This is Your Brain on Adolescence

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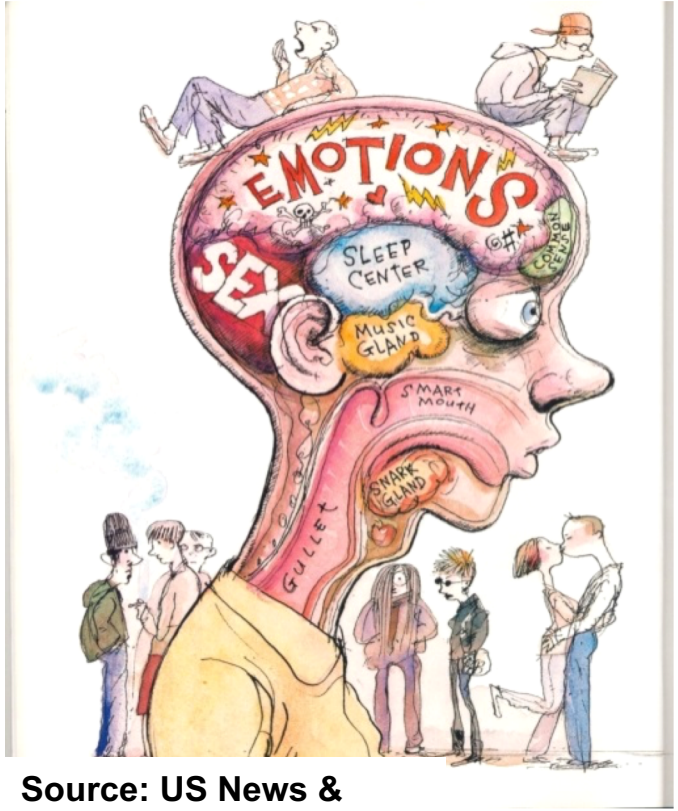


Source: US News & World Report, 2005

Disclosures

None to report

Personal Disclosure

I hope to avoid a reaction from you that was voiced by the famous Italian-American physicist, Enrico Fermi, after he attended a seminar:

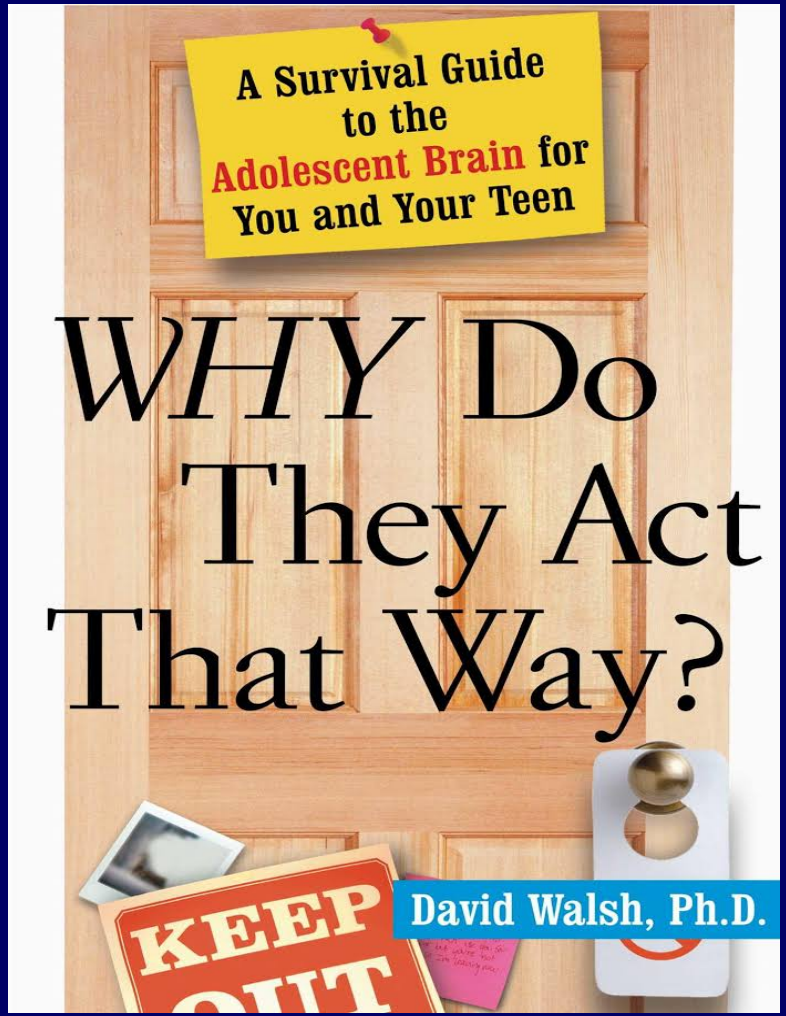
“Before I came here, I was confused about this subject. Having listened to your lecture, I am still confused -- but on a higher level.”

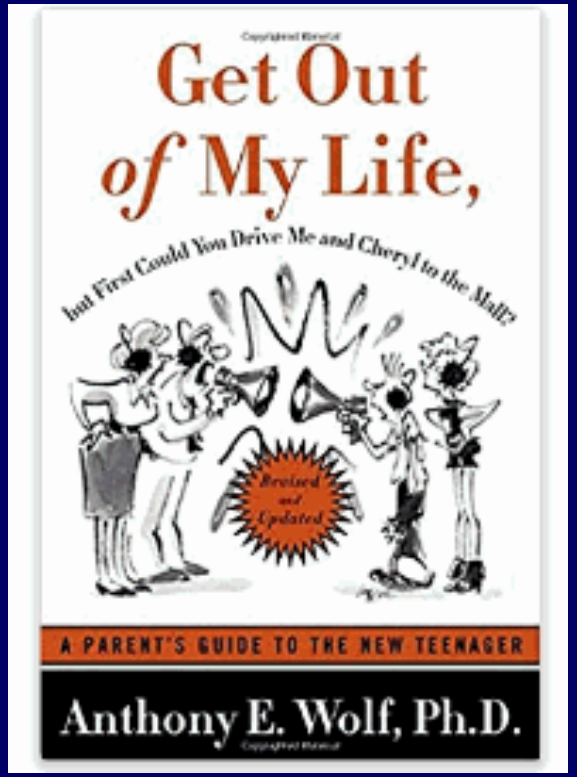
Teen Brain Development Quiz

1. It is an accepted fact the adolescent brain fully develops by about age 25. What 'privilege' in the U.S. requires a young person to be at least 25 years-old?

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

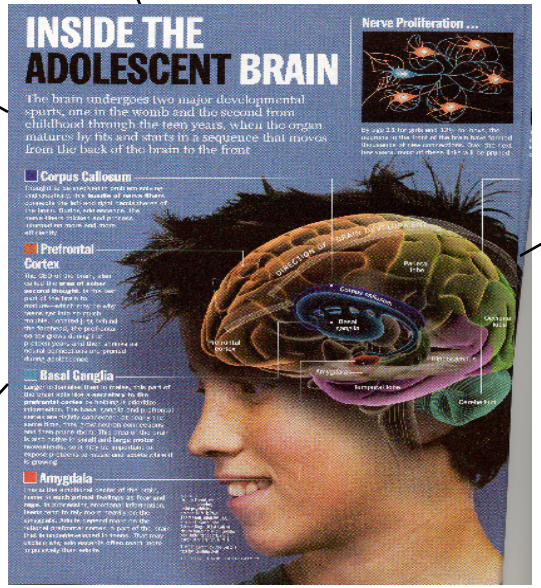
3. Which is more harmful to the developing brain?
   a. chronic, heavy use of marijuana?
   b. Chronic, heavy drinking?


A Survival Guide to the Adolescent Brain for You and Your Teen
WHY Do They Act That Way?
KEEP OUT
David Walsh, Ph.D.


Get Out of My Life,
but First Could You Drive Me and Cheryl to the Mall?
Revised and Updated
A PARENT'S GUIDE TO THE NEW TEENAGER
Anthony E. Wolf, Ph.D.

1. Brain development

4. Summary



2. Developing brain, drug use and mental health

3. Clinical implications

Major Points from My Talk

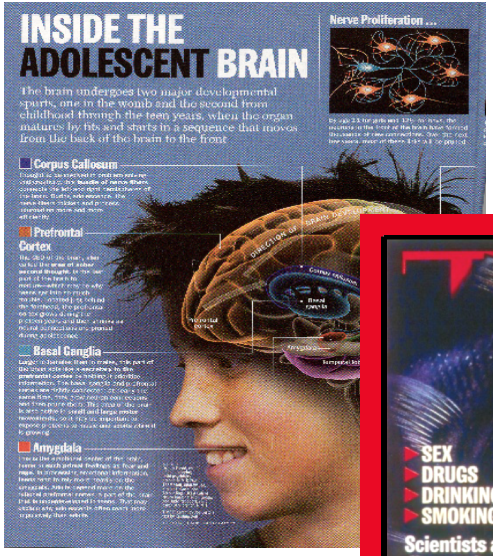
1. **The maturation of the adolescent brain likely contributes to behaviors that are characteristic of this developmental period.**

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

3. **Service providers can leverage teen brain science when working with adolescents and parents.**

Brain Development: Implications for Service Providers

1. Teach youth about brain development and the science of addiction



Brain Development: Implications for Service Providers

2. **Earlier the treatment the better**

Brain Development: Implications for Service Providers

3. Use evidenced-based prevention & treatment approaches

- Prevention: keys to effective prevention, see NIDA's 2nd edition: "Preventing Drug Use among Children and Adolescents"
- Treatment: best approaches summarized in a recent meta analysis and literature summary (Hogue et al., 2018; Tanner-Smith et al., 2012)

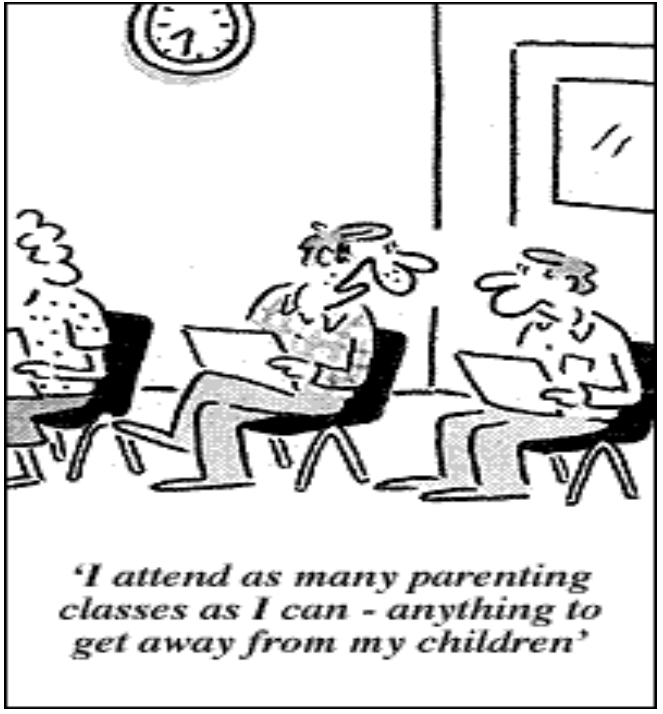
Brain Development: Implications for Service Providers

4. Increase youth "cannabis IQ"

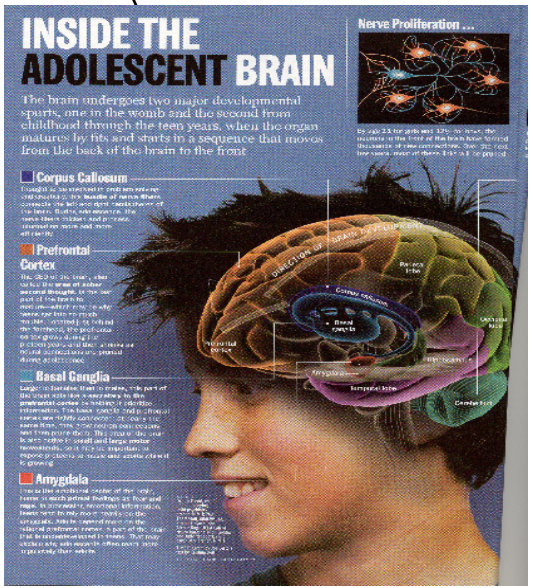
- Many misperceptions and myths about cannabis by are held by youth (and adults, too!)

