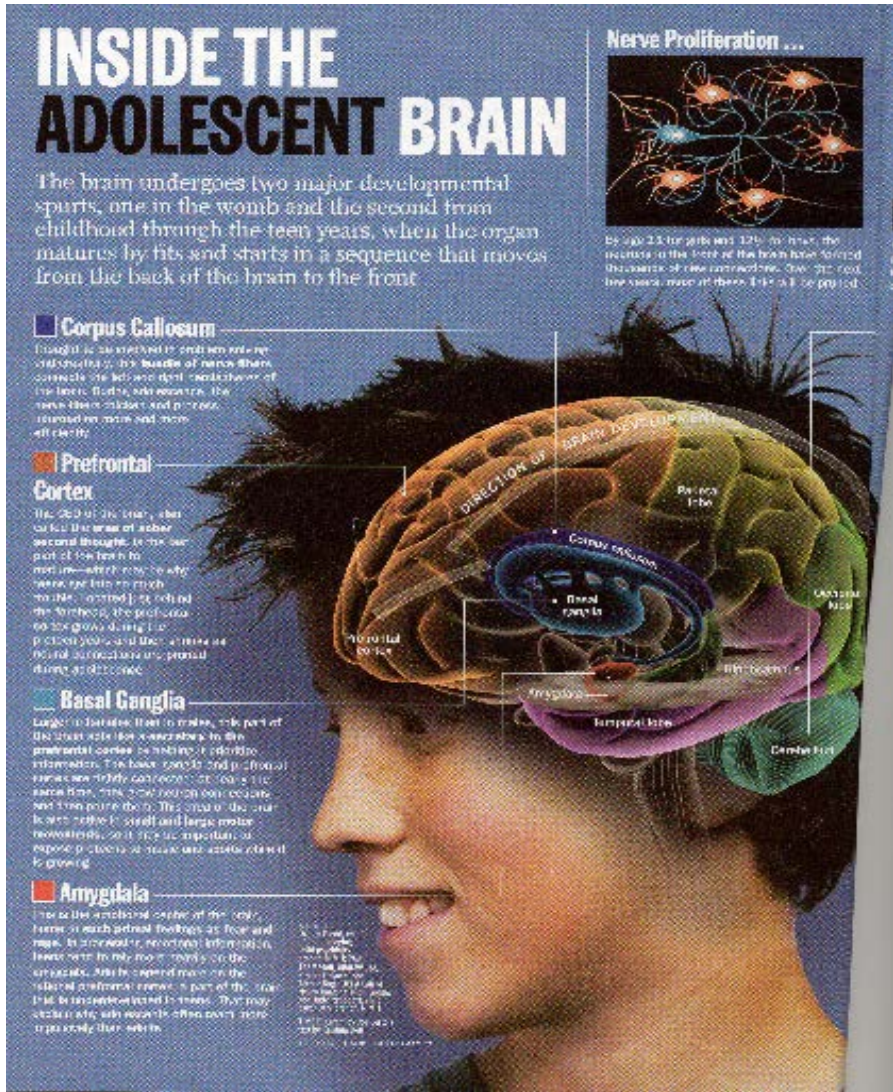
Alcohol and Other Drug Use and Adolescent Brain Development

Ken Winters, Ph.D.
Department of Psychiatry
University of Minnesota
winte001@umn.edu

Prevention, Law Enforcement and Coalitions: Developing Lasting Partnerships to Advance Environmental Prevention

NY OASAS, 2013



1. Addiction as brain disease

2. Brain development

3. Drug susceptibility

4. Summary

5. Clinical opportunities

Acknowledgements

This work was prepared by Ken Winters, Ph.D.
Professor, Dept. of Psychiatry, University of Minnesota

Support for this work was provided by the Archie and Bertha Walker Foundation, RKMC Private Foundation, and the Mentor Foundation.

The author expresses gratitude to these colleagues whose work and consultation significantly contributed to the development of this presentation:

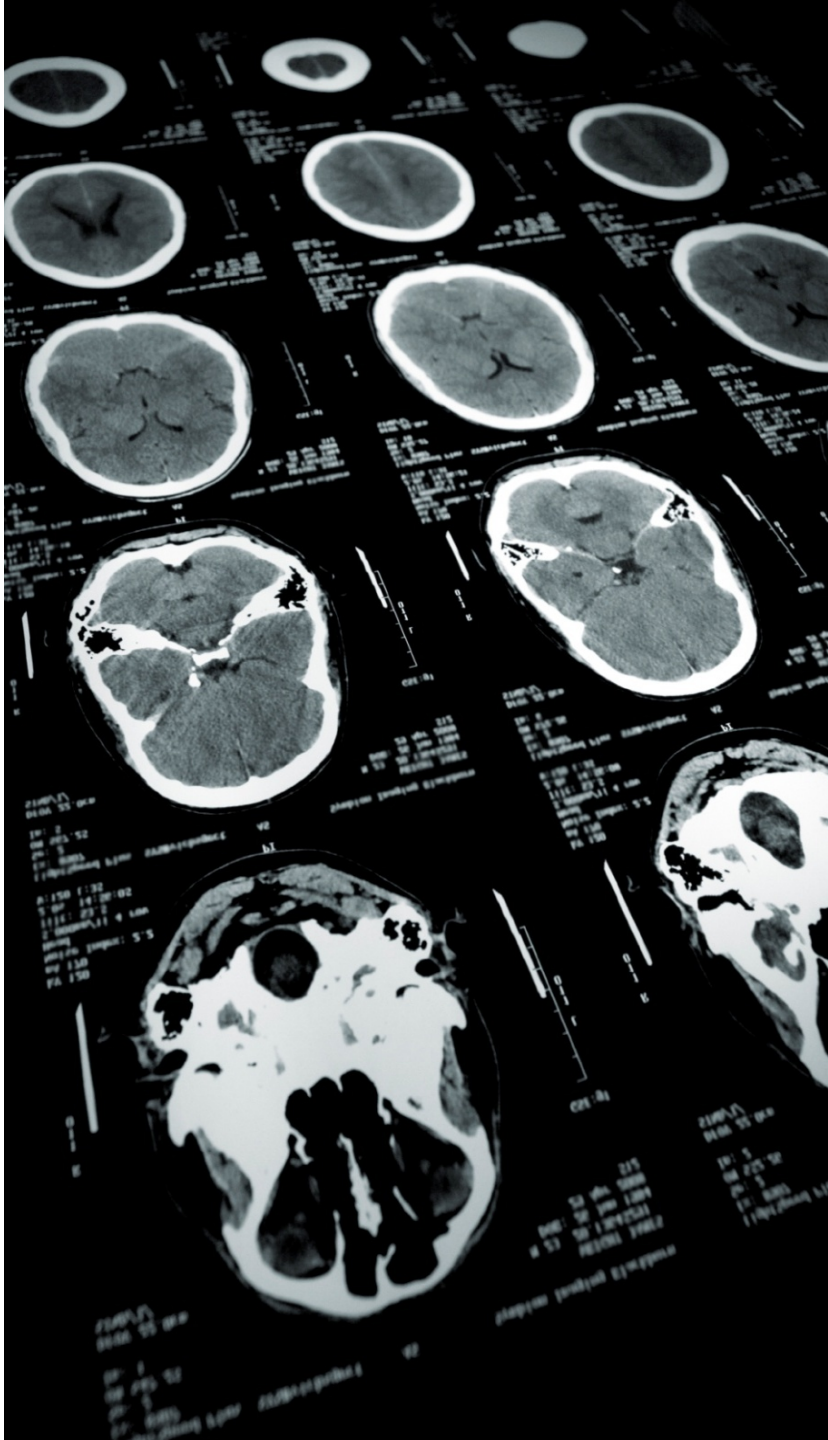
Jay Giedd, National Institute on Mental Health (USA)
Jeff Lee, Mentor Foundation (UK)
Tom McLellan, Treatment Research Institute (USA)
Linda Spear, SUNY at Binghamton (USA)
Susan Tapert, University of California – San Diego (USA)

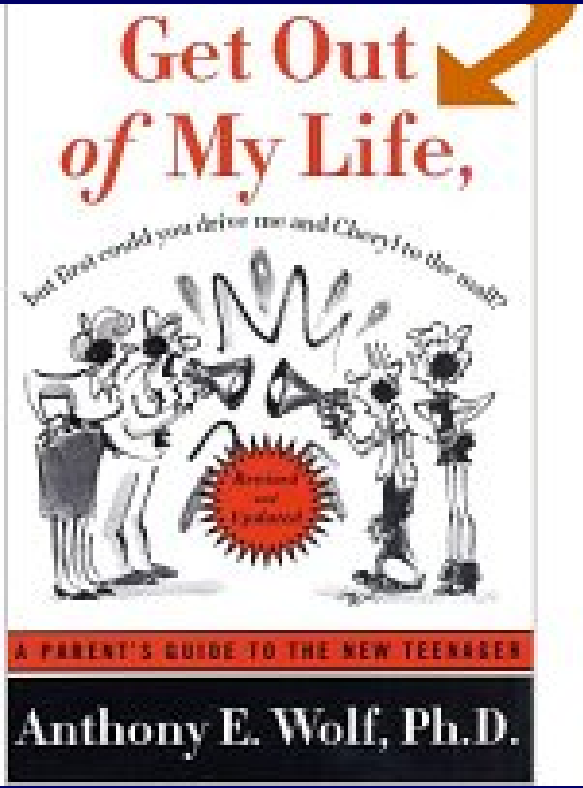
Emerging Science:

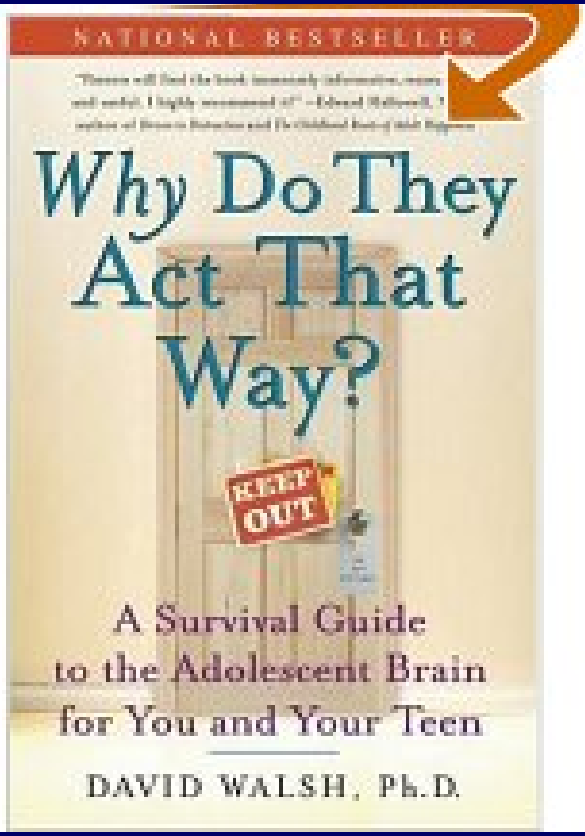
Brain Imaging

New insights because:

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



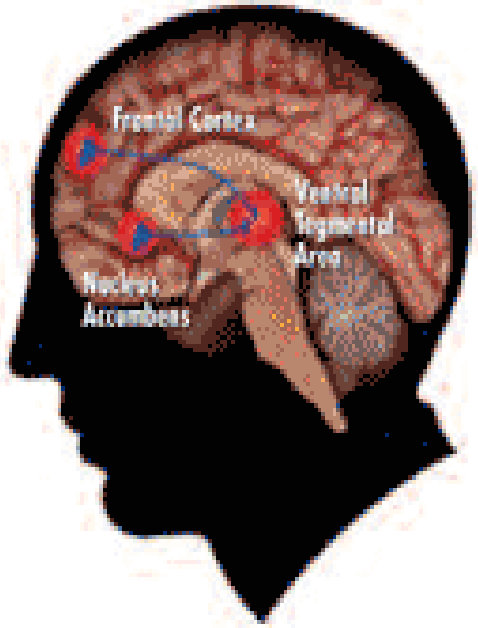

Get Out of My Life,
but first could you drive me and Cheryl to the mall?
A PARENT'S GUIDE TO THE NEW TEENAGER
Anthony E. Wolf, Ph.D.


NATIONAL BESTSELLER
Why Do They Act That Way?
KEEP OUT
A Survival Guide to the Adolescent Brain for You and Your Teen
DAVID WALSH, Ph.D.

1. Addiction as brain disease

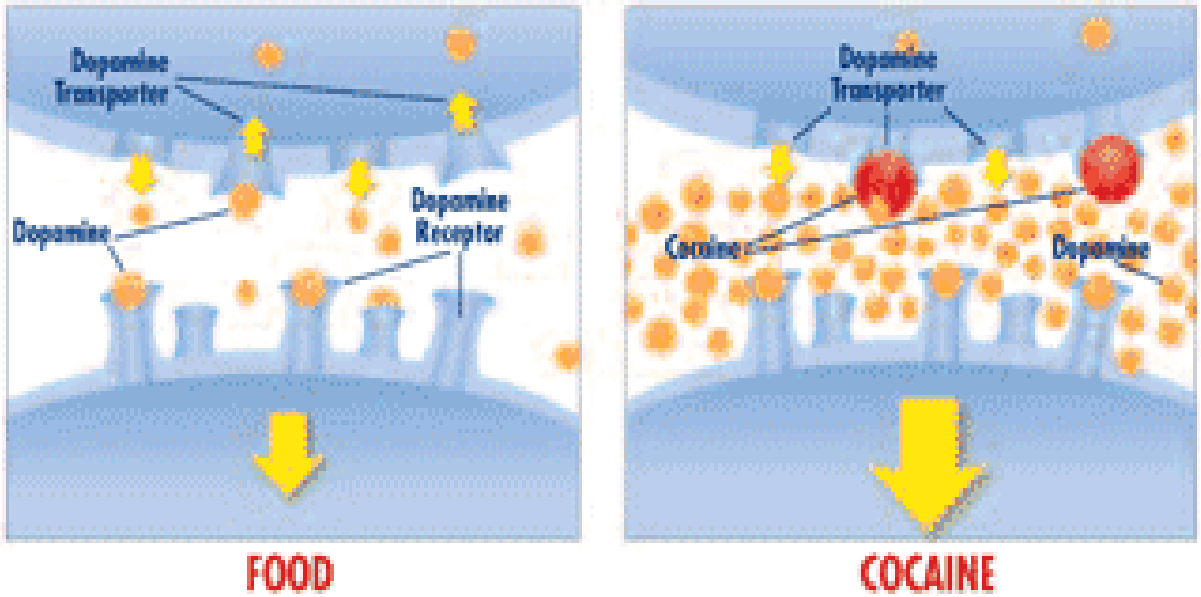
ALL DRUGS OF ABUSE TARGET THE BRAIN'S PLEASURE CENTER

