQ" of adolescents

- Sources of exercises and quizzes
  - Cannabis:
    - 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 & Educators

vi. 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

1.

Mentor International

DRUG PREVENTION FOR PARENTS

MENTOR INTERNATIONAL'S SELECTION OF SUBSTANCE ABUSE PREVENTION RESOURCES FOR PARENTS

2.

NIDA FOR TEENS

National Institute on Drug Abuse for Teens

Advancing Addiction Science

3.

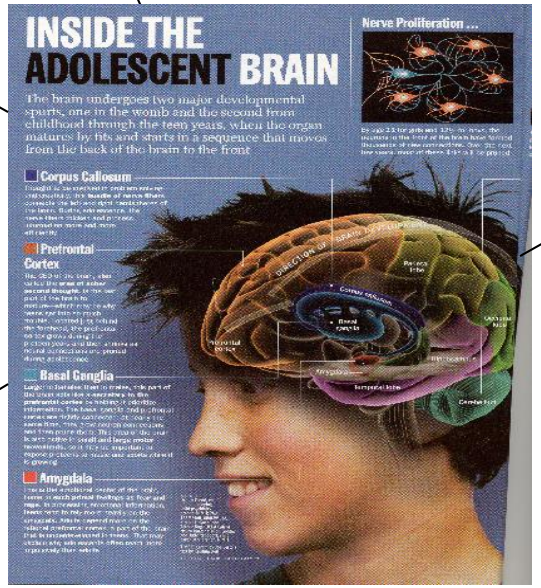
THE PARTNERSHIP™ AT DRUGFREE.ORG

Prevent_Intervene_Get Treatment_Recover

www.drugfree.org

I. Brain development

IV. Summary



II. Developing brain, drugs and mental health

III. Youth Serving Workers

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

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.**

- **It is also a time when personal growth can be shaped in ways that are unique to adolescence**

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 to strengthen parenting with brain development science**

Teen Brain Development Quiz

1. There are several health indices suggesting that teenagers take less risk than in years past.
   True (increased rate of "abstaining" from all substances; lower rate of teenage pregnancies and certain delinquency behaviors)

2. What lifestyle choices during adolescence promote good brain development?
   i. no drug use
   ii. healthy lifestyle (good diet, exercise, sufficient sleep; active social life)

3. Which is more harmful to the developing brain?
   a. Chronic, heavy use of marijuana?
   b. Chronic, heavy drinking?
   Good question!!

THANK YOU

winte001@umn.edu

Questions and Discussion