Brain Development: Implications for Service Providers

5. Teach parents about brain development



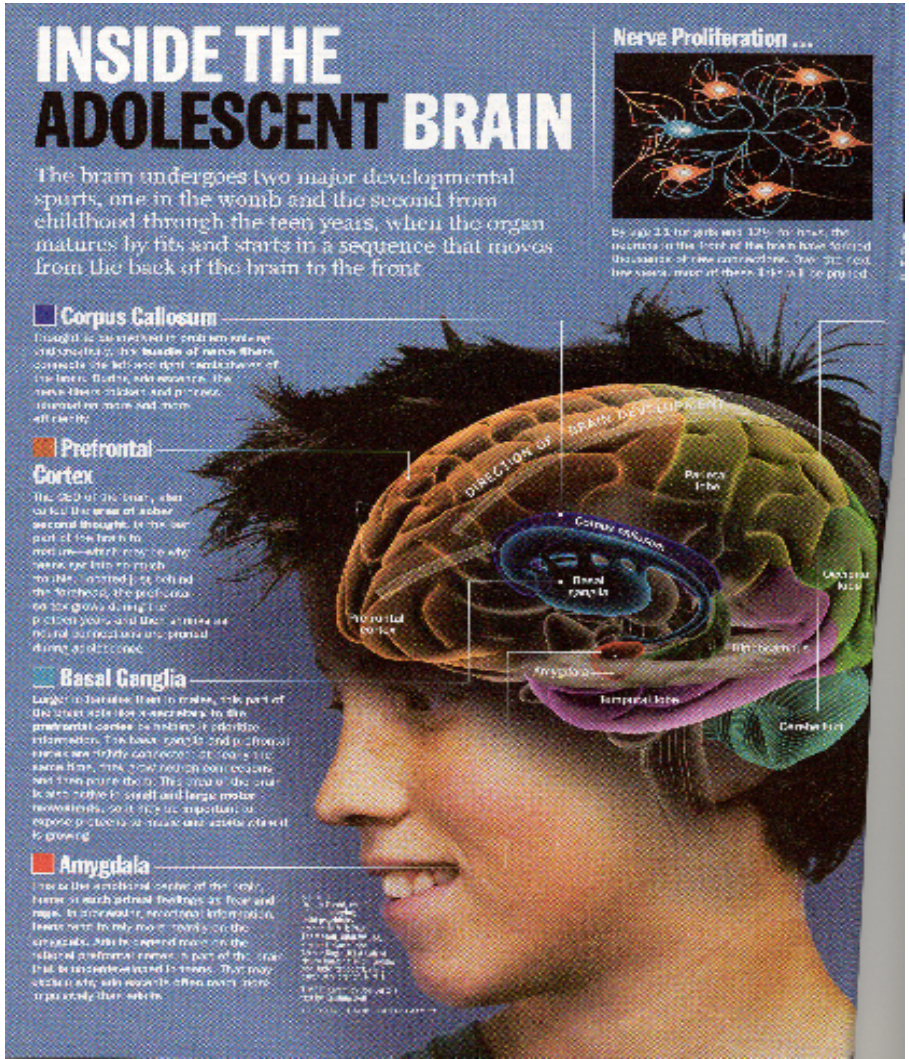
1. Brain development



Cautions

- **Brain imaging studies of development are based on small samples**
  - **gender, ethnic and cultural differences may be significant.**
- **The role of hormones and early experiences on brain development are likely significant**

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



Minimum age for various rights and privileges

- 16: driving, emancipation (in some instances)
- 18: voting, military, smoking (that is changing), gambling (in some instances), legal adult status
- 21: alcohol, marijuana (in some instances)
- 25? renting a car

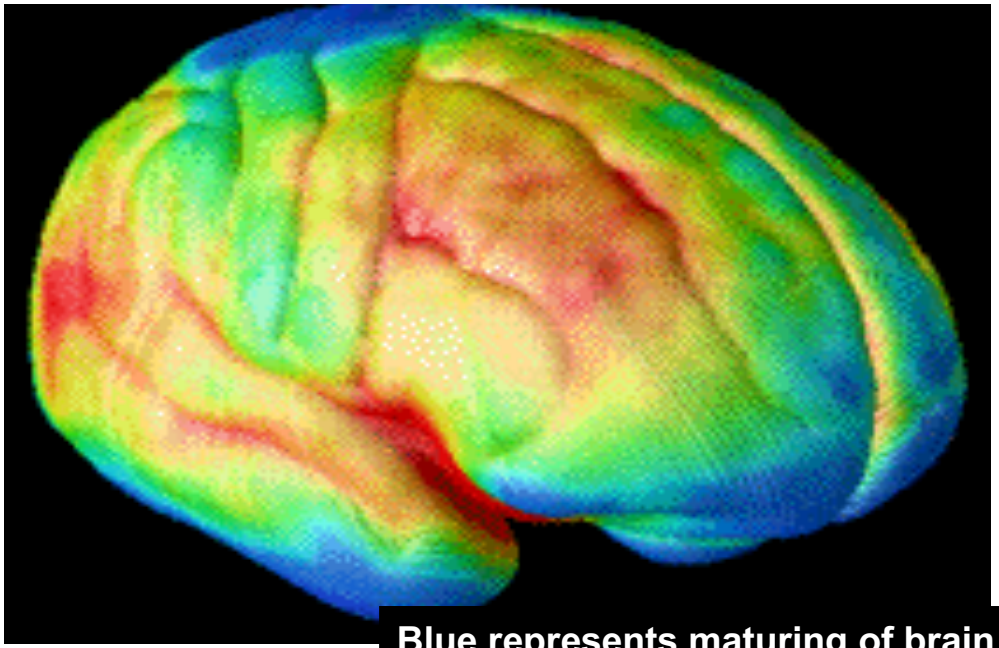
An Immature Brain =
Less Brakes on the "Go" System

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: Prefrontal
- Judgment



Blue represents maturing of brain areas

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

Implications of Brain Development for Adolescent Behavior

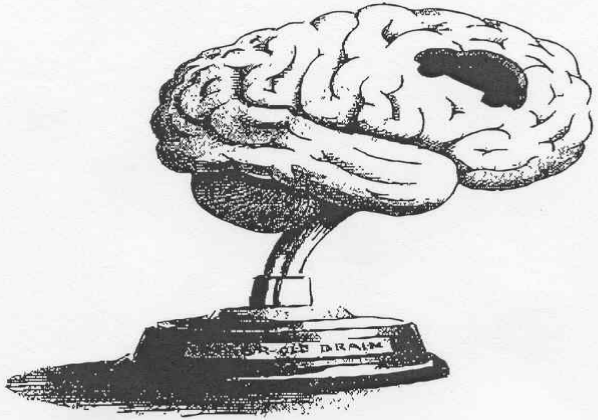
- **Preference for ….**
  1. **physical activity**
  2. **high excitement and rewarding activities**
  3. **activities with peers that trigger high intensity/arousal**
  4. **novelty**
- **Less than optimal..**
  5. **control of emotions**
  6. **consideration of negative consequences**
- **Greater tendency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

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.



Allstate ad, *NY Times*, May, 2007

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

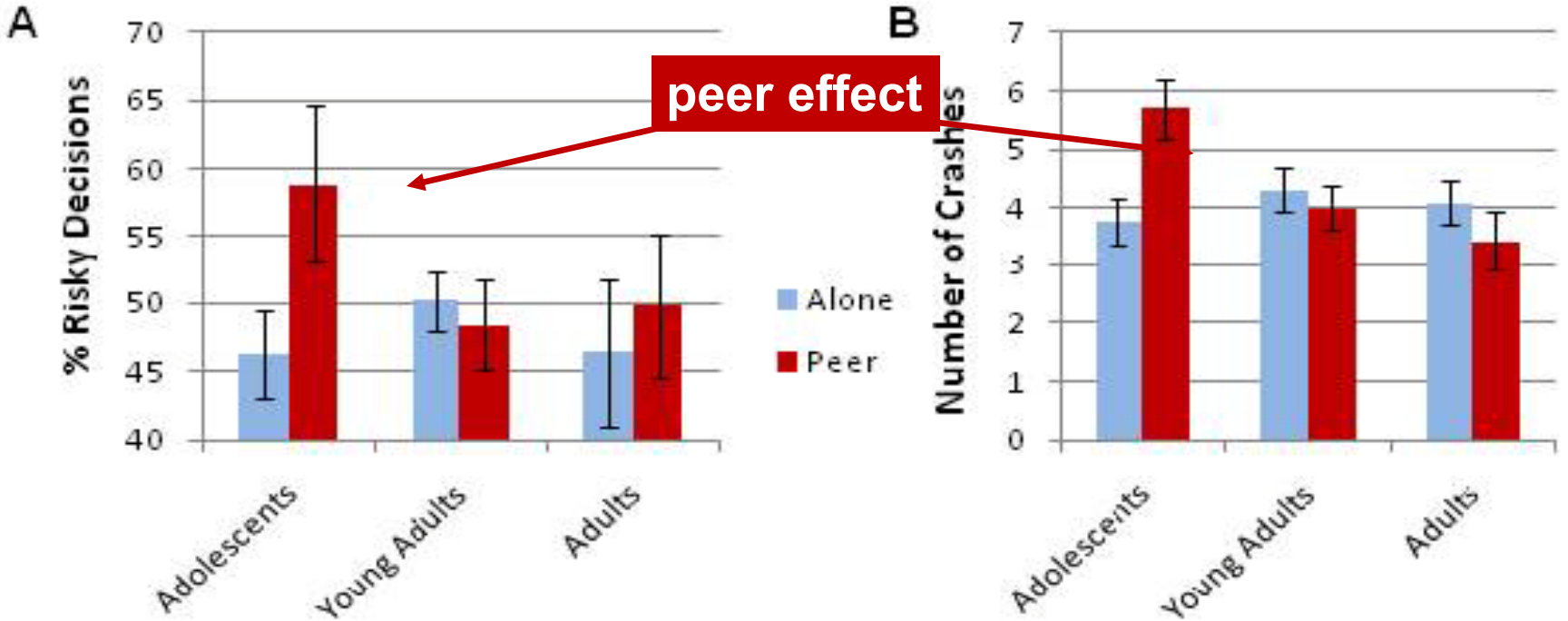
But when that happens, it's not really their fault. It's because their brain hasn't finished developing. The underdeveloped area is called the dorsal lateral prefrontal cortex. It plays a critical role in decision making, problem solving and understanding future consequences of today's actions. Problem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