Brain reward (dopamine) pathways



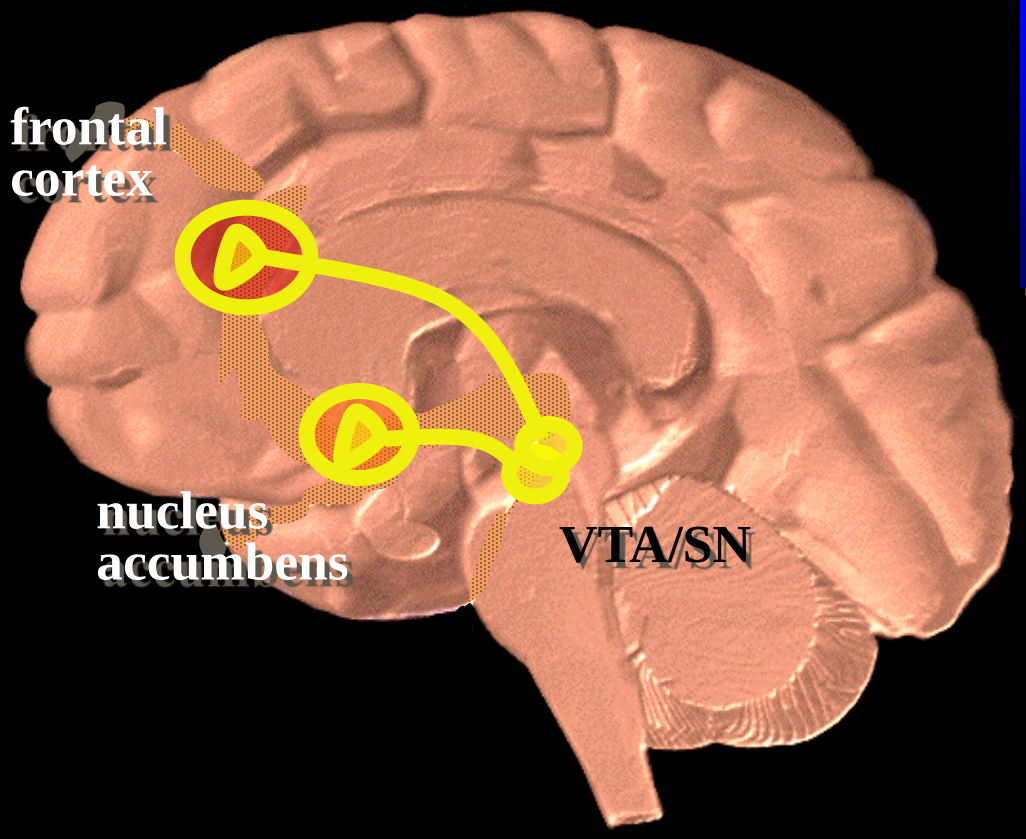
These brain circuits are important for natural rewards such as food, music, and art.

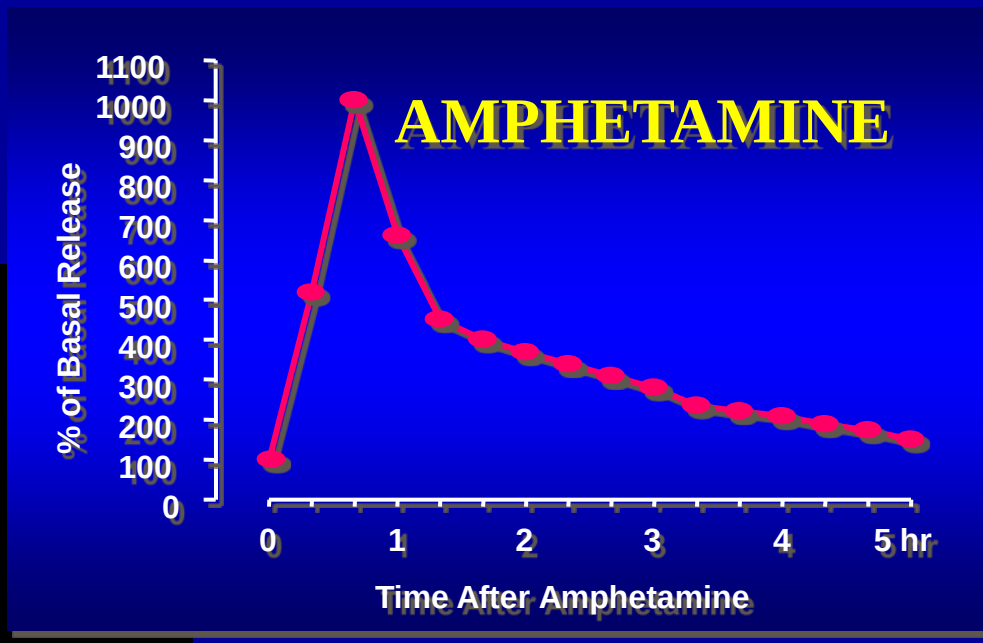
All drugs of abuse increase dopamine

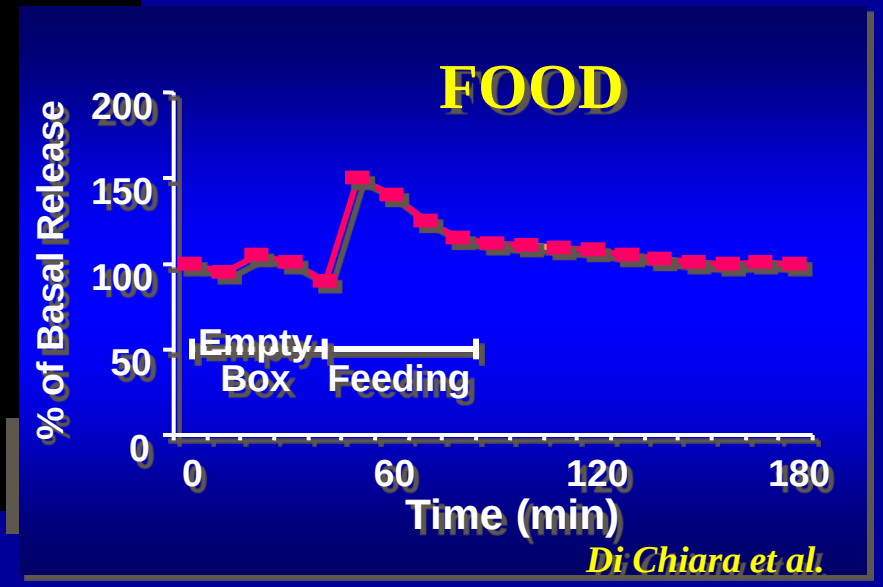


Typically, dopamine increases in response to natural rewards such as food.
When cocaine is taken, dopamine increases are exaggerated, and communication is altered.

Dopamine Neurotransmission

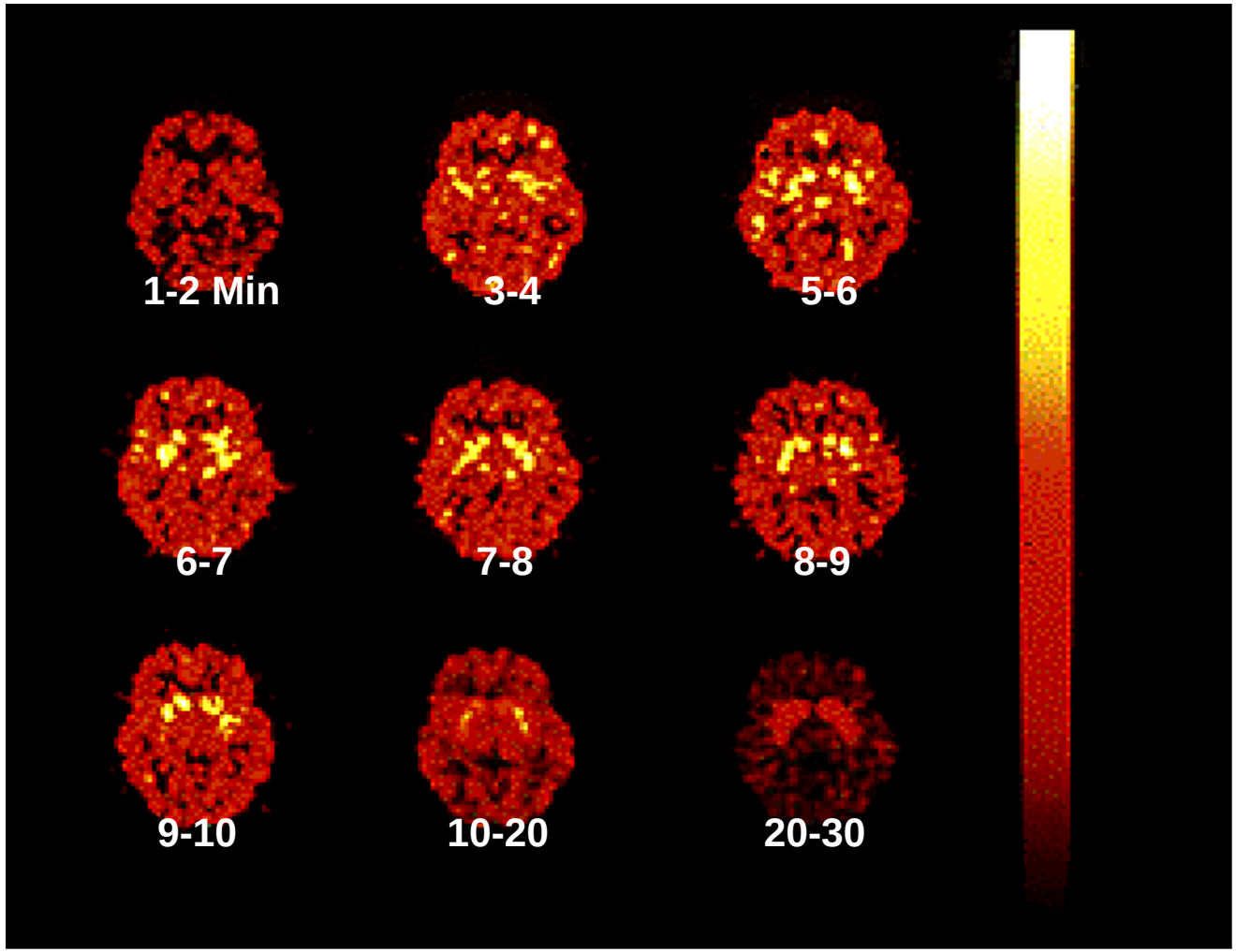






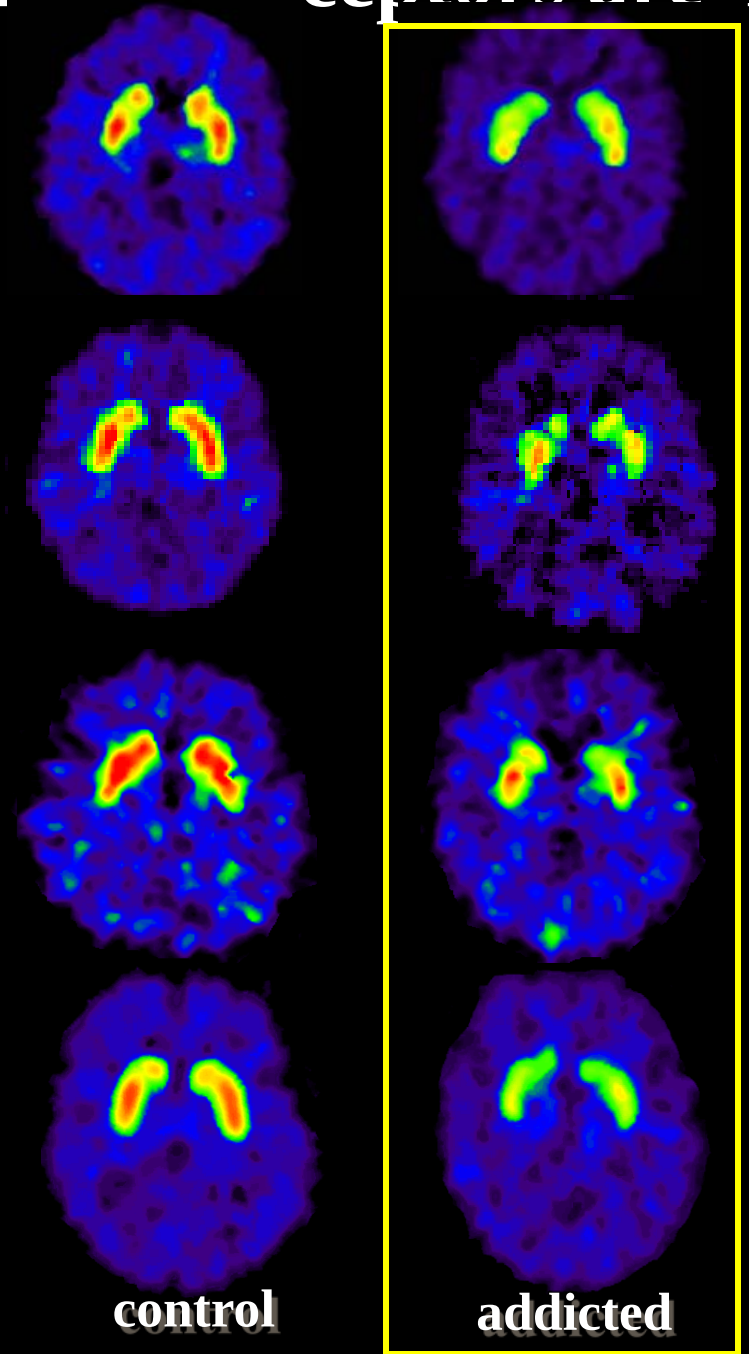
Your Brain on Cocaine

PET scan



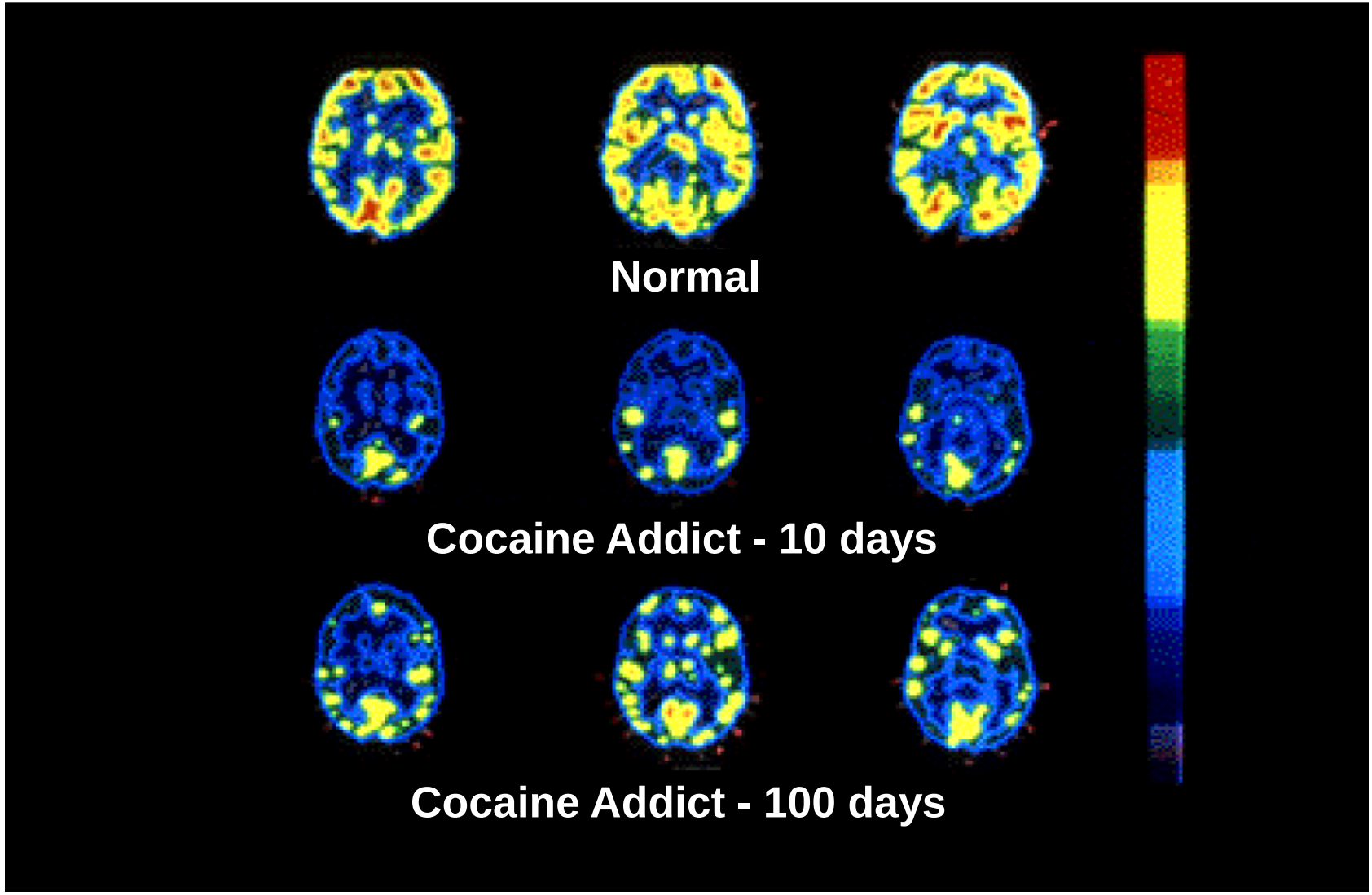
Yellow = cocaine is binding or attaching itself to areas of the brain