Impact of Peer Presence on Risky Driving in Simulated Context



Chein et al., in press

Risk-Taking & Self-Control

Resisting the marshmallow and the success of self-control

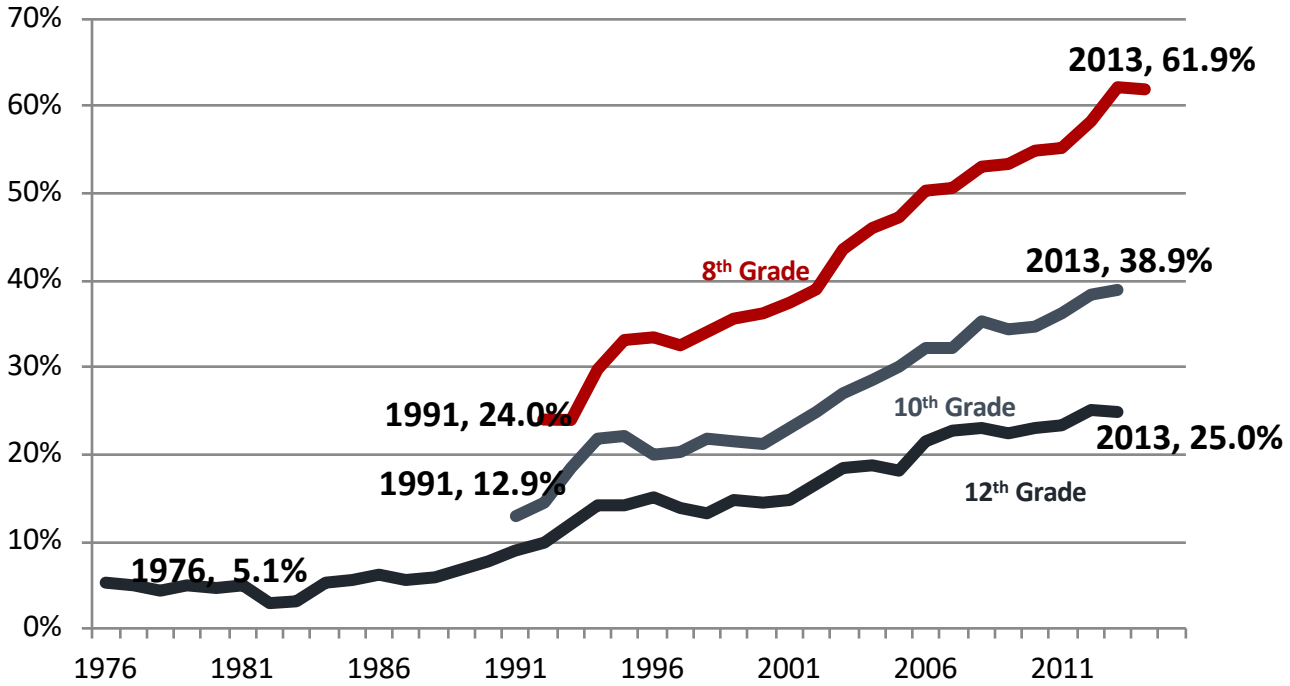
PBS NewsHour

81K views

Adolescent Trends in Risk Taking

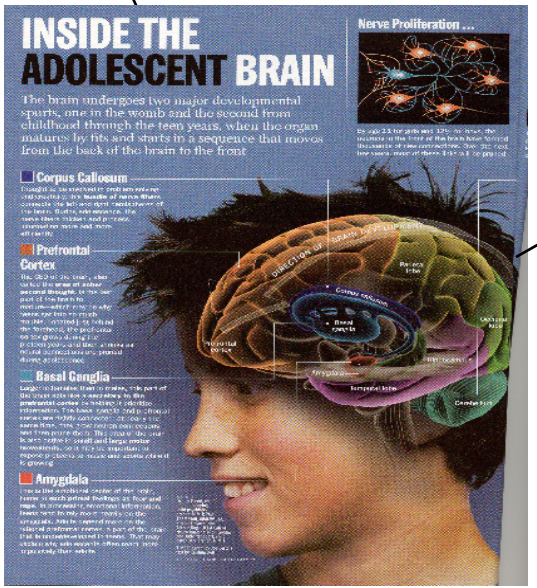
- There are several health indices suggesting that teenagers take less risk than in years past. True
- Declines in prevalence of…
  - Teenage pregnancy
  - Delinquency behaviors
- Increase in prevalence of abstaining from all substances

Abstaining from Illicit Drugs, Alcohol and Cigarettes – Lifetime



Monitoring the Future

1. Brain development



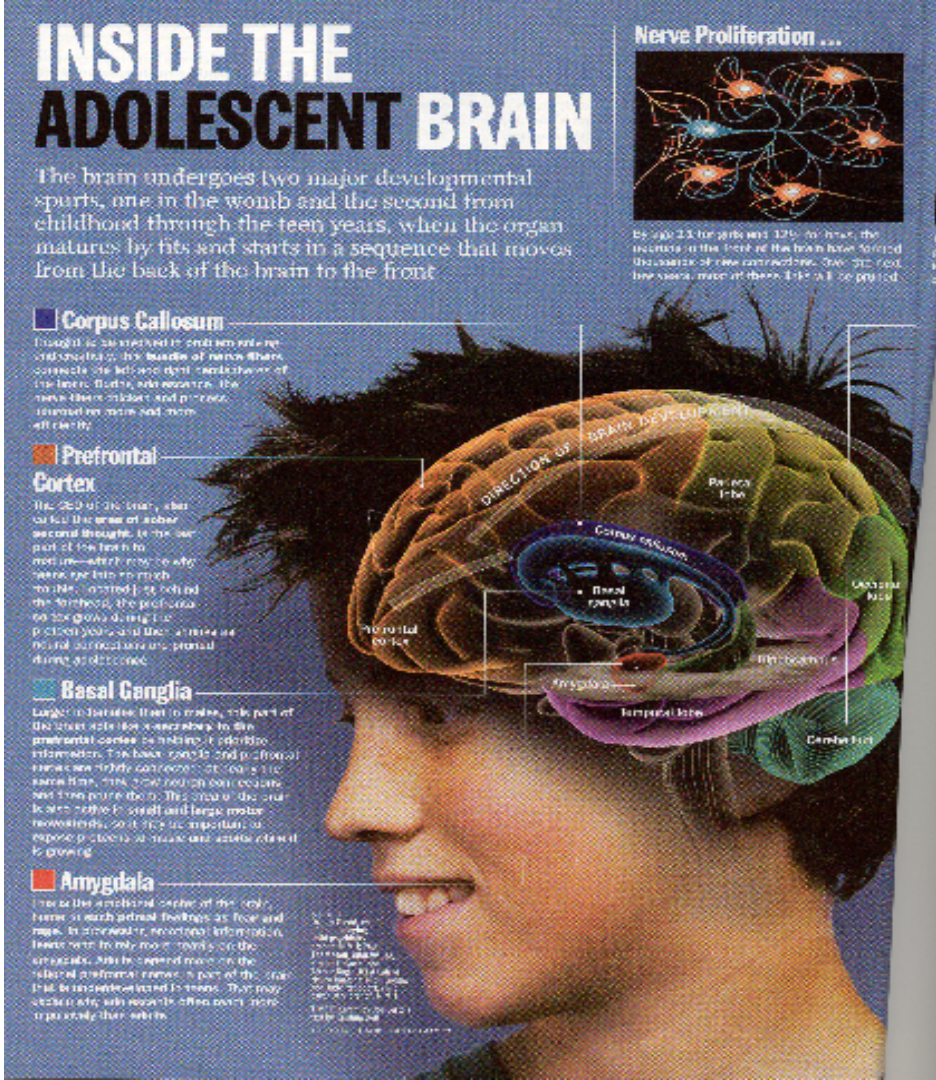
2. Developing brain, drug use and mental health

1. drug use

2. behavioral disorders

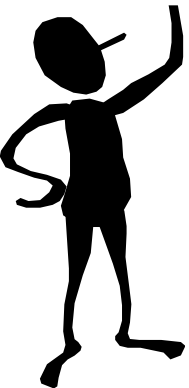
3. early experiences

1. **Health issue: Developing brain and drugs**



Implications of Brain Development for Drug Abuse Vulnerability

Are adolescents more susceptible than adults to drugs?



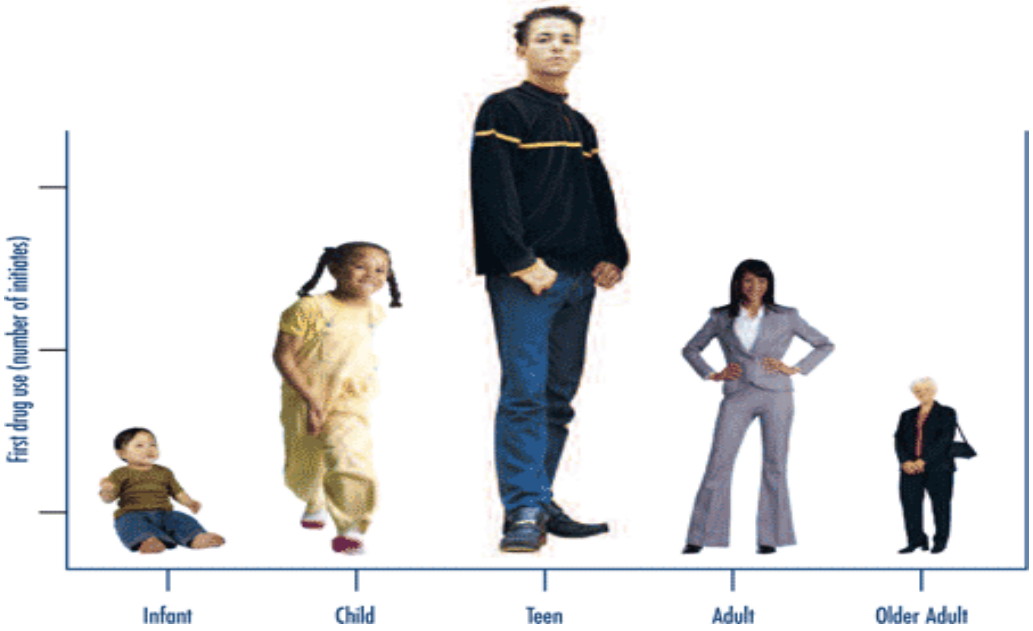
Several lines of evidence

(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.