Dopamine D2 Receptors are Lower in Addiction



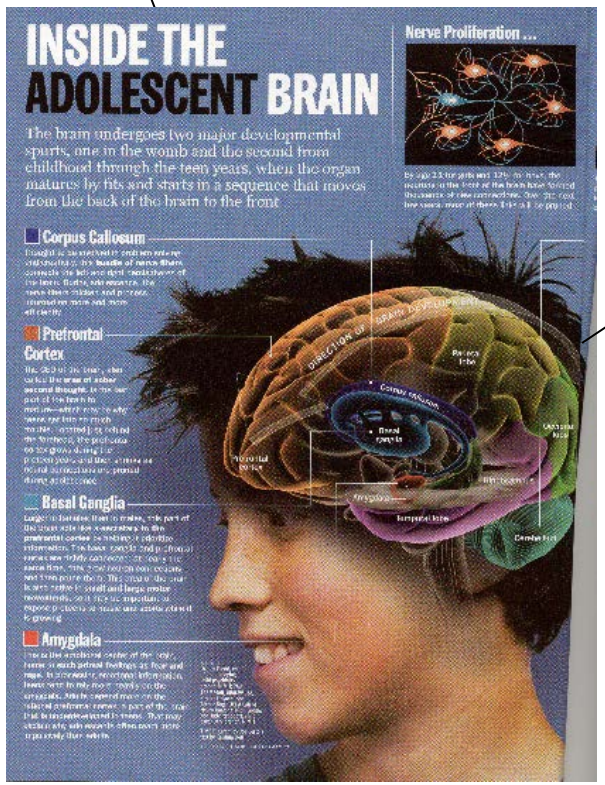
What about recovery?

Your Brain After Cocaine



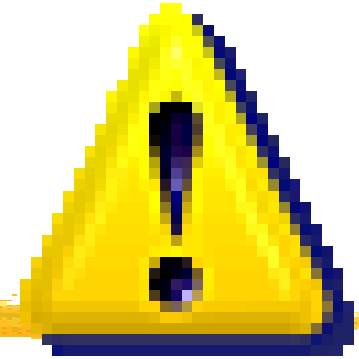
Yellow = normal brain functioning

1. Addiction as brain disease



2. brain development

Cautions

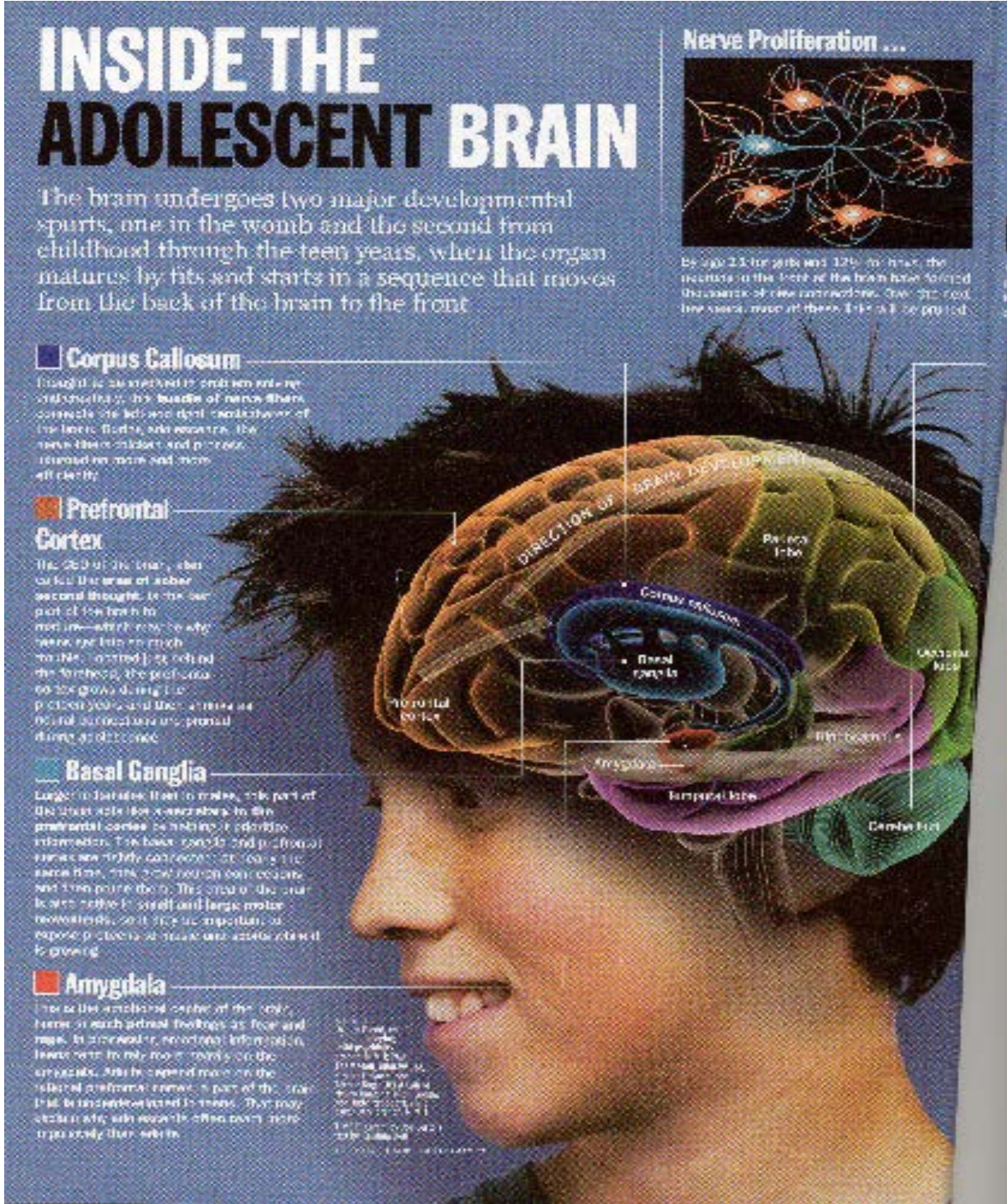


- **Brain imaging studies are based on small samples**
  - **gender, ethnic and cultural differences may be significant.**

- **Adolescence is a period of profound brain maturation.**

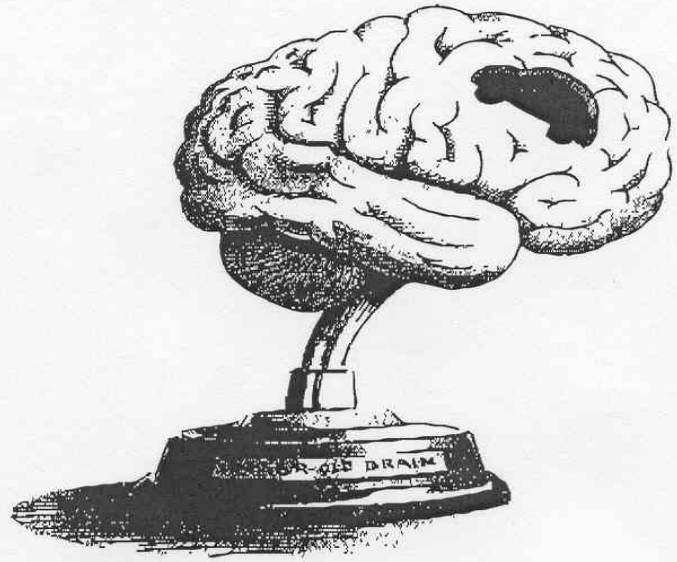
- **We *thought* brain development was complete by adolescence**

- **We now know… maturation is not complete until about [age 25!!!]**



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.

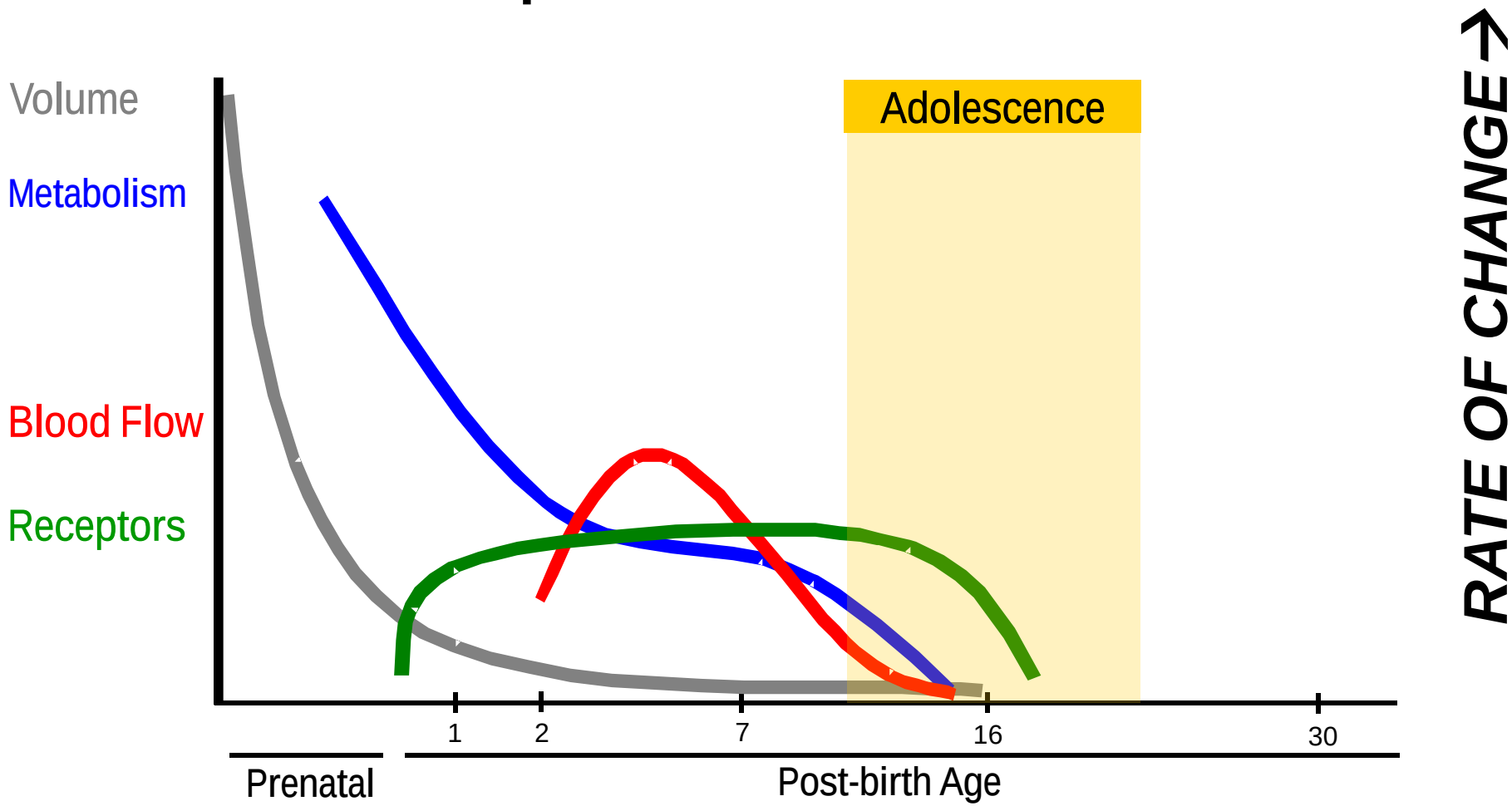
It's one reason 16-year-old drivers have crash rates three times higher than 17-year-olds and five times higher crashes. These laws restrict the more dangerous kinds of driving teens do, such as nighttime driving and driving with teen passengers. Since North Carolina implemented one of the most comprehensive 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

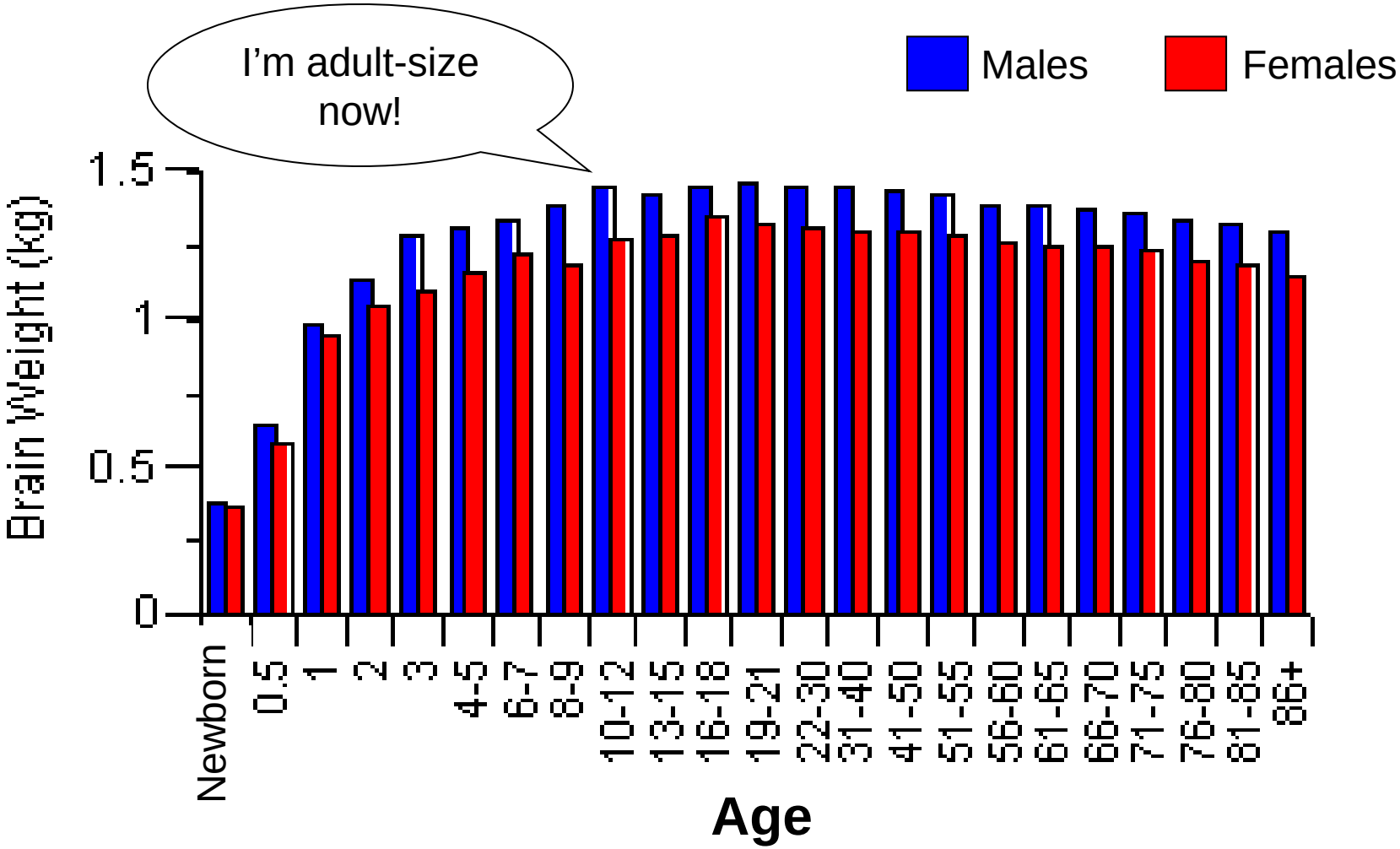
An Immature Brain =
Less Brakes on the “Go” System

Brain Development



Tapert & Schweinsburg (2005)

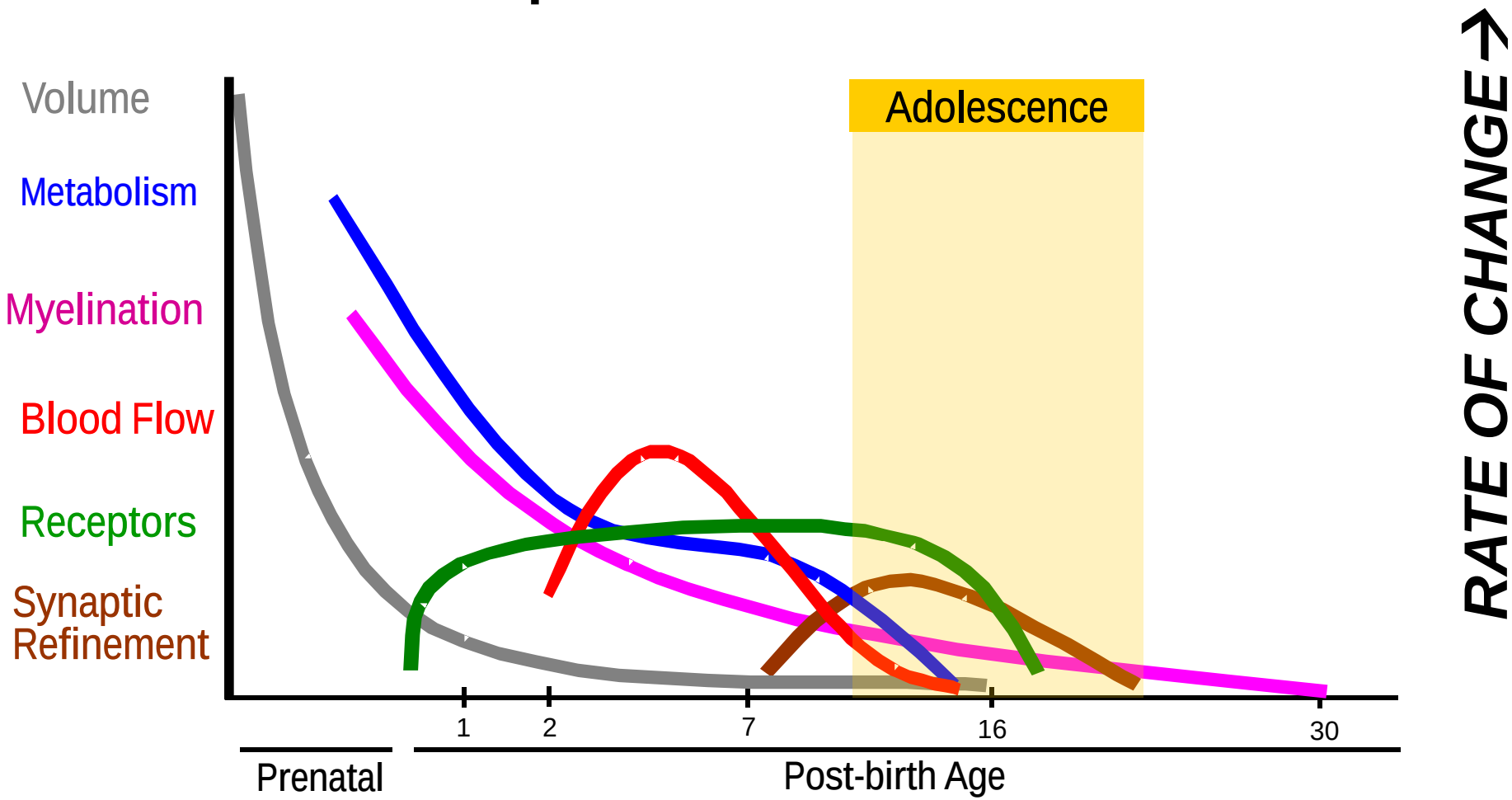
Brain Weight by Age



Source: Dekaban, A.S. and Sadowsky, D. *Annals of Neurology*, 4:345-356, 1978

Slide courtesy
Sion Kim Harris, Ph.D.

Brain Development

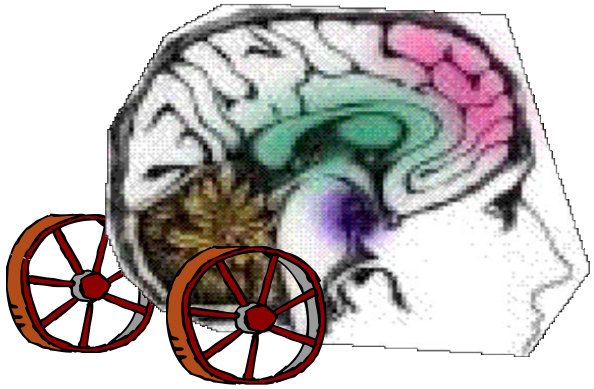


Tapert & Schweinsburg (2005)

Construction Ahead

- **When the pruning is complete, the brain is faster and more efficient.**

- **But… during the pruning process, the brain is not functioning at full capacity.**



Maturation Occurs from Back to Front of the Brain

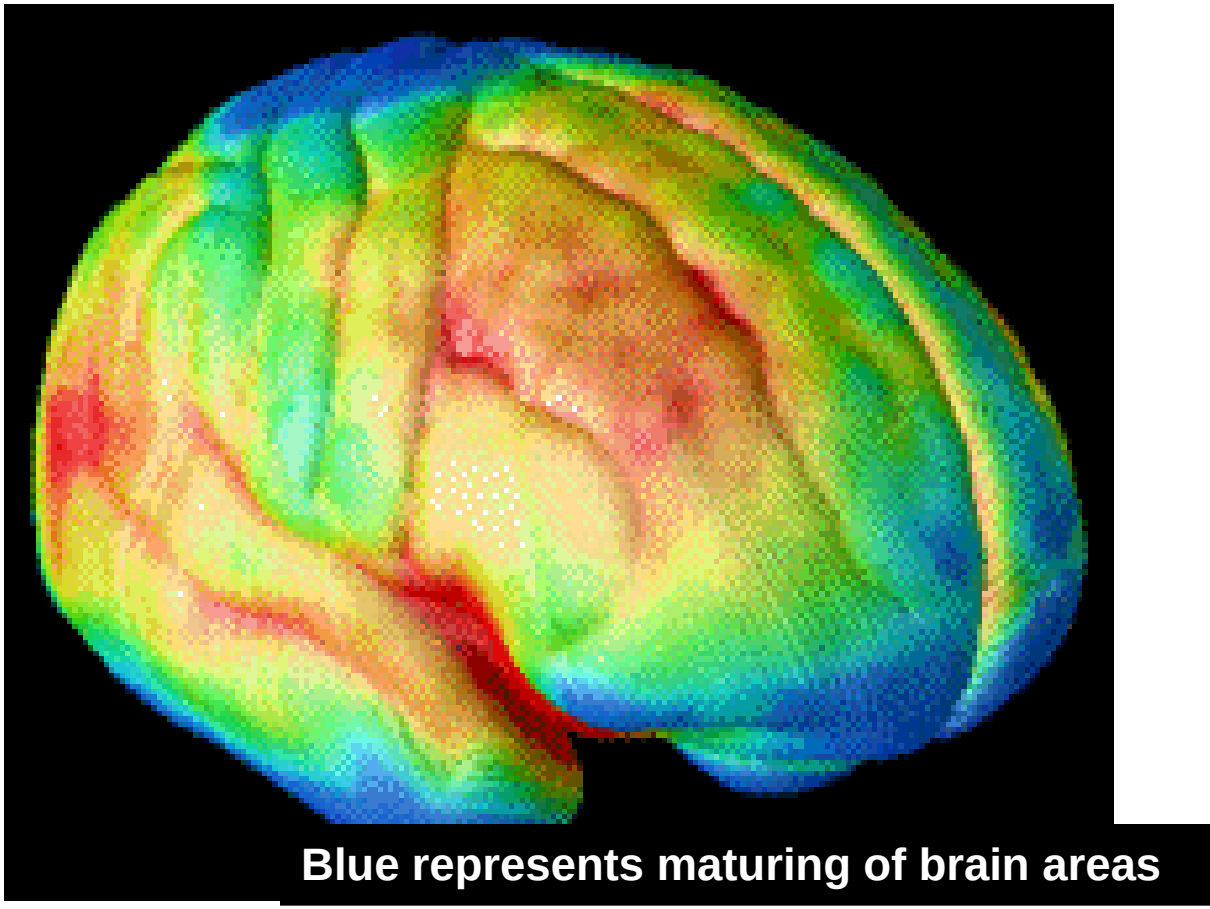
Images of Brain Development in Healthy Youth (Ages 5 – 20)

Earlier: Limbic system

- **Processing emotions**
- **Processing social info**
- **Experience reward, punishment**

Later: Prefrontal cortex

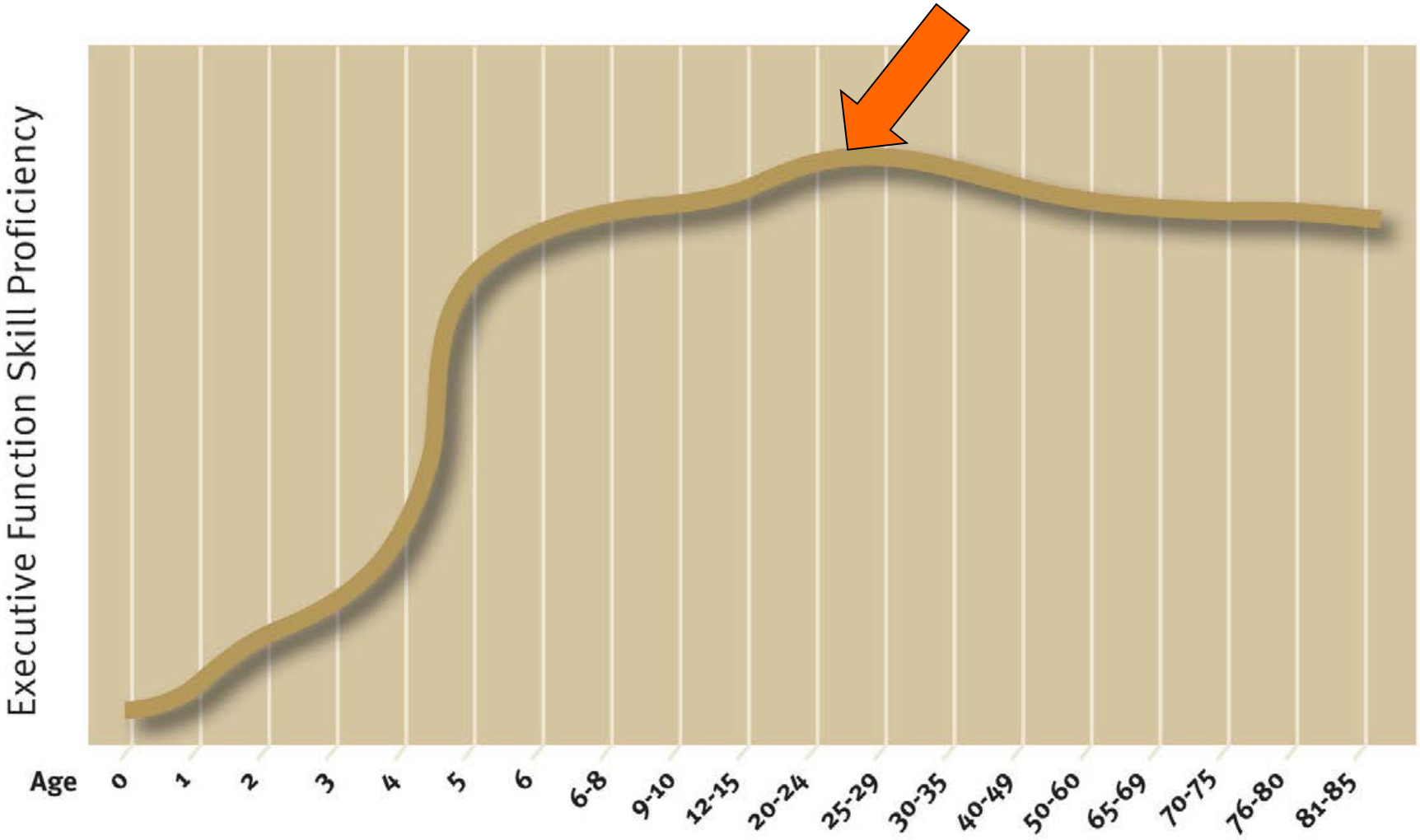
- **Deliberative thinking**
- **Logical reasoning**
- **Planning ahead**
- **Weighing costs and benefits**
- **Regulating impulses**



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

Limbic System

Executive Function Skills Build Into the Early Adult Years

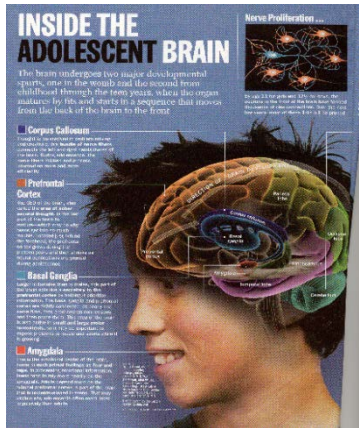


Source: Weintraub et al. (Submitted for Publication)

Tests measuring different forms of executive function skills indicate that they begin to develop shortly after birth, with ages 3 to 5 a window of opportunity for dramatic growth in these skills. Development continues throughout adolescence and early adulthood.