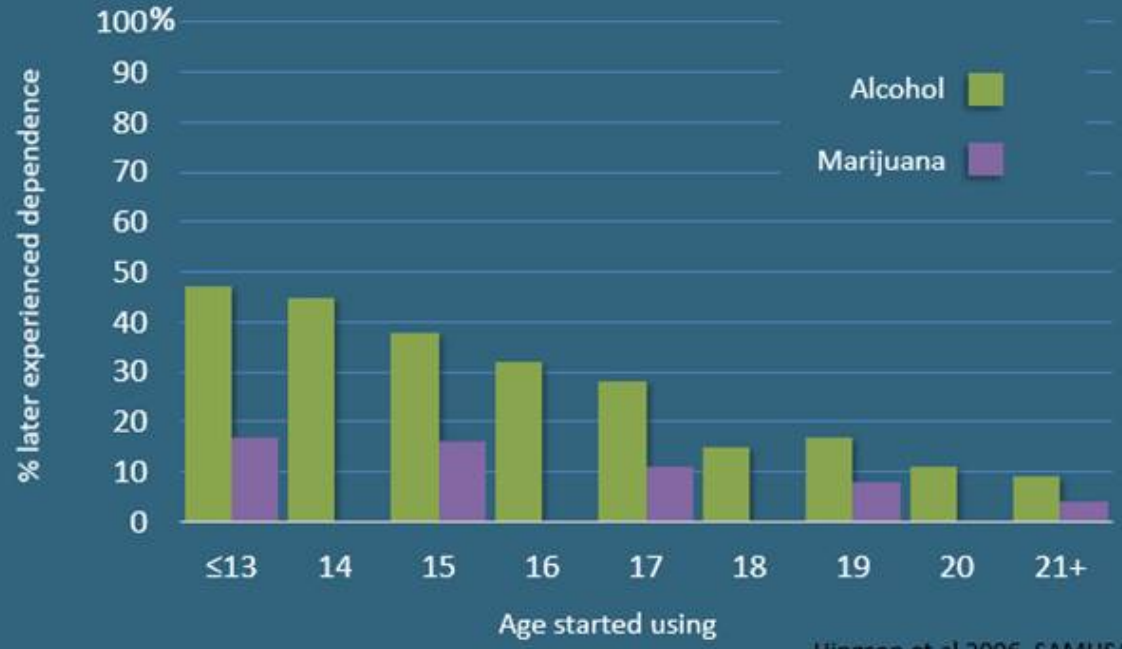
Evidence from epidemiological studies

Drug use starts early and peaks in the teen years



SBIRT

Age at substance use onset and later addiction



Hingson et al 2006, SAMHSA 2010

Implications of Brain Development for Drug Abuse Vulnerability

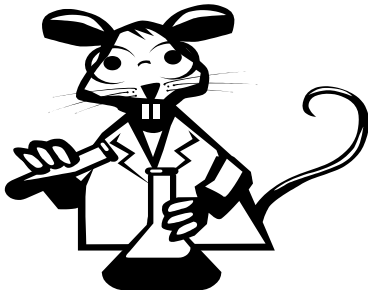
Alcohol

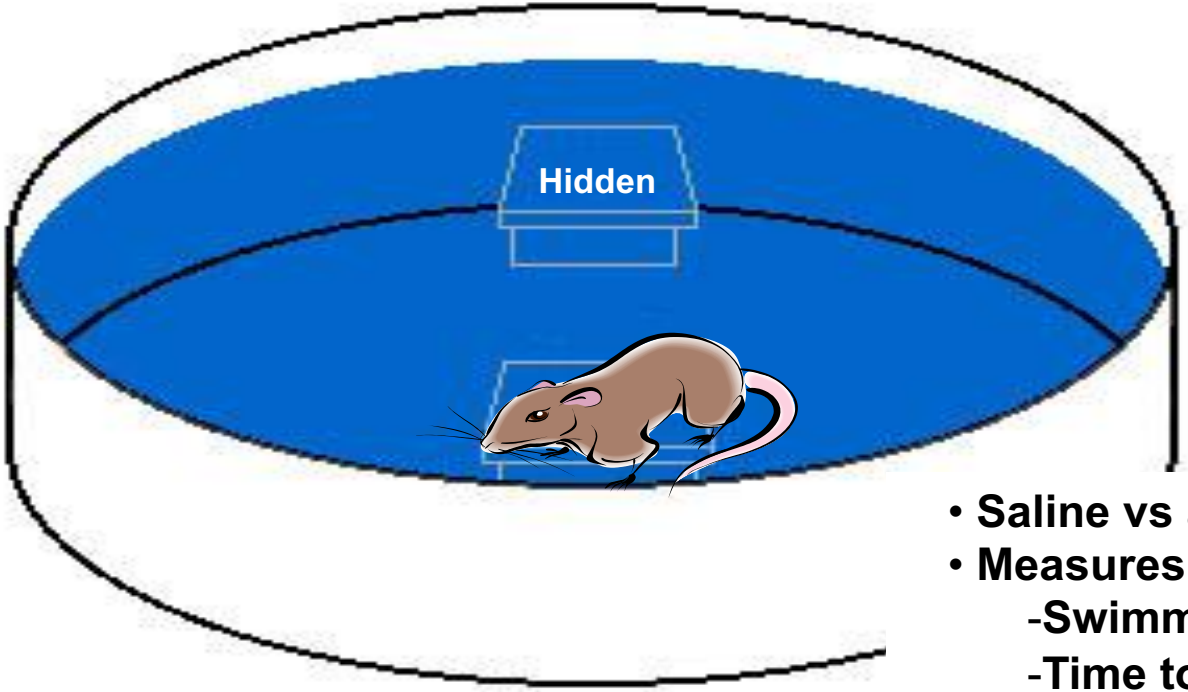
Are adolescents more susceptible to alcohol than adults?

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

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

The Water Maze Test





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

Slide courtesy
Sion Kim Harris, Ph.D.

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: maturation of frontal connectivity disrupted**
  - **Personality data: the developmental improvement of impulsivity was slowed down**

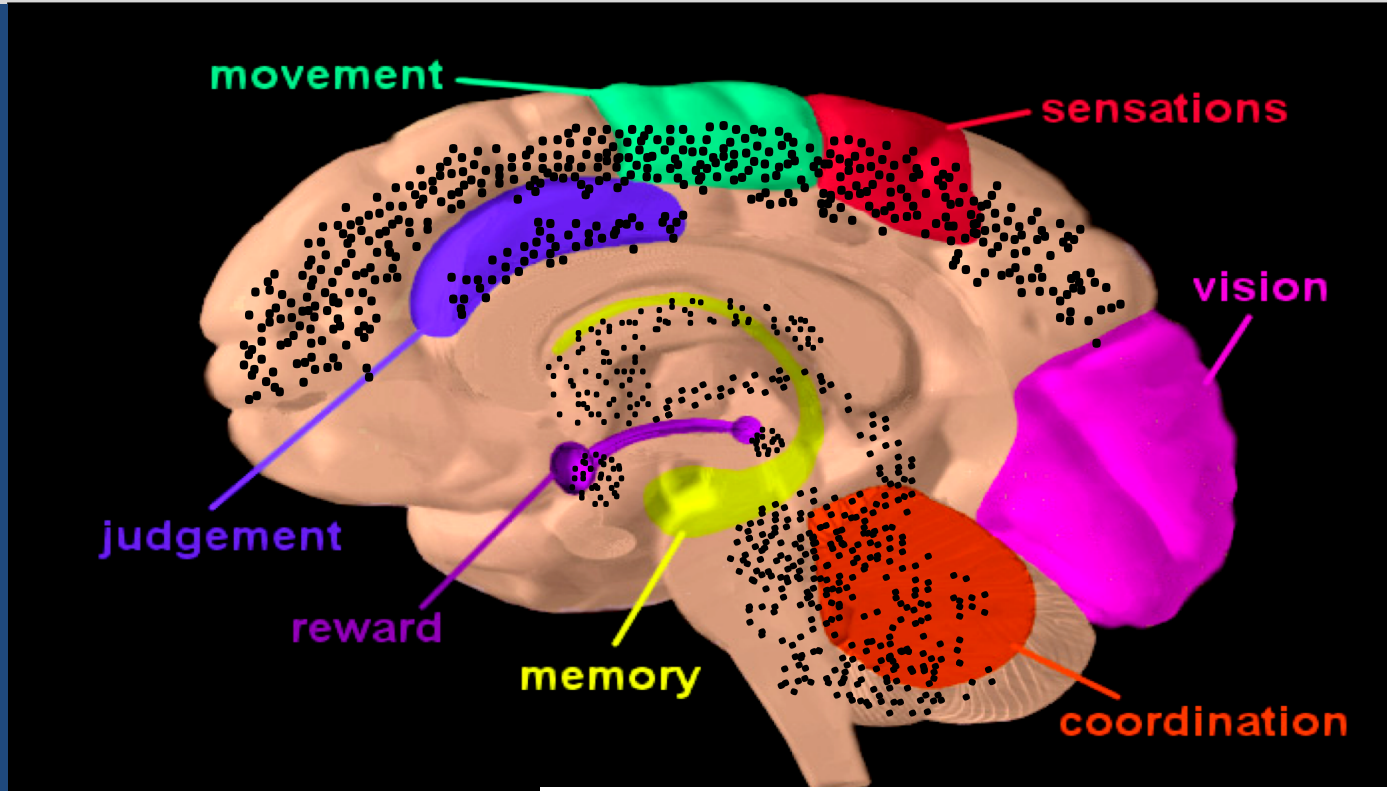
Implications of Brain Development for Drug Abuse Vulnerability

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

Adverse Health Effects of Chronic Marijuana Use: Those Effects Strongly Associated with Initial Marijuana Use Early in Adolescence

(Volkow et al., 2014)

"Low Level of Confidence"

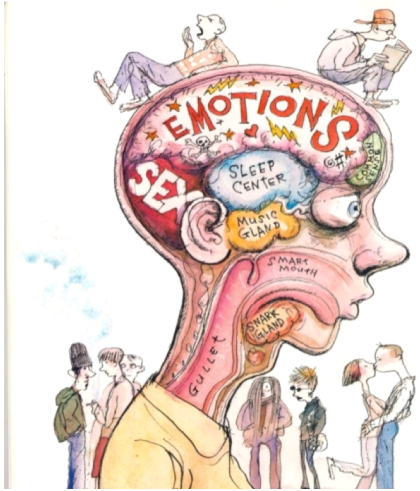
1. Lung cancer

"Medium Level of Confidence"

2. Altered brain development
3. Progression to use of other drugs
4. Cognitive impairment
5. Increased risk of chronic psychosis disorders (including schizophrenia and depression) in persons with a predisposition to such disorders

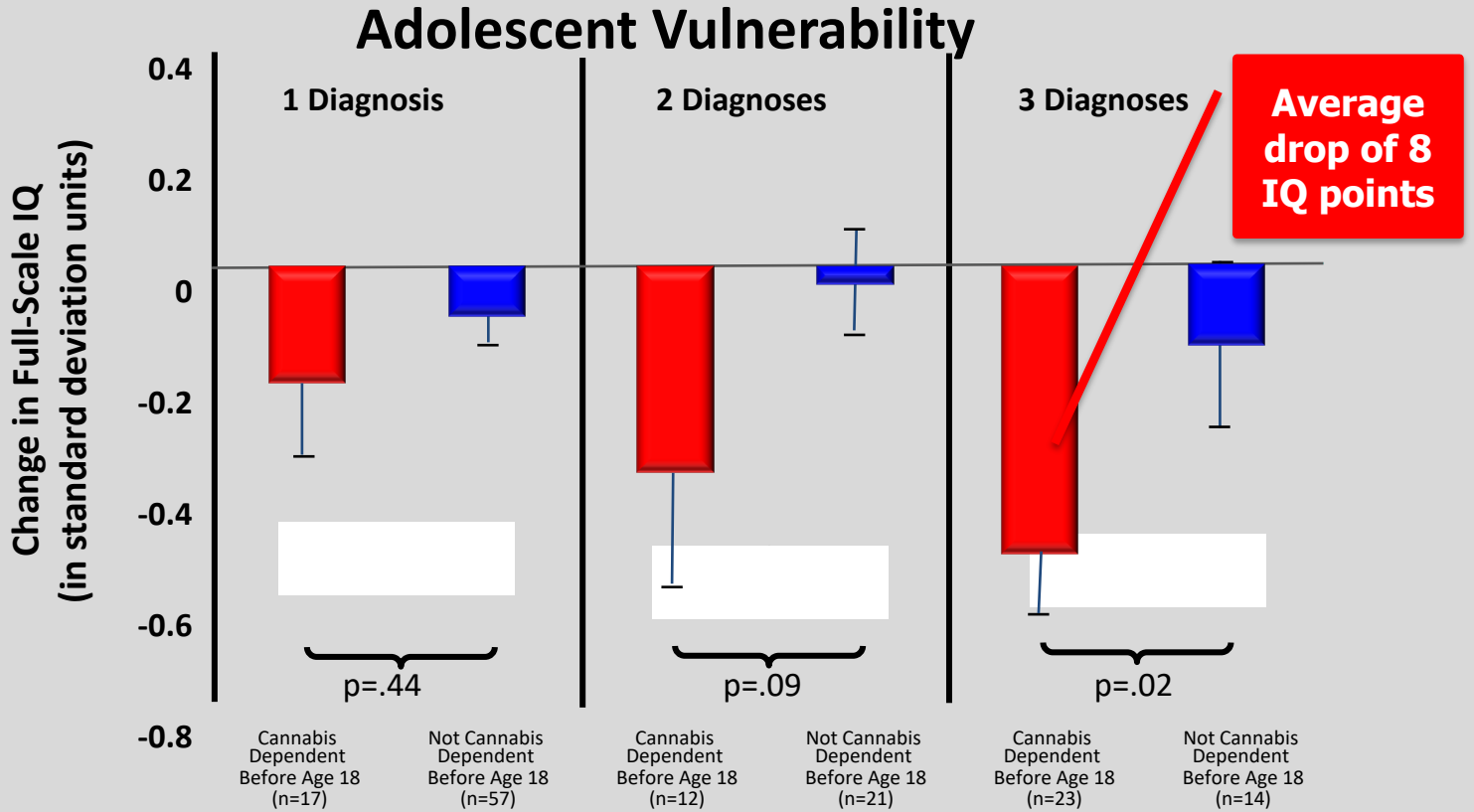
"High Level of Confidence"

6. Addiction
7. Diminished life satisfaction and achievement (including poor educational outcome)
8. Symptoms of chronic bronchitis