Implications of Brain Development for Adolescent Behavior

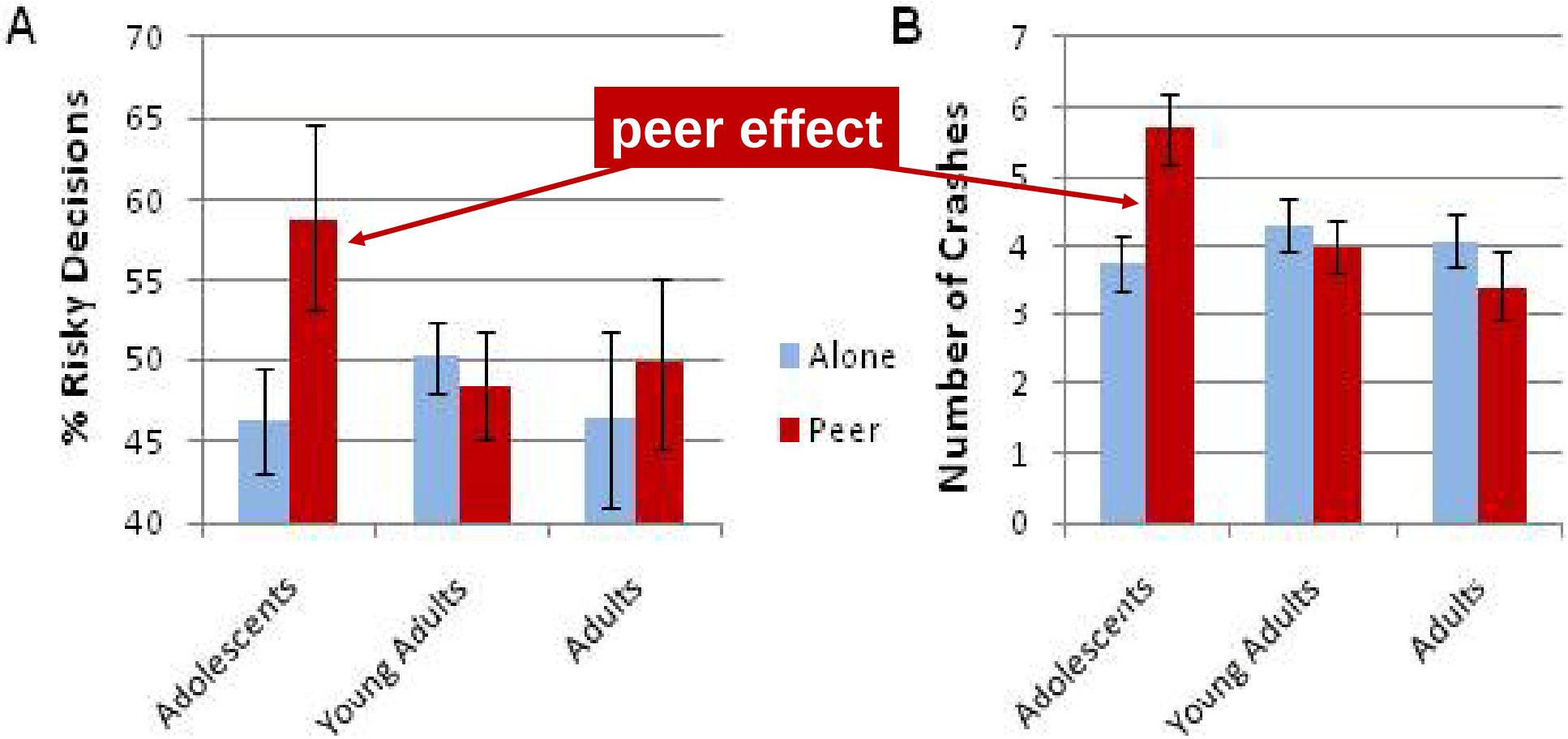
- **Preference for ....**
  1. **physical activity**
  2. **high excitement and rewarding activities**
  3. **activities with peers that trigger high intensity/arousal**
  4. **novelty**
- **Less than optimal..**
  5. **control of emotional arousal**
  6. **consideration of negative conseq.**
- **Greater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



Risk-Taking

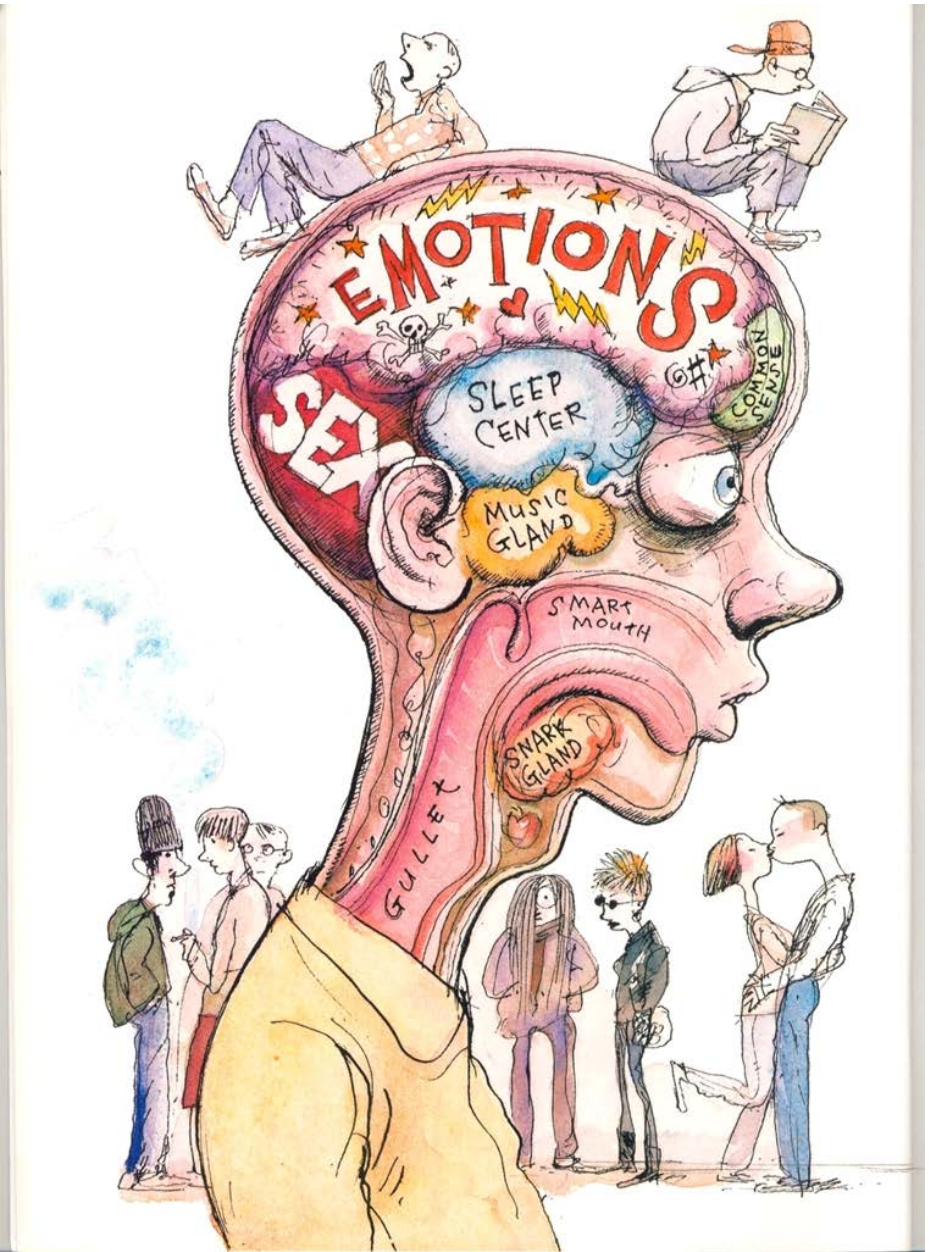
- **Based on science of brain development, a modern view of risk taking in adolescence is…**
  - **normative; important to development**
  - **evolutionarily adaptive**
  - **significant individual differences**
  - **is due primarily to <u>emotional and contextual</u>, not cognitive, factors**

Impact of Peer Presence on Risky Driving in Simulated Context



Chein et al., in press

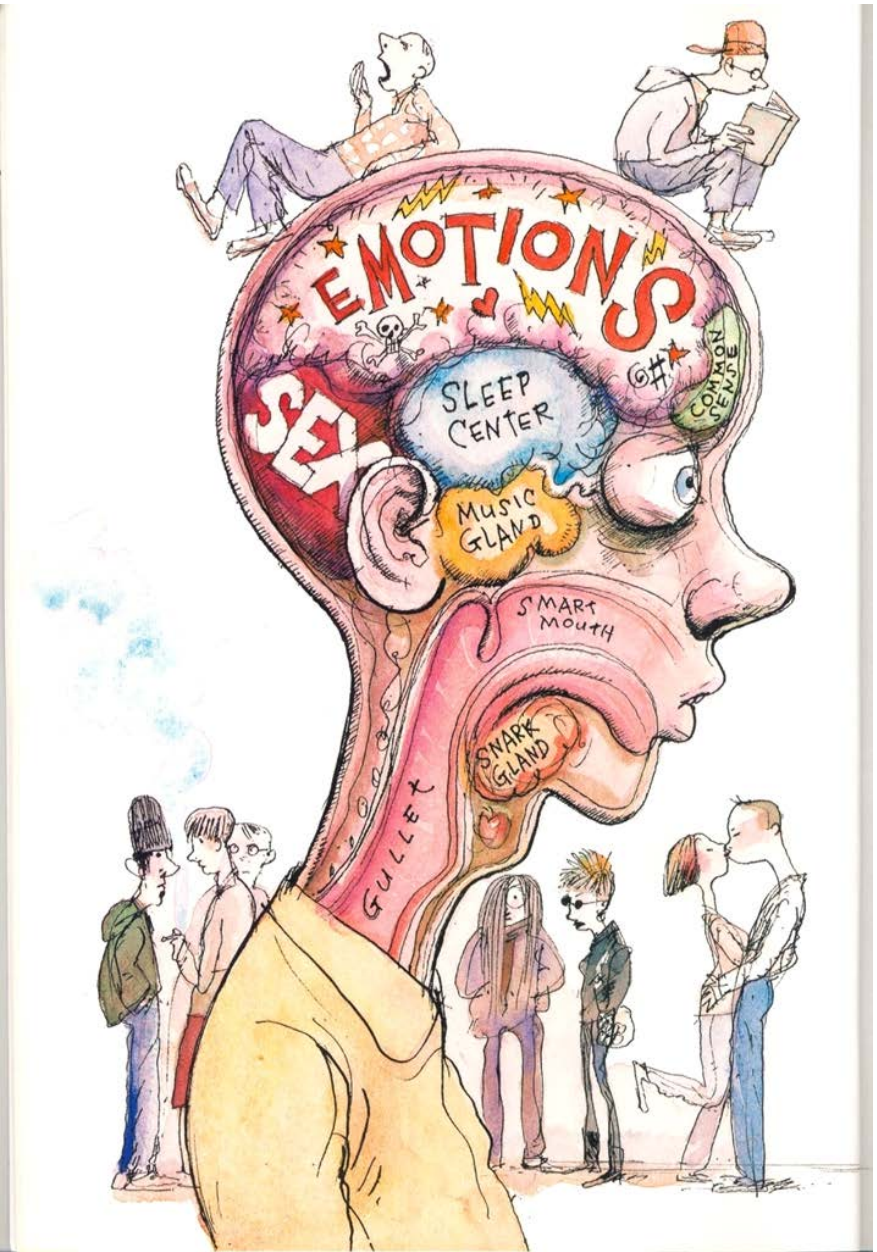
An Immature Brain ≠ Low Brain Power



Source: US News & World Report, 2005

An Immature Brain ≠

Risky Judgment is Pervasive



reward incentives > perception of consequences

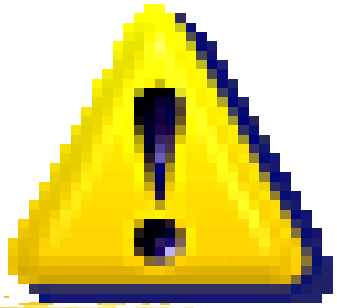
Source: US News & World Report, 2005

1. Addiction as brain disease

Brain development

3. Developing brain & drug risk

Implications of Brain Development for Drug Abuse Vulnerability

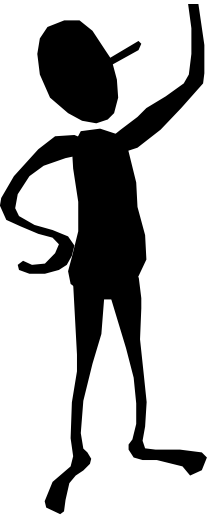


Are adolescents more susceptible than adults to drugs?

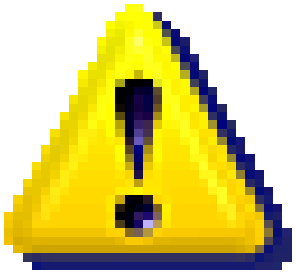
4 lines of evidence

(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.