Source: US News & World Report, 2005

Marijuana and Cognitive Development



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

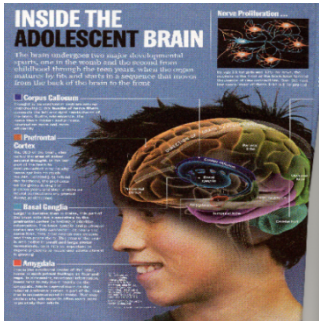
National Institute on Drug Abuse

NIH

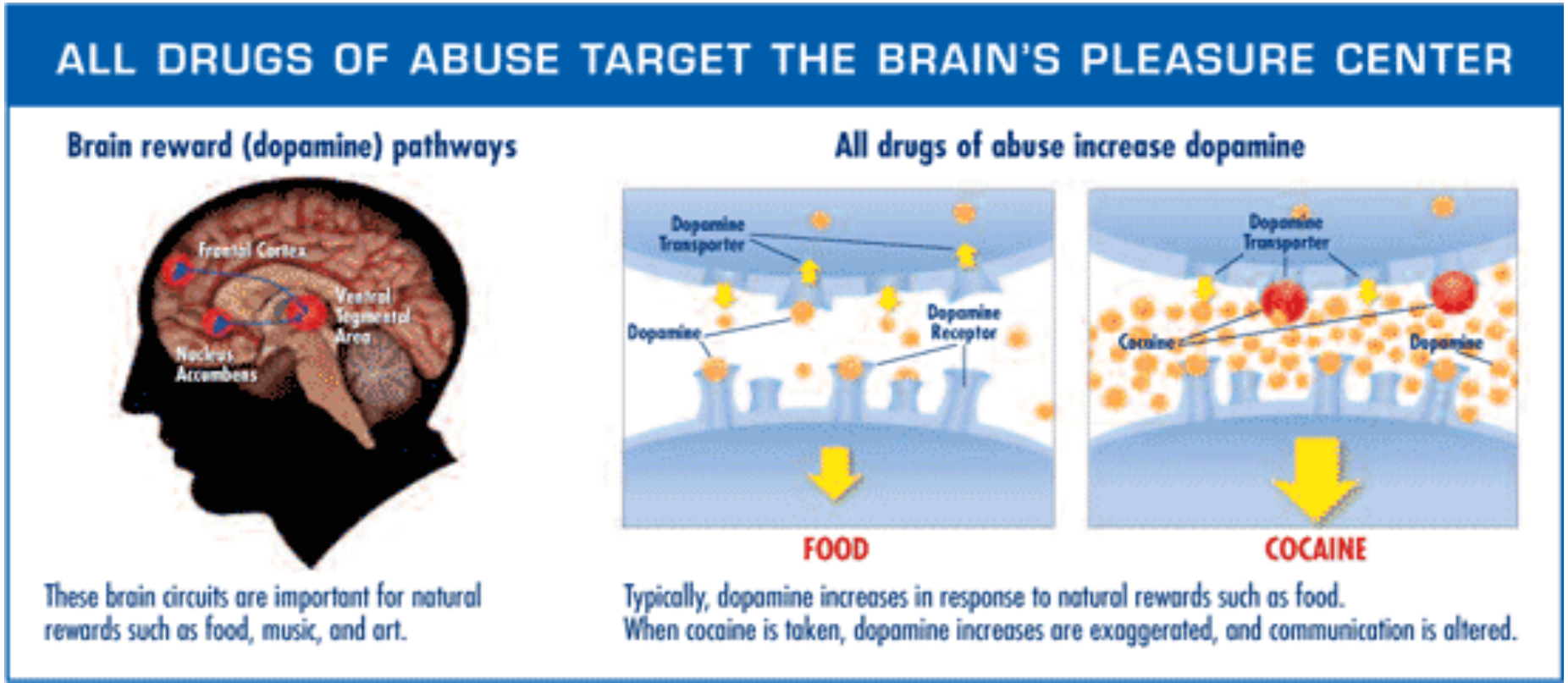
WHY?

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

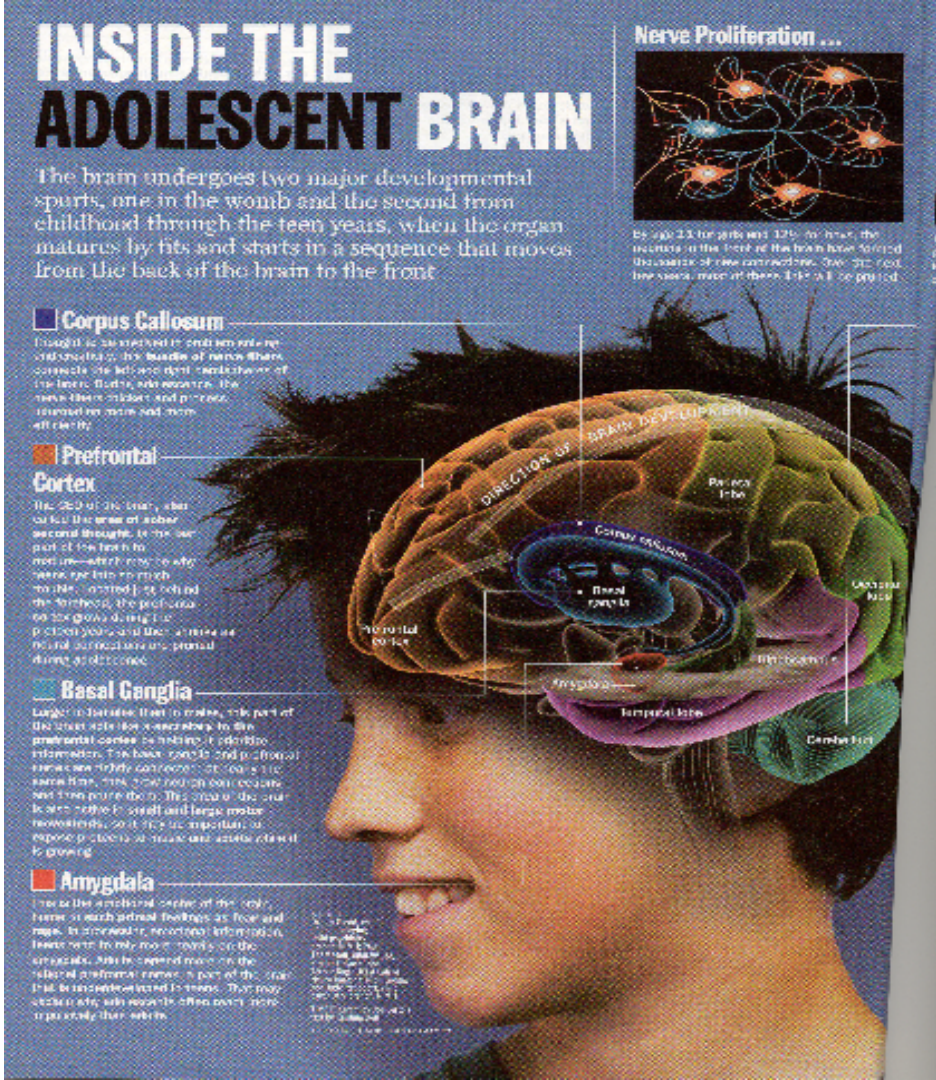
- **Preference for ….**
  1. physical activity
  2. high excitement and rewarding activities
  3. activities with peers that trigger high intensity/arousal
  4. novelty
- **Less than optimal..**
  5. control of emotions
  6. consideration of negative conseq.
- **Greater tendency to…**
  7. be attentive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



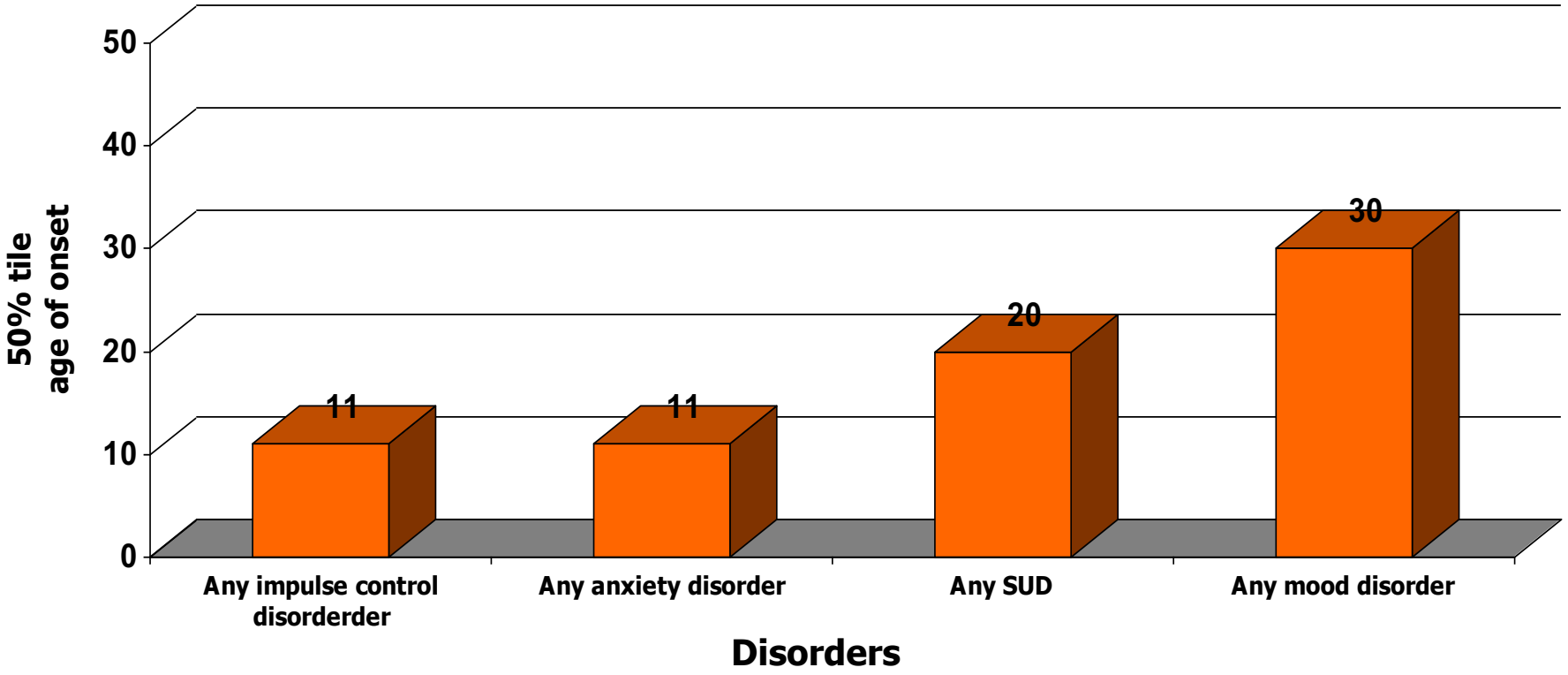
2. Health issue: Brain development and behavioral disorders



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)