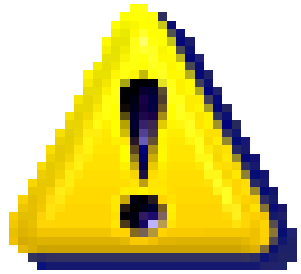


Cautions



- **Animal data – interpret cautiously**
  - **We are assuming commonality across species pertaining to .....**
    - **key characteristics of the adolescent developmental stage**
    - **acute effects of intoxication**
  - **Lab rats are administered ethanol via injection or directly into the stomach**
    - **stress -→ impacts absorption and behavioral effects**

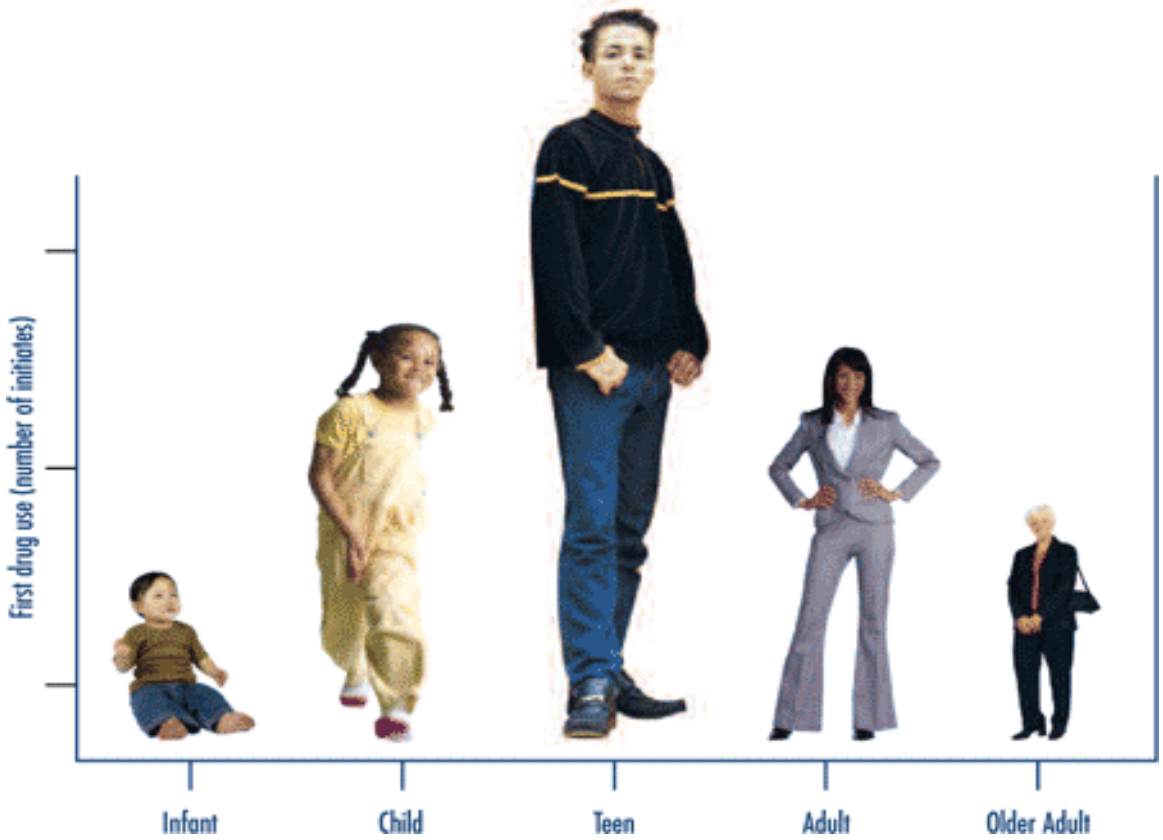
Cautions



- **Human data – incomplete picture**
  - **Other developmental factors, such as hormonal changes, are also biomedical contributors to drug sensitivity.**

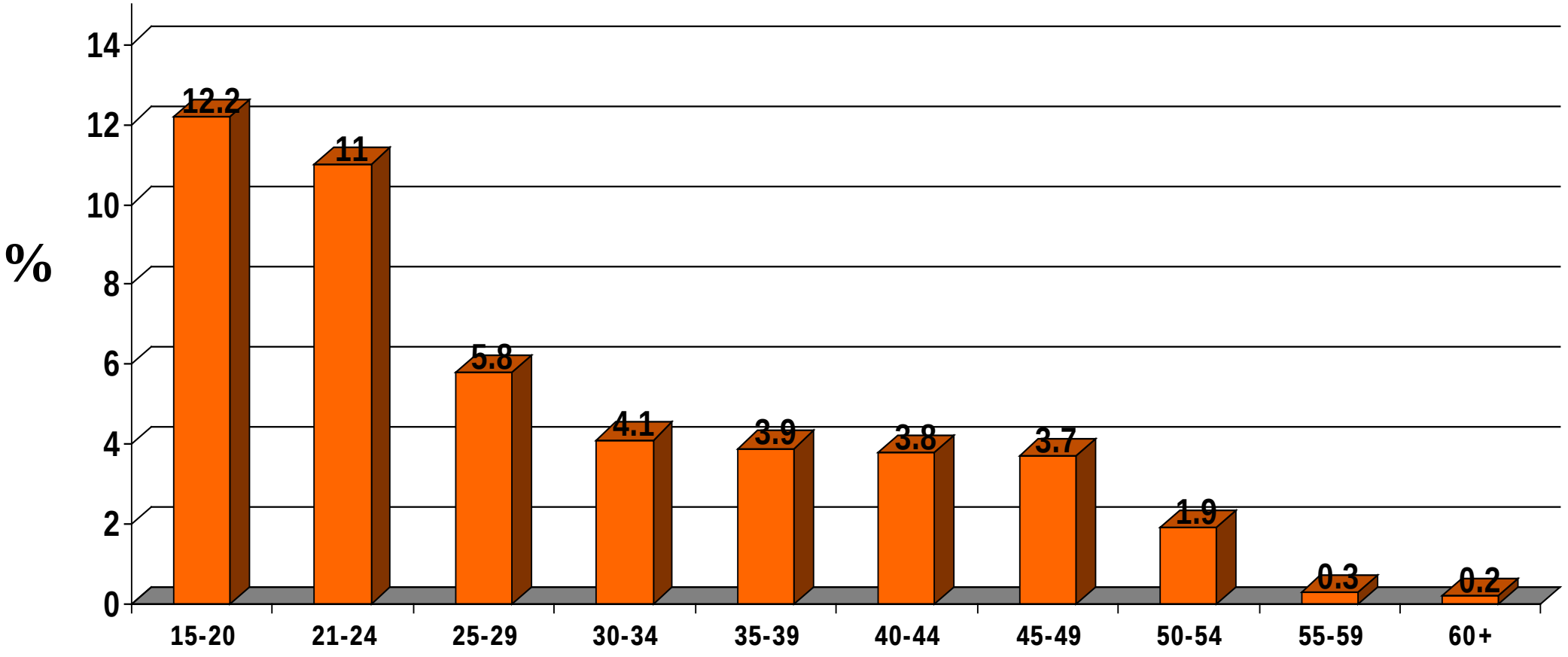
1. Evidence from <u>epidemiological studies</u>

Drug use starts early and peaks in the teen years

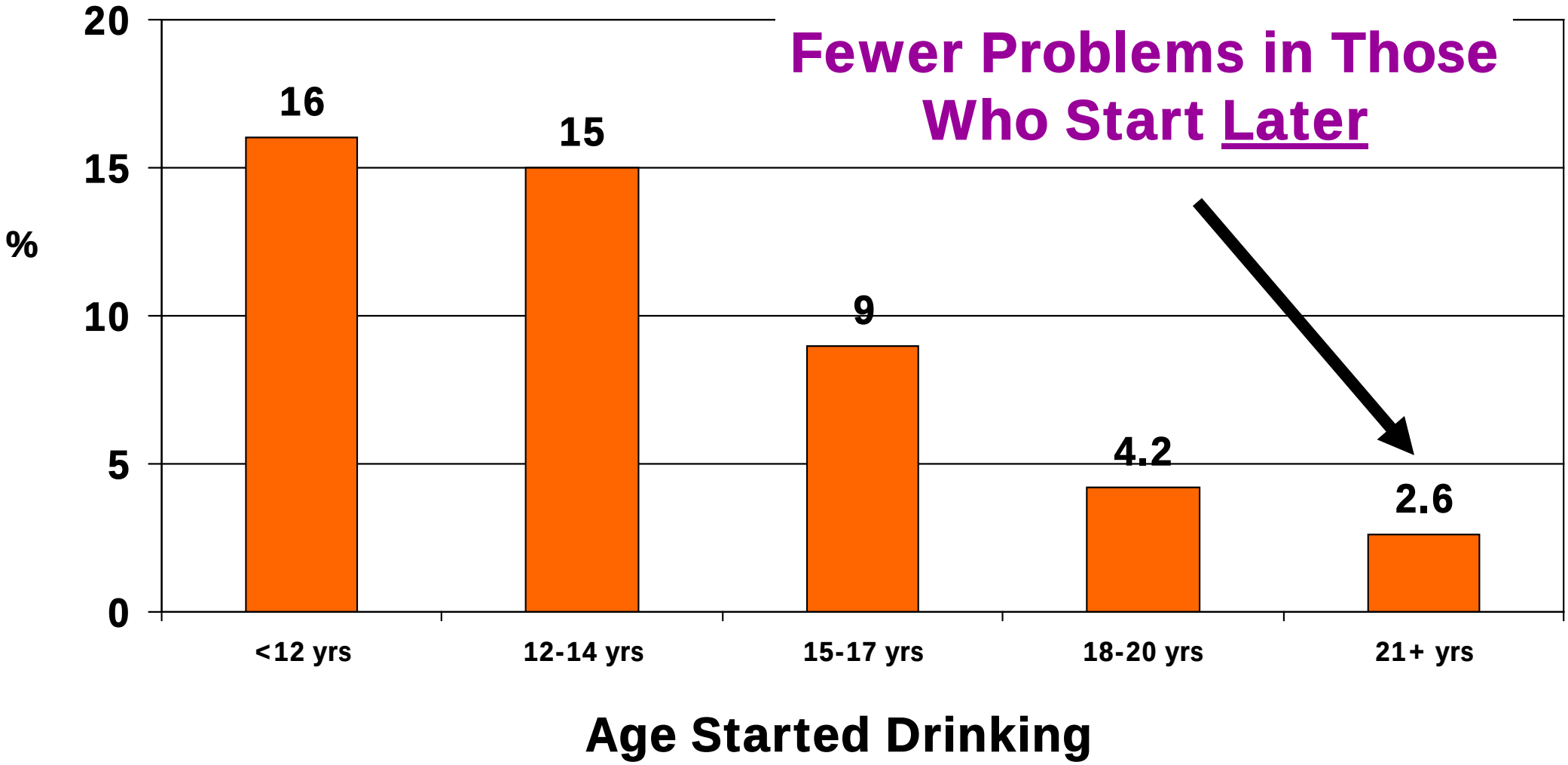


Prevalence of Past-Year DSM-IV Alcohol Dependence: United States, 2001-2002

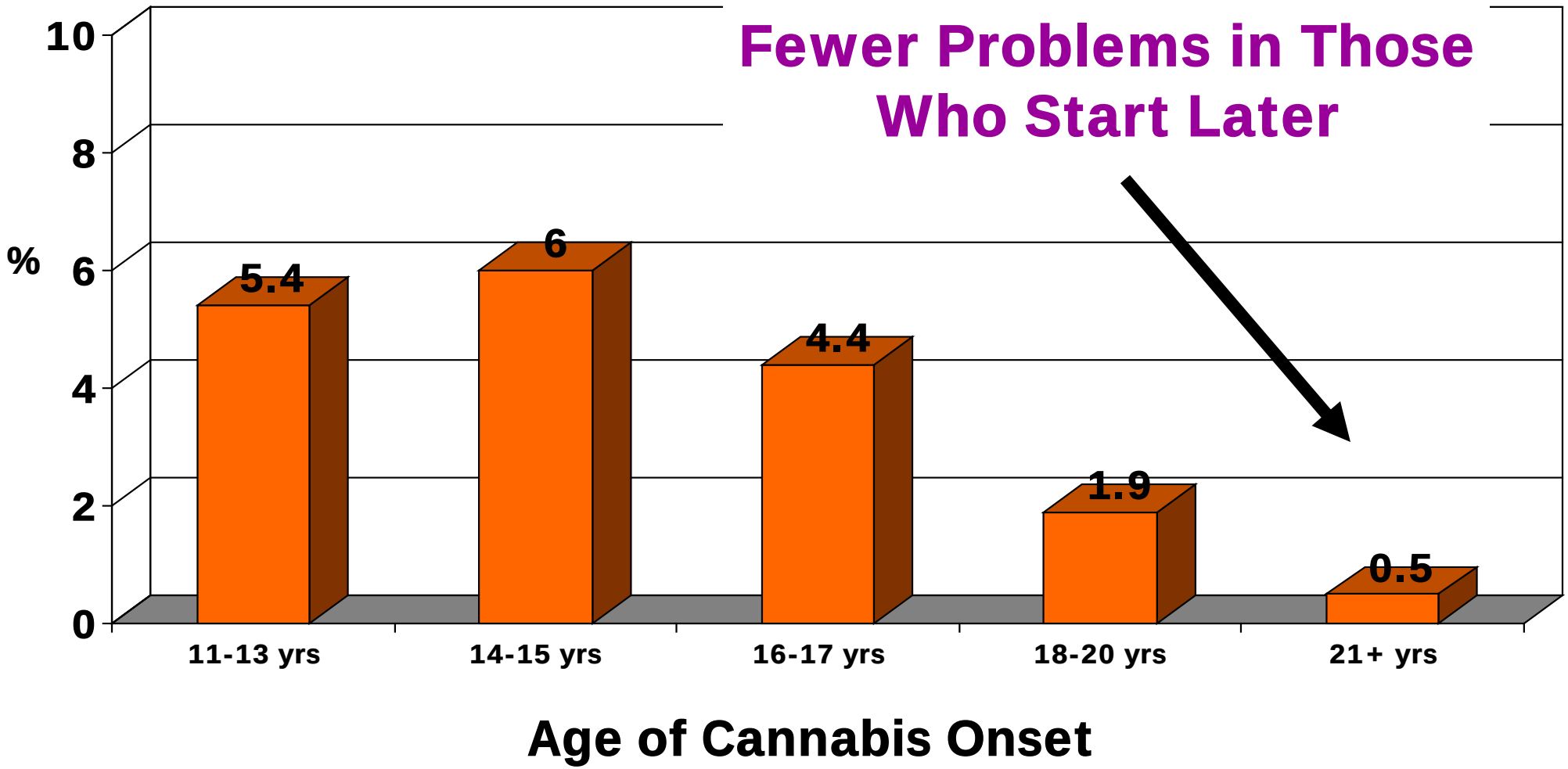
(Grant, B.F., et al., *Drug and Alcohol Dependence*, *74*, 223-234, 2004)



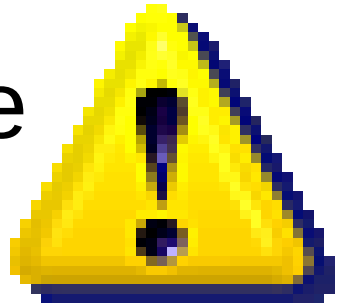
Percentages of Past Year Alcohol Use Disorder (Abuse or Dependence) Among Adults Aged 21 or Older, by Age of First Use (SAMHSA, 2005)



Percentages of Current Cannabis Dependence as a Function of Cannabis Use Onset (National Household Survey on Drug Abuse, 2000-2001)



Are adolescents more susceptible to alcohol than adults?

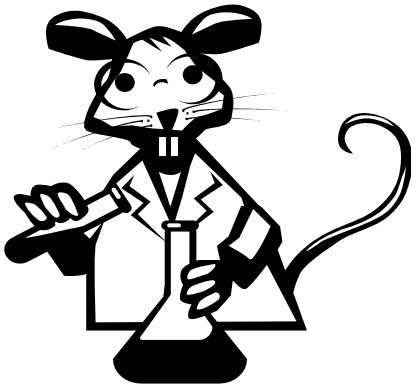


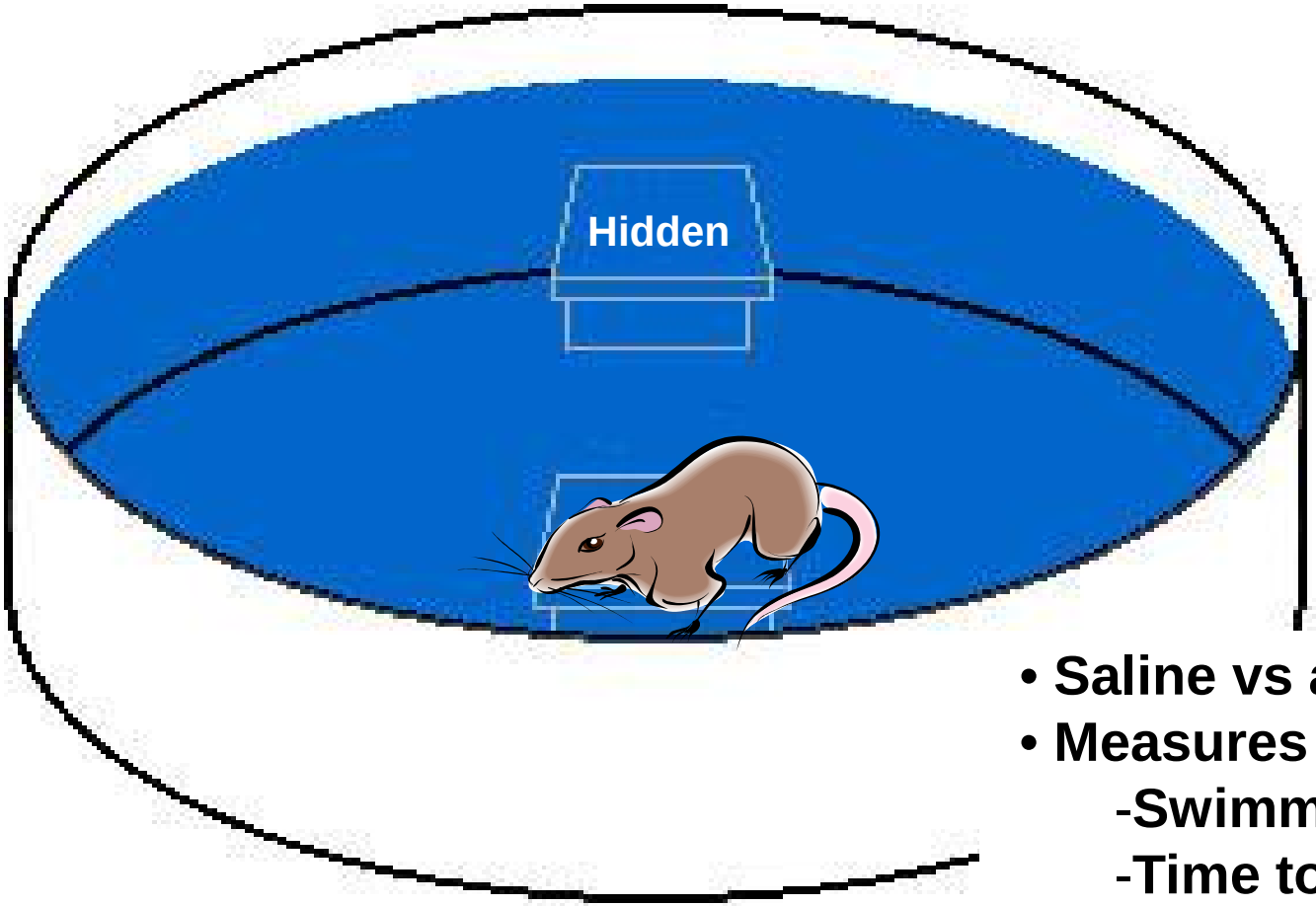
1. Epidemiological data

Comparing adolescent and adult rats, both having no prior exposure to alcohol and matched on temperament….

2. **Adolescent rats are <u>less sensitive</u> to the sedative and motor impairment effects of <u>intoxication</u>.**
   - **more drinking before "signals to stop"**

The Water Maze Test





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

Slide courtesy
Sion Kim Harris, Ph.D.

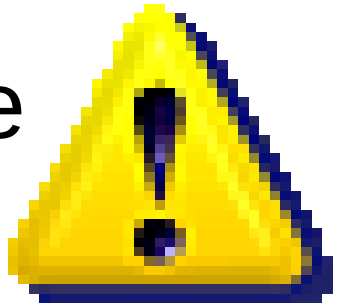
Are adolescents more susceptible to alcohol than adults?

1. Epidemiological data
2. Adolescent rats are less sensitive to the sedative and motor impairment effects of intoxication.

3. **Adolescent rats are more sensitive to the social disinhibition effects of alcohol.**
   - **greater social comfort from intoxication**

Wanna look for some cheese with me?
Sure!

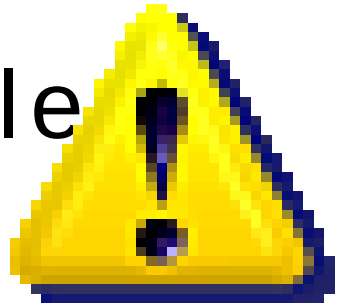
Are adolescents more susceptible to alcohol than adults?



1. Epidemiological data
2. **Adolescent rats are <u>less sensitive</u> to the sedative and motor impairment effects of <u>intoxication.</u>**
3. **Adolescent rats are <u>more sensitive</u> to the social disinhibition effects of alcohol.**

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

Are adolescents more susceptible to alcohol than adults?



1. Epidemiological evidence
2. Adolescent rats are <u>less sensitive</u> to the sedative and motor impairment effects of <u>intoxication.</u>
3. Adolescent [illegible] <u>more sensitive</u> to the social disinhibit[illegible]s of alcohol.

4. Alcohol may produce <u>greater cognitive disruptions</u> in adolescents.

Human Data: Alcohol's Effects on Memory

4. **Adolescent rats more sensitive to..**

- **disruption in memory**
- **impairment of neurotransmission in hippocampus and cortex**

Source: Spear, 2002

Human Data: Alcohol's Effects on the Hippocampus

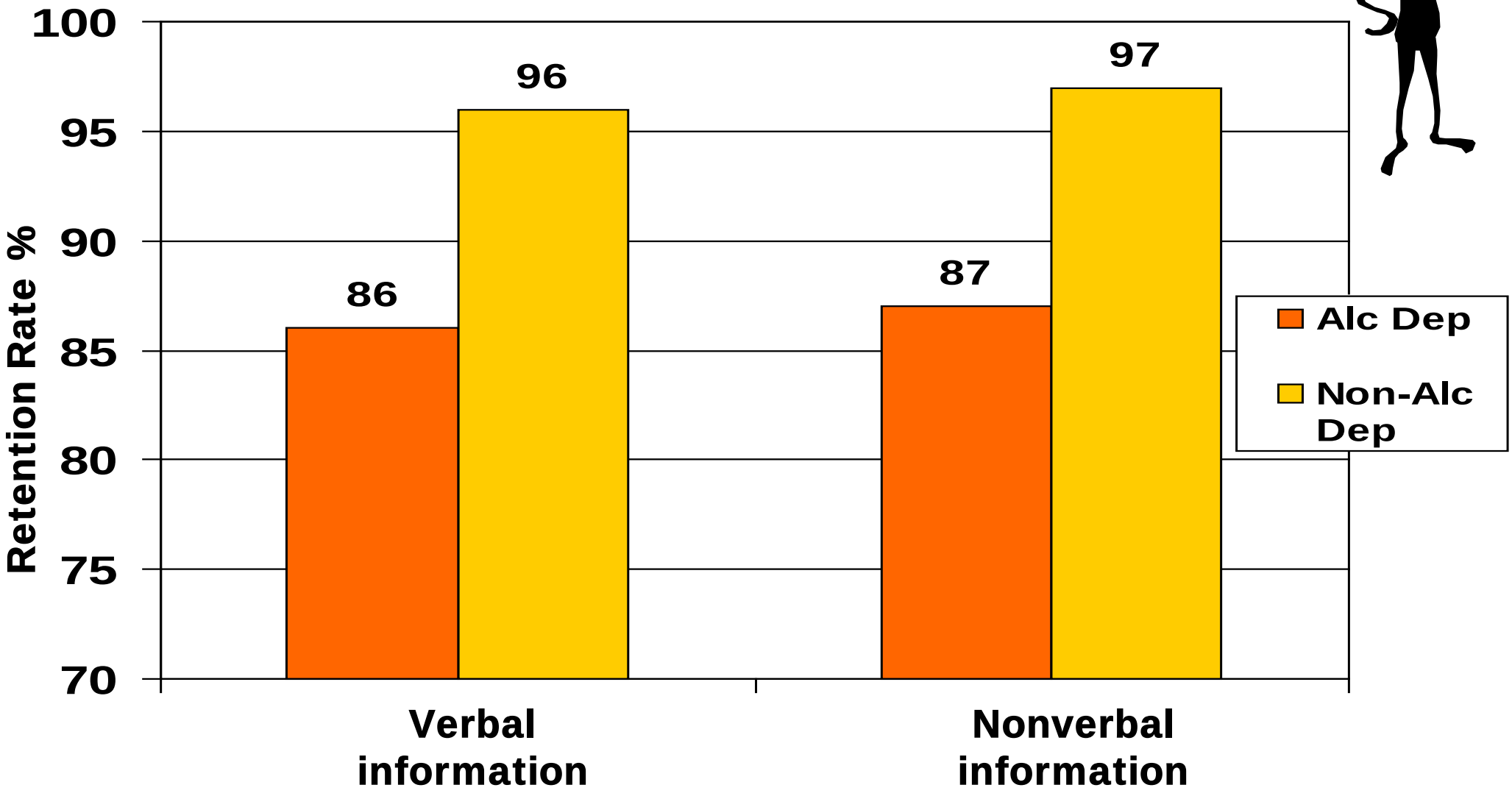
4. Adolescents with a history of alcohol use disorder….