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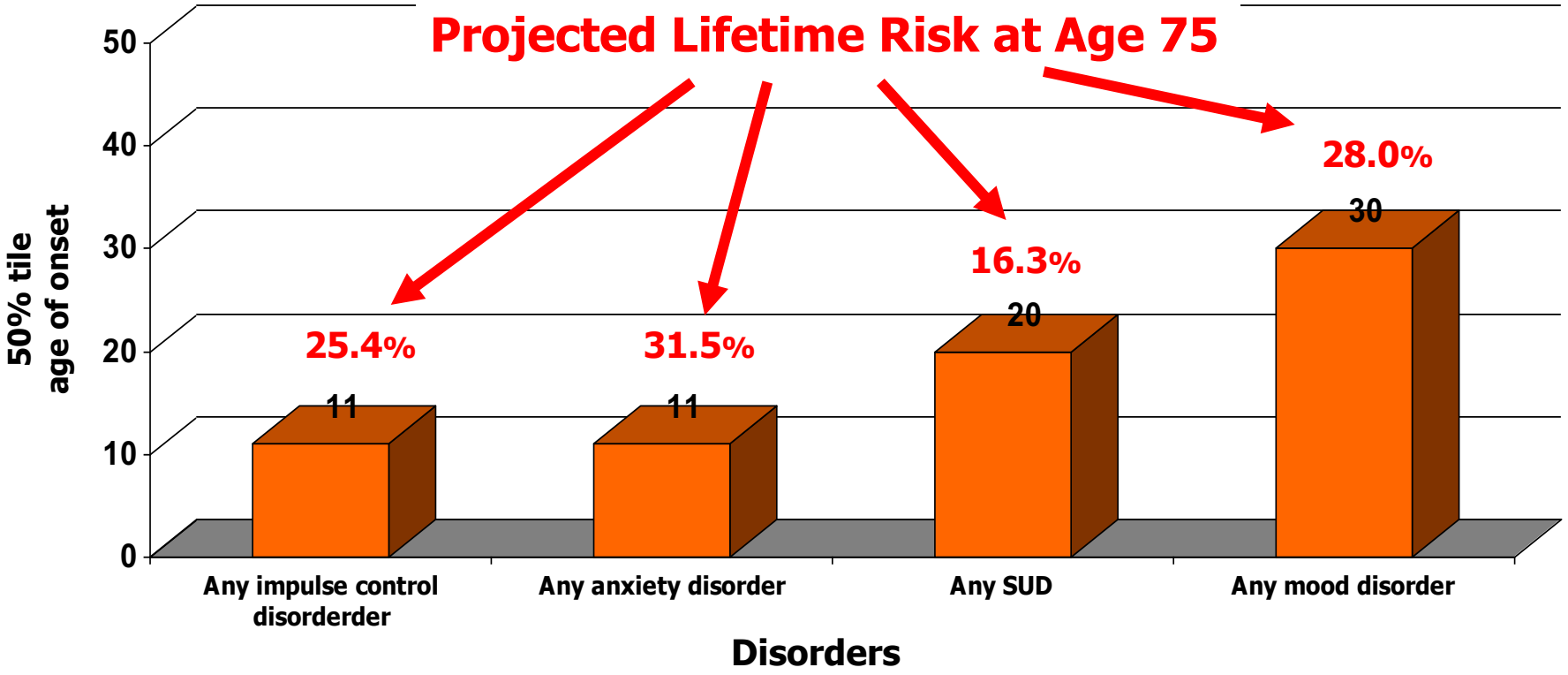
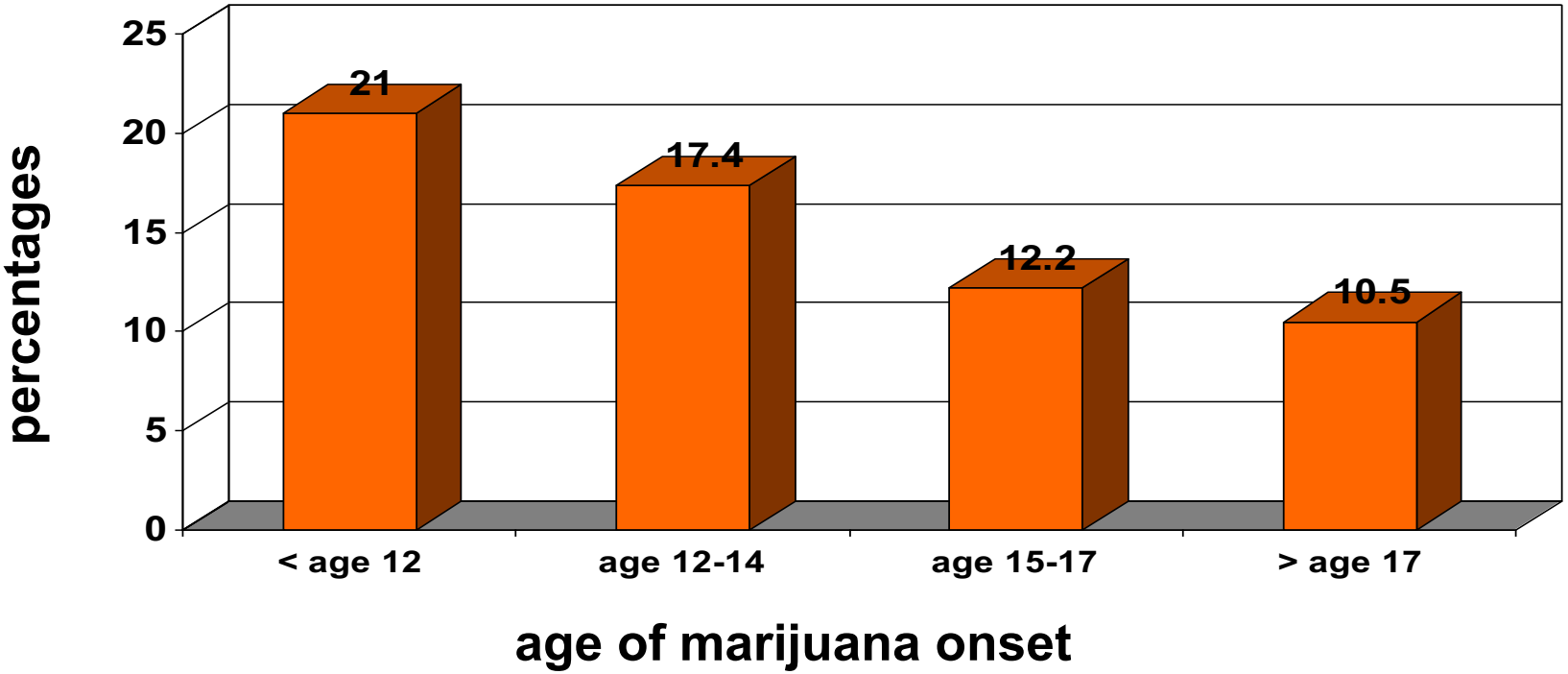


Adolescent Use of Marijuana and Behavioral Disorders

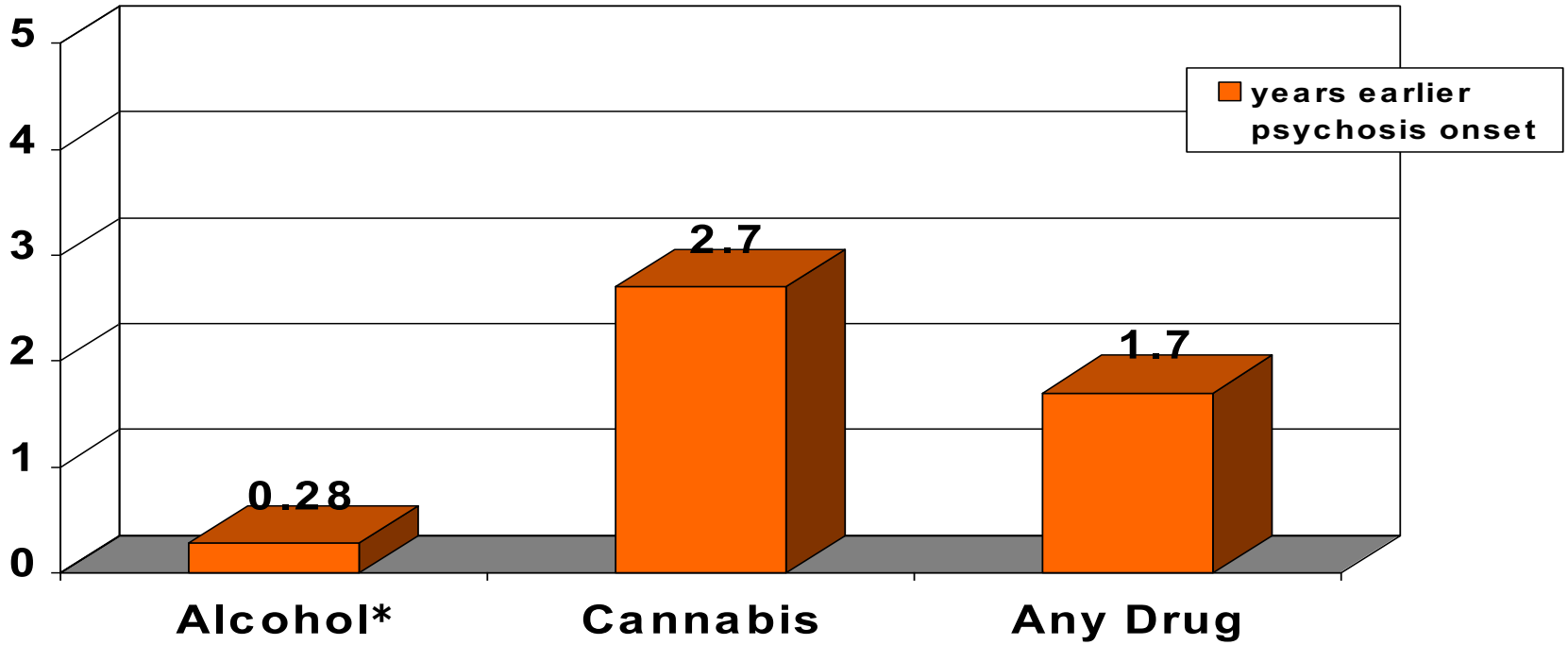
Psychosis: Prevalence of Past Year Serious Mental Illness Among Lifetime Marijuana Users Aged 18+

(SAMHSA, 2005; data collected 2002-2003)



Psychosis: Drug Use and Age at Onset of Psychosis Based on a Meta-Analysis

(Large et al., 2011)



mean years earlier of age at onset of psychosis compared to non-drug using controls

* = nonsig. with controls

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 •

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)**

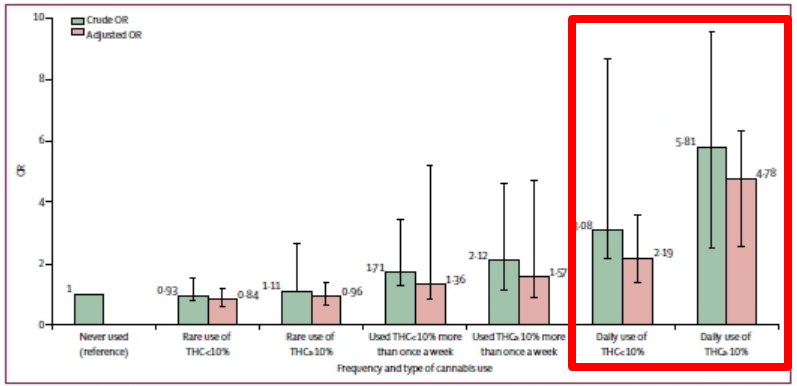


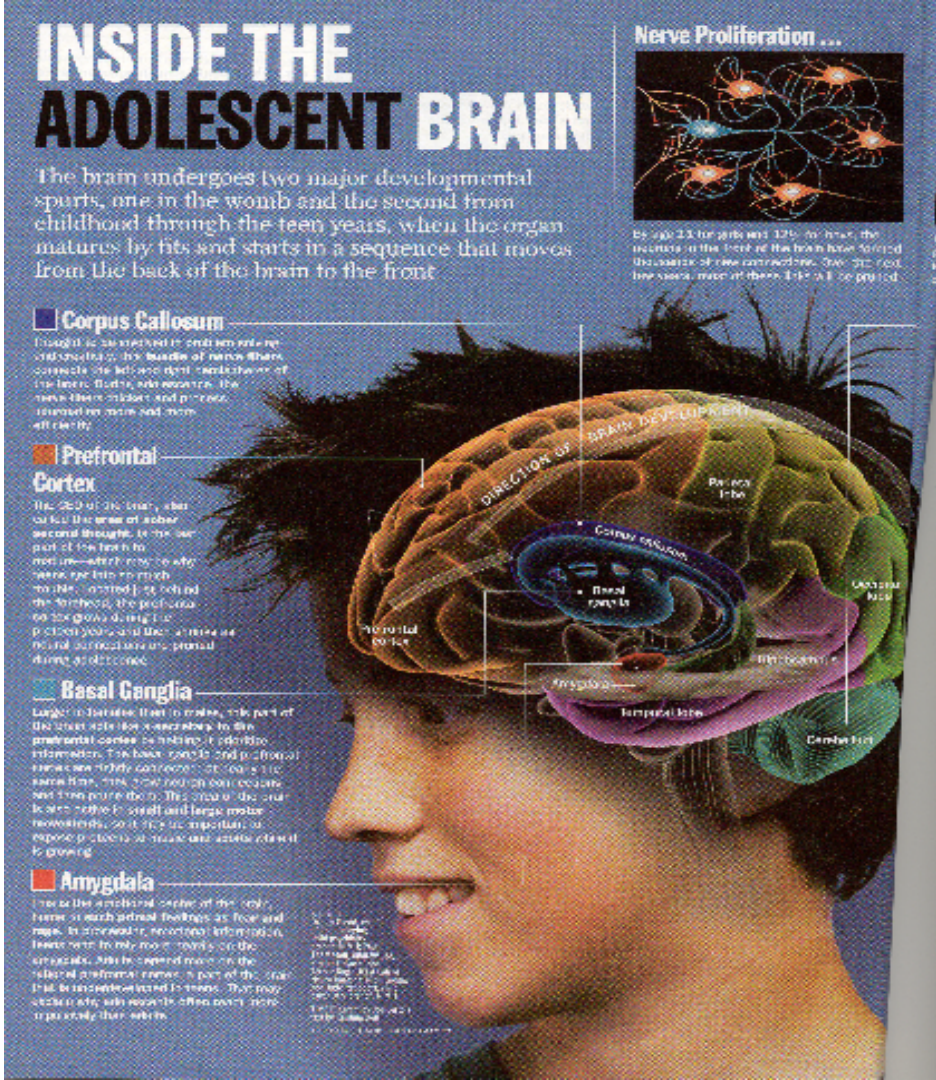
Figure 1: Crude and fully adjusted ORs of psychotic disorders for the combined measure of frequency plus type of cannabis use in the whole sample
Crude ORs are adjusted only for age, gender and ethnicity and fully adjusted ORs are additionally adjusted for level of education, employment status, and use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

Cautionary Notes

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

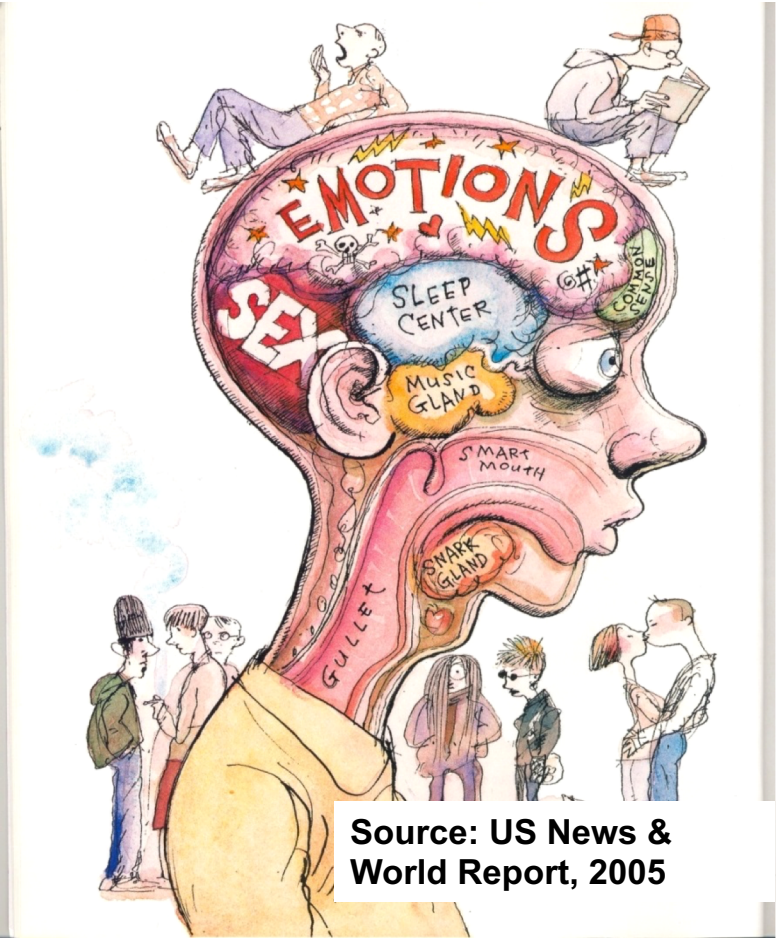
- **Early drug use may be a marker of underlying genetic risk and not causative, or only partially causative.**

3. **Health issue: Impact of early experiences on the developing brain can alter 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*)

Early experiences can alter brain development in positive ways

CDC 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[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

Early experiences can alter brain development in negative ways

SAMHSA
Substance Abuse and Mental Health Services Administration

The impact of child traumatic stress can last well beyond childhood. Associated with…

- **Learning problems**
- **Increased use of health services, including mental health services**

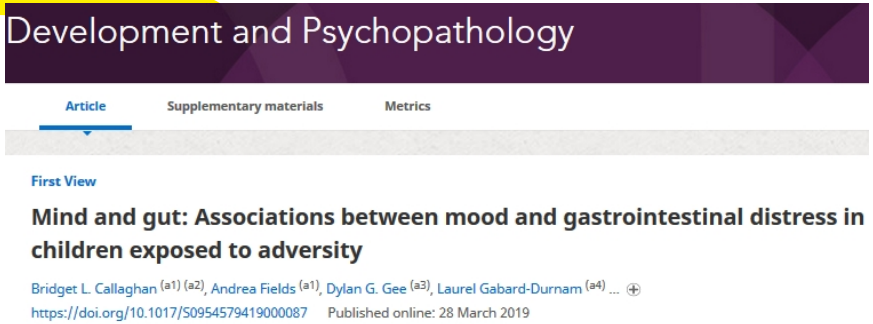
Early experiences can alter brain development in <u>negative</u> ways

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…..**
  - **altered hormonal changes and 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] ...

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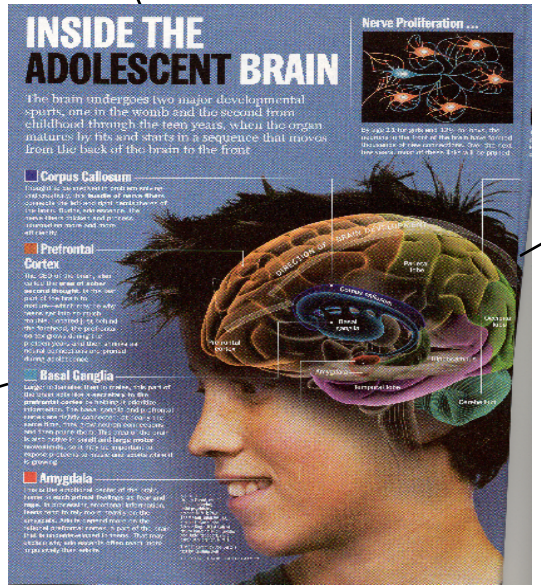
- **Children deprived of parents early in life (orphans), compared to children with parents, revealed….**
  - **increased gastrointestinal symptoms**
  - **pattern of gut microbiomes linked to concurrent and future anxiety, and prefrontal cortex activation to emotional faces**

1. Brain development

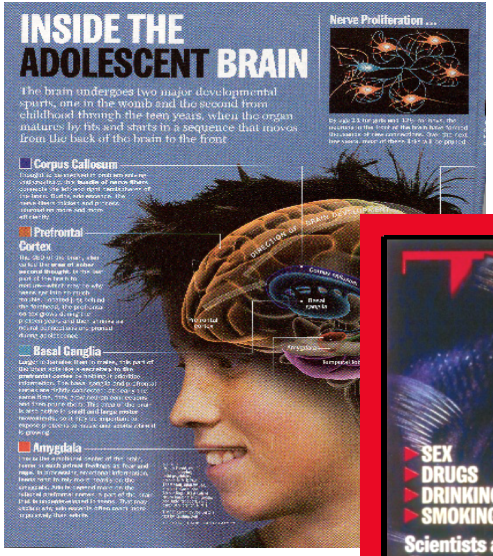


2. Developing brain, drug use and mental health

3. Clinical implications

Brain Development: Implications for Service Providers

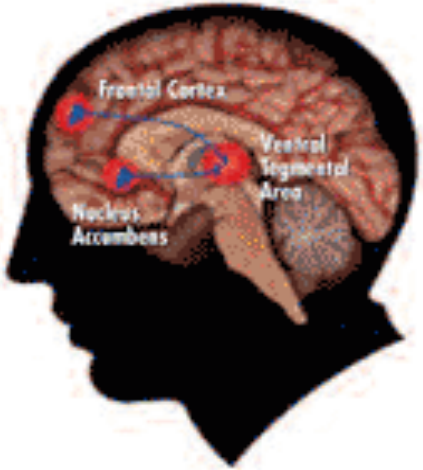
1. **Teach youth about brain development and the science of addiction**



See NIDA's website:
https://www.drugabuse.gov/publications/drugfacts/

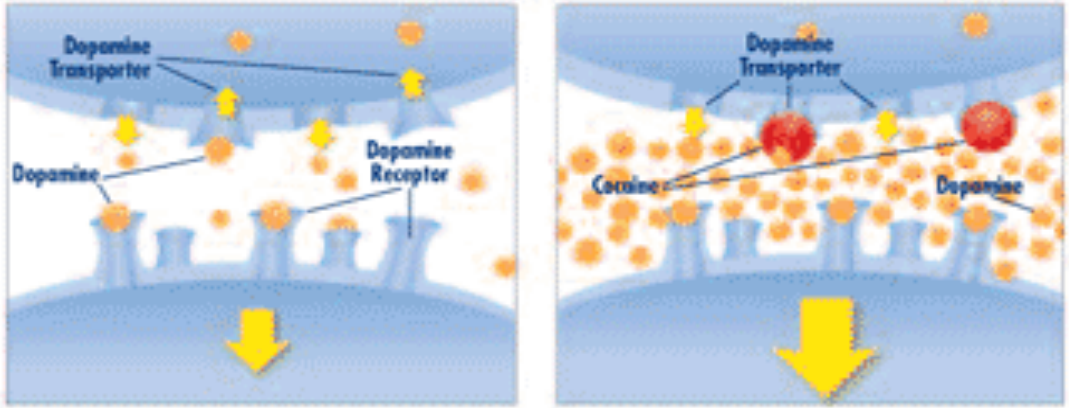
ALL DRUGS OF ABUSE TARGET THE BRAIN'S PLEASURE CENTER

Brain reward (dopamine) pathways



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

All drugs of abuse increase dopamine

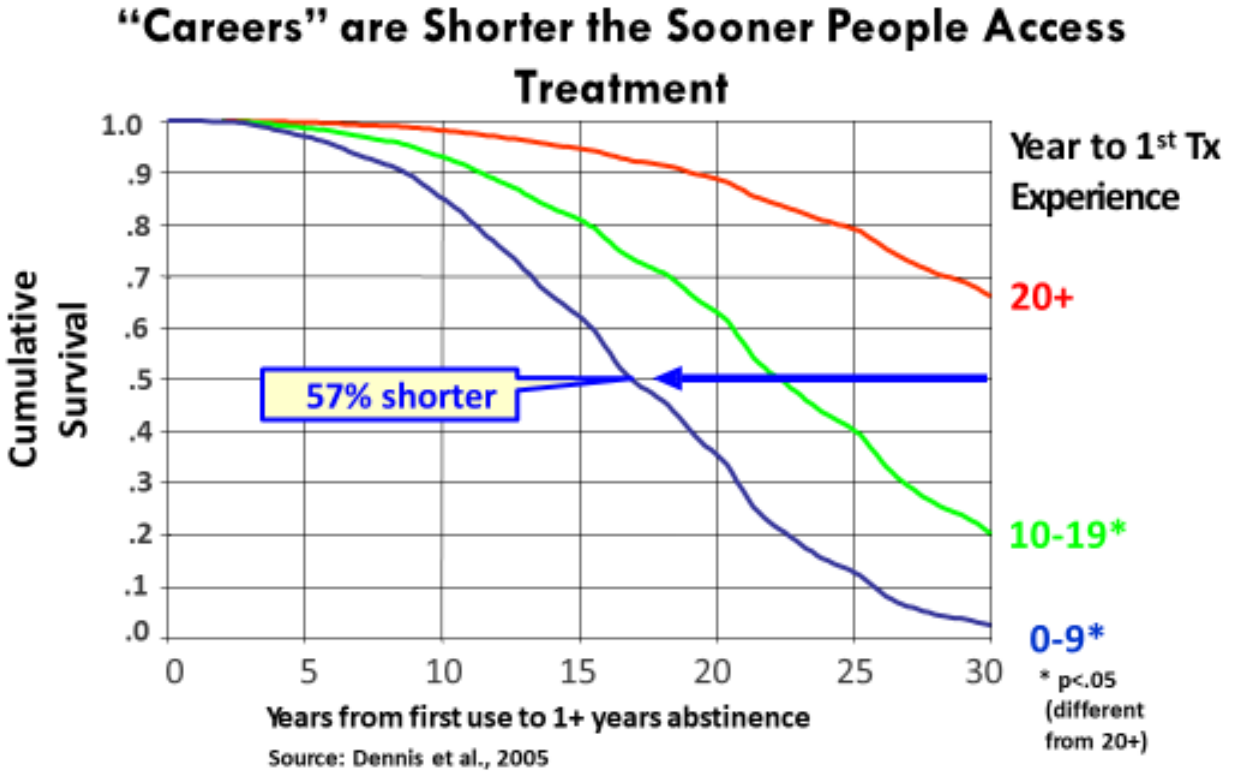


Typically, dopamine increases in response to natural rewards such as food.
When cocaine is taken, dopamine increases are exaggerated, and communication is altered.