↓ **Hippocampus volume (10%)**

Hippocampus converts information to memory

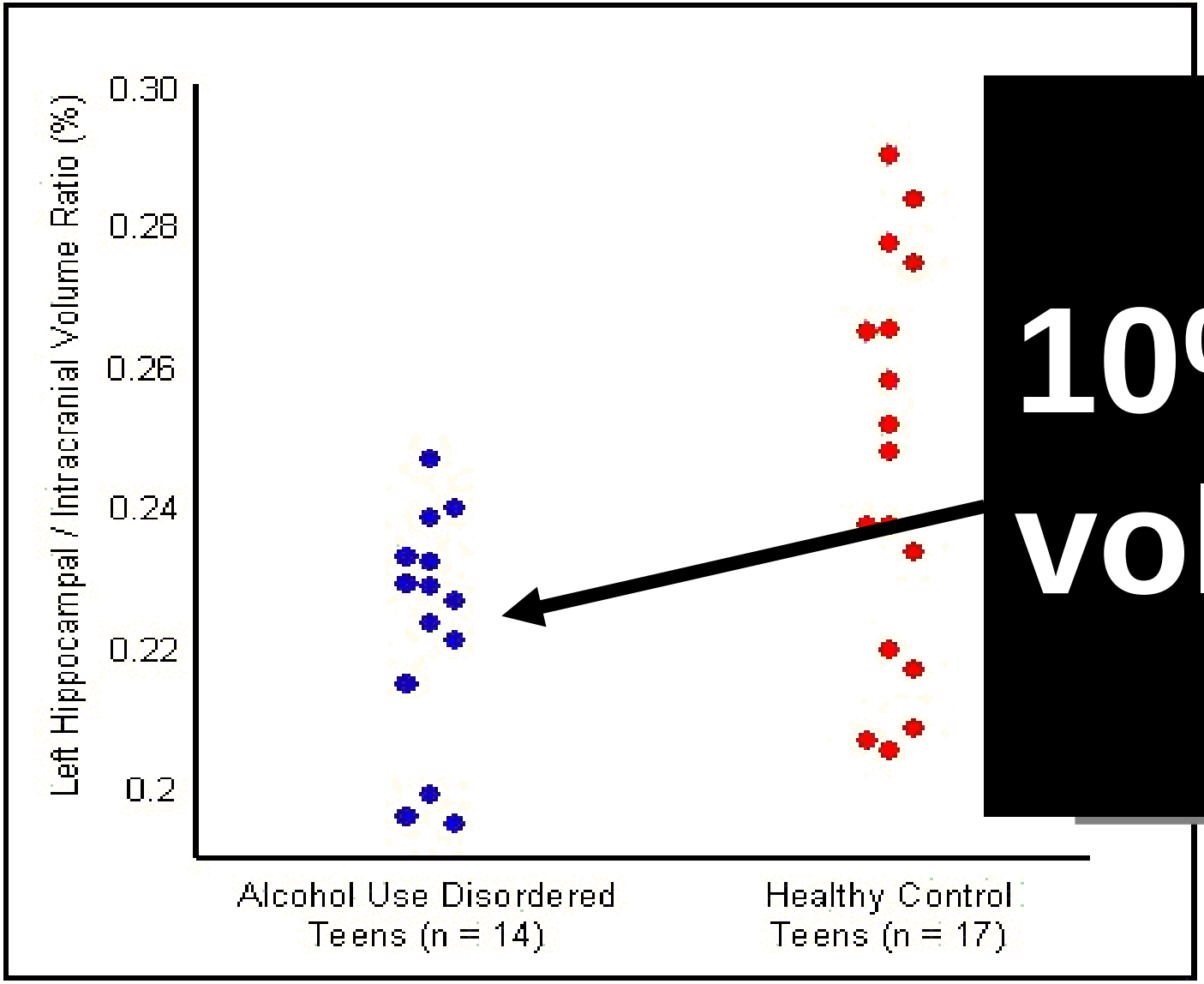
Source: Tapert & Schweinsburg, 2005

Human Data: Alcohol's Effects



Source: Brown et al., 2000

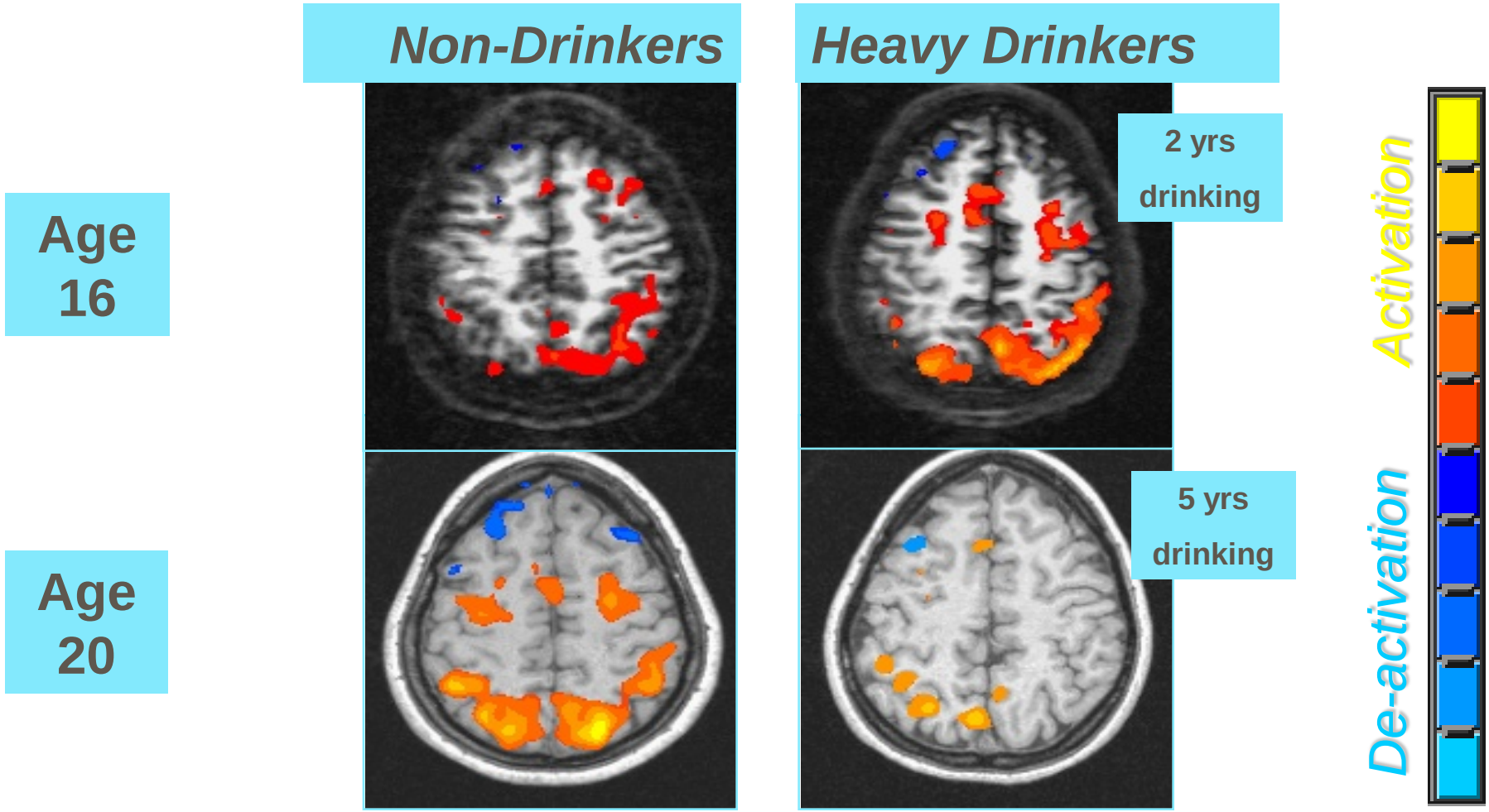
MRI: Hippocampal Size



10% smaller volume

Nagel, Schweinsburg, Pham, & Tapert, 2005

Teen Drinking & Brain Activation

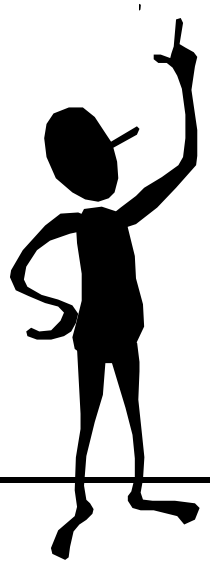


Slide courtesy of Susan Tapert, PhD.

Tapert et al., 2001, 2004

Are adolescents more susceptible to cannabis than adults?

4. Cannabis may produce <u>greater cognitive disruptions</u> in adolescents.



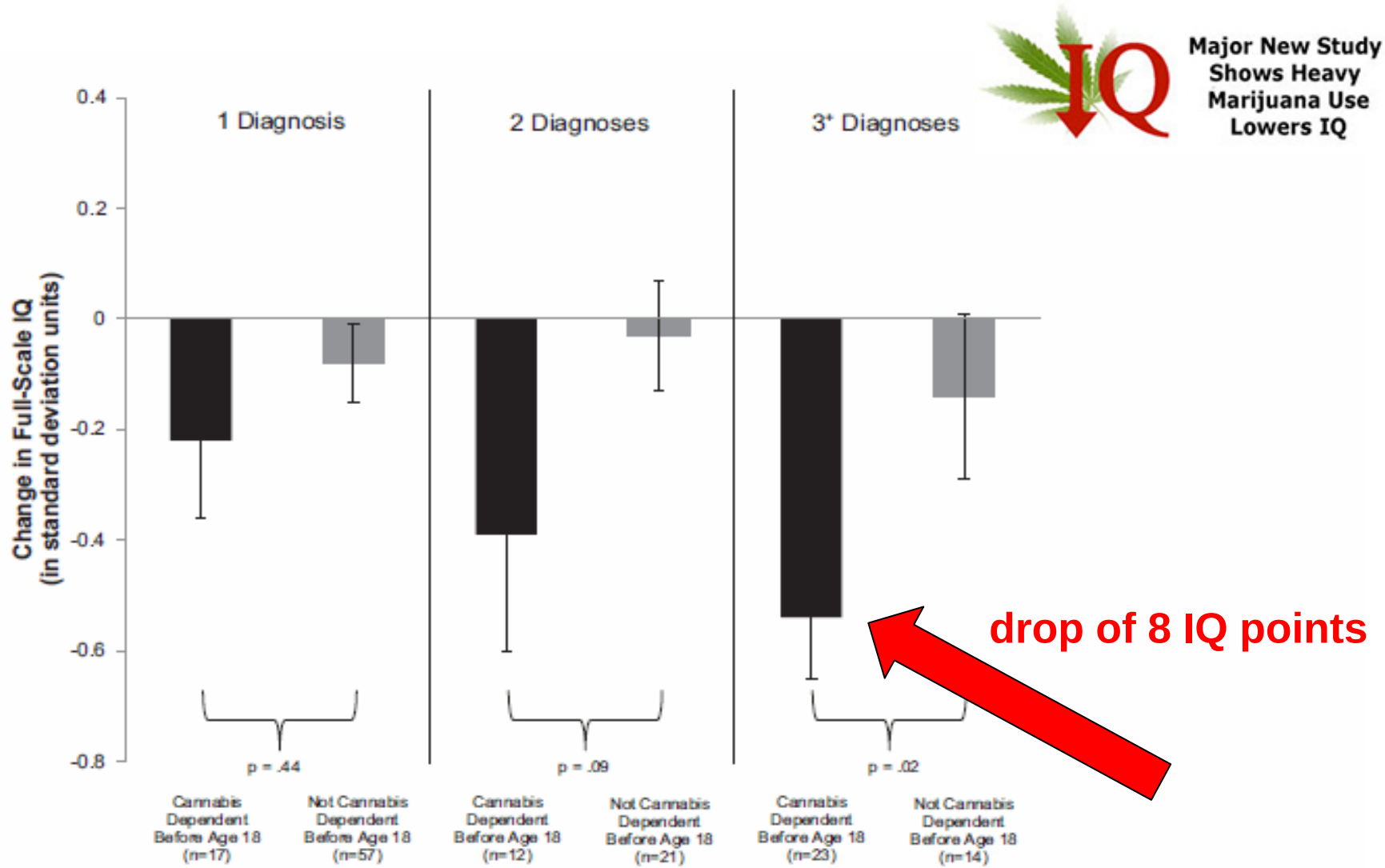


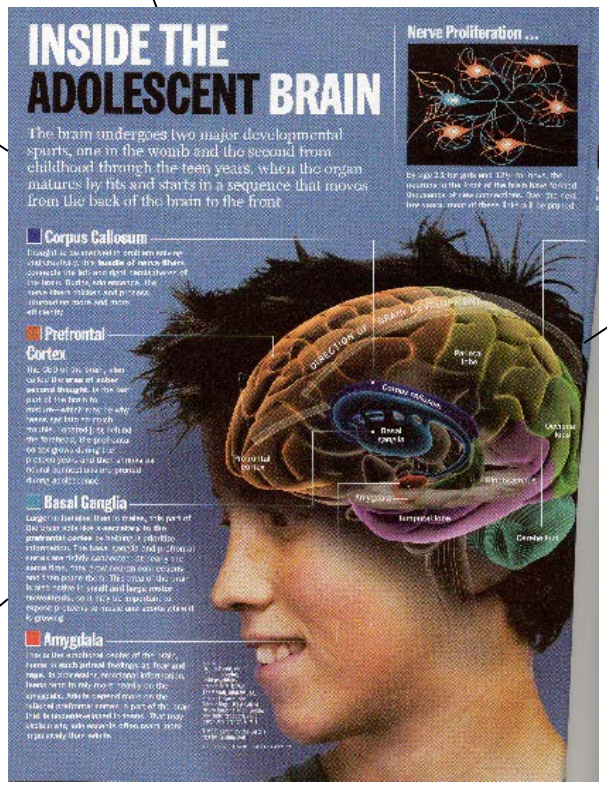
Fig. 2. Adolescent vulnerability. Shown is change in full-scale IQ (in SD units) from childhood to adulthood among study members with 1, 2, or 3+ diagnoses of cannabis dependence as a function of age of onset of cannabis dependence. Individuals with adolescent-onset cannabis dependence (black bars) experienced greater IQ decline than individuals with adult-onset cannabis dependence (gray bars). IQ decline of approximately –0.55 SD units among individuals with adolescent-onset cannabis dependence in the 3+ group represents a decline of 8 IQ points. Error bars = SEs.

PNAS proof

Meier et al., 2012; *PNAS*

1. Addiction as brain disease

4. Summary



2. Brain development

3. Developing brain & alcohol risk

Summary

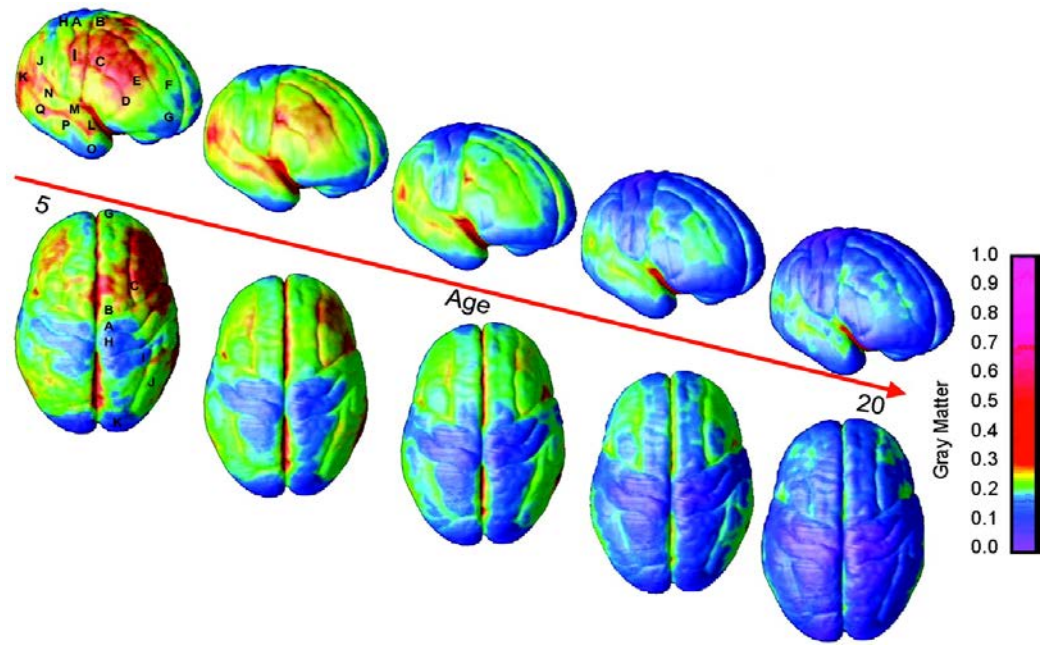
- **Adolescence is an extended period of transition from reliance on adults to independence**
- **Normal adolescence is characterized by….**
  - **increase in conflicts with family members**
  - **desire to be with one's friends**
  - **resistance to messages from authority**
  - **irritability**
  -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

Summary

- **The brain undergoes a considerable amount of development during the teen years.**

- **The last area to mature is the prefrontal cortex region; involved in planning, decision making and impulse control.**

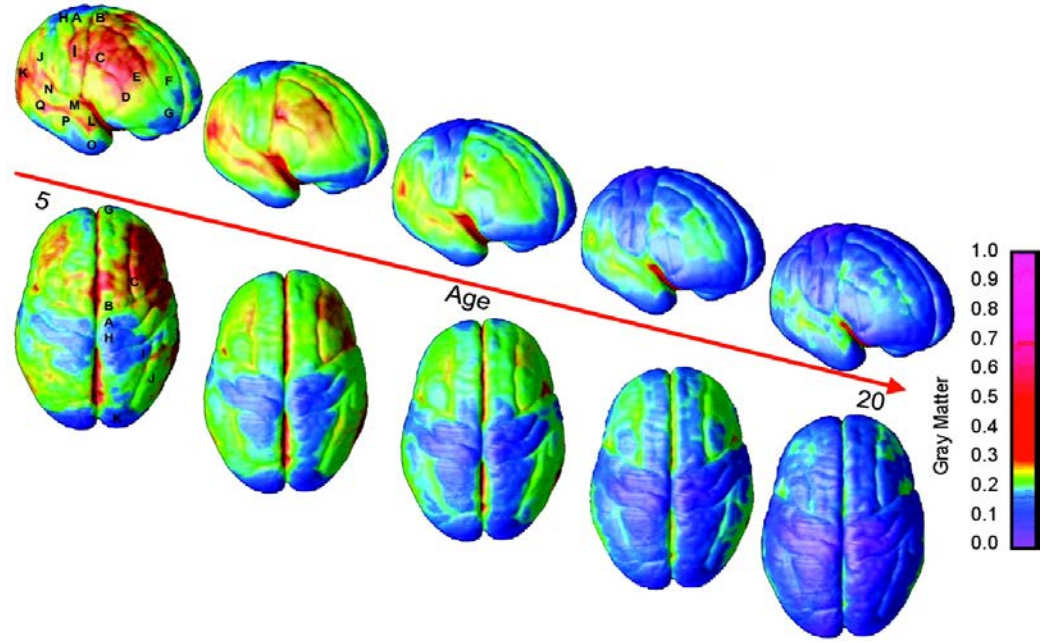
Gray Matter Maturation, Age 4-21
Gogtay et al., 2004



Summary

reward incentives > perception of consequences

Gray Matter Maturation, Age 4-21
Gogtay et al., 2004



1. Addiction as brain disease

5. Clinical opportunities

4. Summary

2. Brain development

3. Alcohol susceptibility

Brain Development: Reinforcing the Need for Prevention and Treatment

- **Youth is a particularly vulnerable period for developing a substance use disorder.**
- **Prevention and treatment programs are vital.**

Implications for Prevention and Treatment

- **I favor programs that focus on teaching skills associated with thoughtful, planful decision making**
  - **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

Advantages of Motivational Interviewing

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

'I attend as many parenting classes as I can - anything to get away from my children'

Parent Take Home Summary

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** 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.

THE PARTNERSHIP™
AT DRUGFREE.ORG

Prevent_Intervene_Get Treatment_Recover

www.drugfree.org

THANK YOU!

winte001@umn.edu

Suggested Readings

Dahl, R.E. & Spear, L.P. (Eds.) (2004). *Adolescent brain development: vulnerabilities and opportunities*. NY, NY: *Annals of the New York Academy of Sciences,* Volume 1021.

Dubuc, B. (n.d.). *The brain from top to bottom*. Retrieved September 1, 2004, from McGill University Web site: http://www.thebrain.mcgill.ca/flash/index_d.html#

Nestler, E. J., & Malenka, R. C. (2004, March). The addicted brain. *Scientific American, 290* (3), 78-85.

Wallis, C. (2004, May 10). What makes teens tick? *Time, 163*, 57-65.

U.S. News & World Report. (Special Issue, 2005). Mysteries of the teen years. Author.