Source: https://www.drugabuse.gov.

Brain Development: Implications for Service Providers

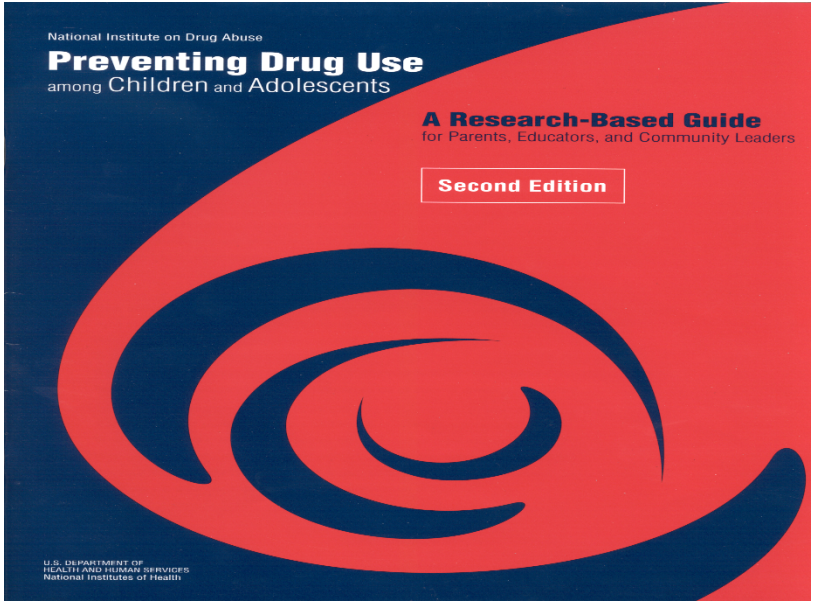
2. **Earlier the treatment the better**



Brain Development: Implications for Service Providers

3. Use evidenced-based approaches prevention

- Prevention: 16 principles of effective prevention summarized in NIDA's 2nd edition of their research guide



http://www.drugabuse.gov

Brain Development: Implications for Service Providers

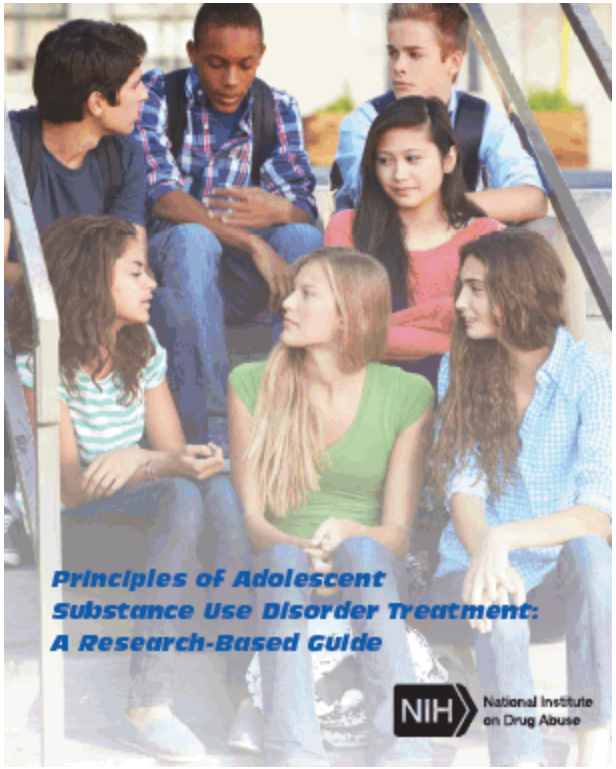
3. Use evidenced-based treatment

- Treatment: Recent literature summary and meta-analysis (Tanner-Smith et al., 2012; Hogue et al., 2018)
  - Treatment "as usual" is no better than prevention education only or no treatment.
  - A wide range of more recent evidenced-based treatments (EBTs) do significantly better.

Evidenced-Based Treatment

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

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



Characteristics of Motivational Interviewing

(Miller & Rollnick, 2013)

- **De-emphasize labels**
- **Emphasis on personal choice and responsibility**
- **Therapist focuses on eliciting the client's own concerns**
- **Resistance is met with reflection and non-argumentation**
- **Treatment goals are negotiated; client's involvement is seen as vital**

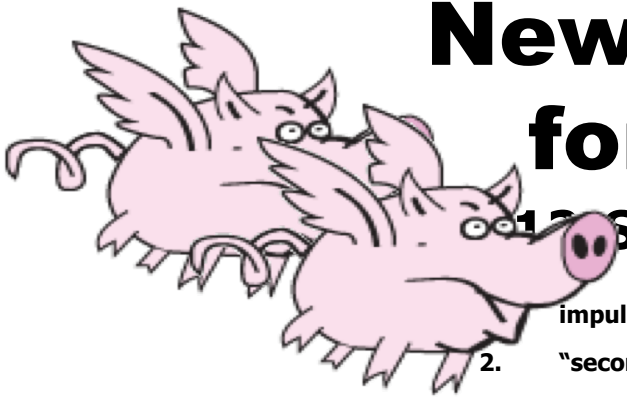
Characteristics of CBT

- Focus on immediate, relevant and specific problems

- Solutions are realistic, concrete, specific

CBT Helpful for Teaching and Supporting Self-Regulation

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



New 12-Step Program for Adolescents ?

12 Steps of Self-Regulation

1. impulse control
2. "second thought" processes
3. social decision making
4. dealing with risk situations
5. taking healthy risks
6. attention regulation
7. anger control
8. modulating reward incentives
9. choosing options
10. considering consequences
11. minimizing arousal
12. dealing with peer influences

Characteristics of Family-Based Approaches (Bobek et al., in press)

- Adolescent's drug problem is part of a family unit problem
- Engage the whole family; key to long-term health of the youth
- Address poor family communication, cohesiveness and problem solving

Brain Development: Implications for Service Providers

4. **Increase the "Cannabis IQ" of Adolescents**

   - **Sources of exercises and quizzes**

     - **www.dfaf.org (Busting the Top Ten Myths of Marijuana)**

     - **www.learnaboutsam.org**

Brain Development: Implications for Service Providers

5. 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. THE PARTNERSHIP™ AT DRUGFREE.ORG

Prevent_Intervene_Get Treatment_Recover

www.drugfree.org

2. NIDA FOR TEENS — National Institute on Drug Abuse for Teens — *Advancing Addiction Science*

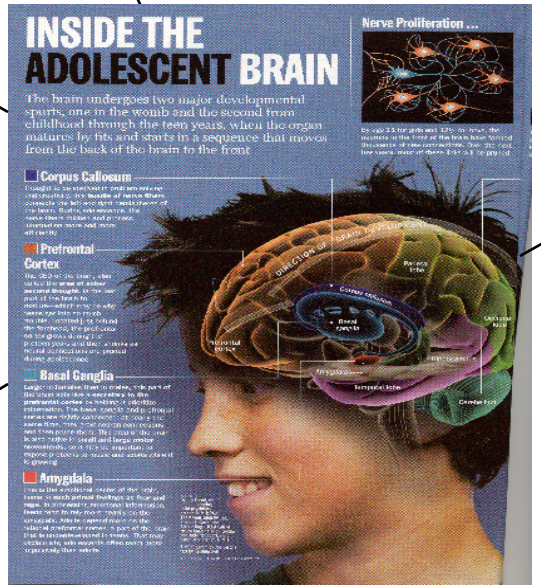
3. 

Preventing Teen Drug Use

Prevent your teen from starting or continuing drug use.

1. Brain development

4. Summary



2. Developing brain, drugs and mental health

3. Clinical Implications

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.**

Summary

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

Teen Brain Development Quiz

1. It is an accepted fact the adolescent brain fully develops at about age 25. What privilege or milestone in the U.S. requires a young person to be 25 years-old? Renting a car
2. There are several health indices suggesting that teenagers take less risk than in years past. True
3. Which is more harmful to the developing brain: Chronic, heavy use of marijuana? Chronic heavy drinking? Debatable

THANK YOU

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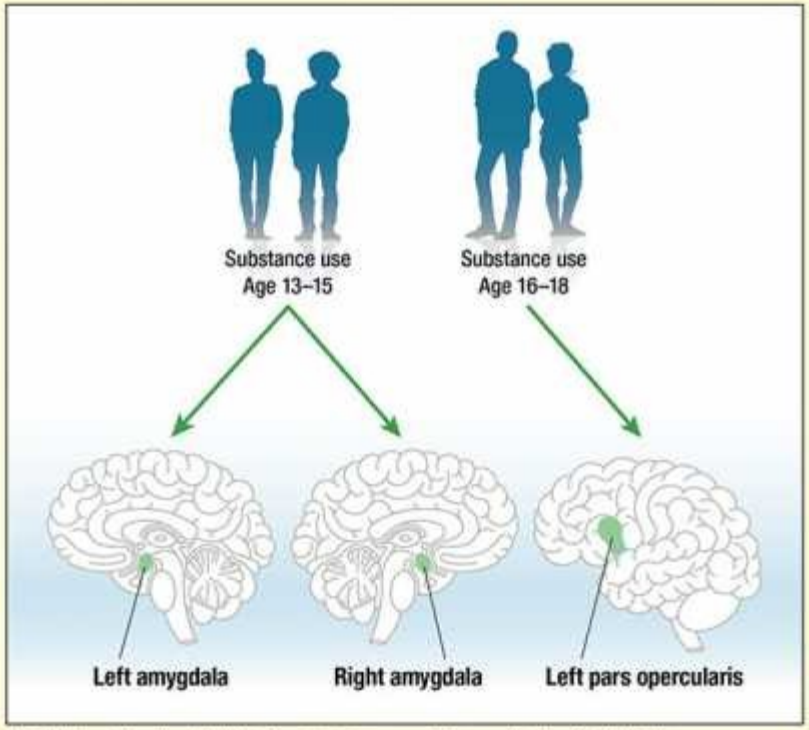
Questions and Discussion

Poly-Substance Abuse
(Windle et al. 2019)



- **Dr. Michael Windle at Emory University and colleagues from other institutions performed magnetic resonance imaging of the brains of 110 25-year-old African Americans. The young men and women had participated in a study of Strong African American Families, a program designed to reduce the impact of childhood poverty on rural African Americans. During the study, they had reported their substance use to researchers annually from age 11 to 21.**

- **The researchers found that higher levels of alcohol, cigarette, and marijuana use before age 19 correlated with smaller gray matter volume in two brain areas (see Figure). The amygdala was smaller in youths who had reported higher use of the substances at ages 12 to 15. The pars opercularis, a subregion of the inferior frontal gyrus, was smaller in those who reported higher use of the substances at ages 16 to 18. To the researchers' knowledge, theirs is the first study to show a relationship between substance exposure and the pars opercularis.**