



National Institute
on Alcohol Abuse
and Alcoholism

UNDERAGE DRINKING

Acute and Chronic Effects of Alcohol on the Adolescent Brain

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National Institute on Alcohol Abuse and Alcoholism

National Institutes of Health

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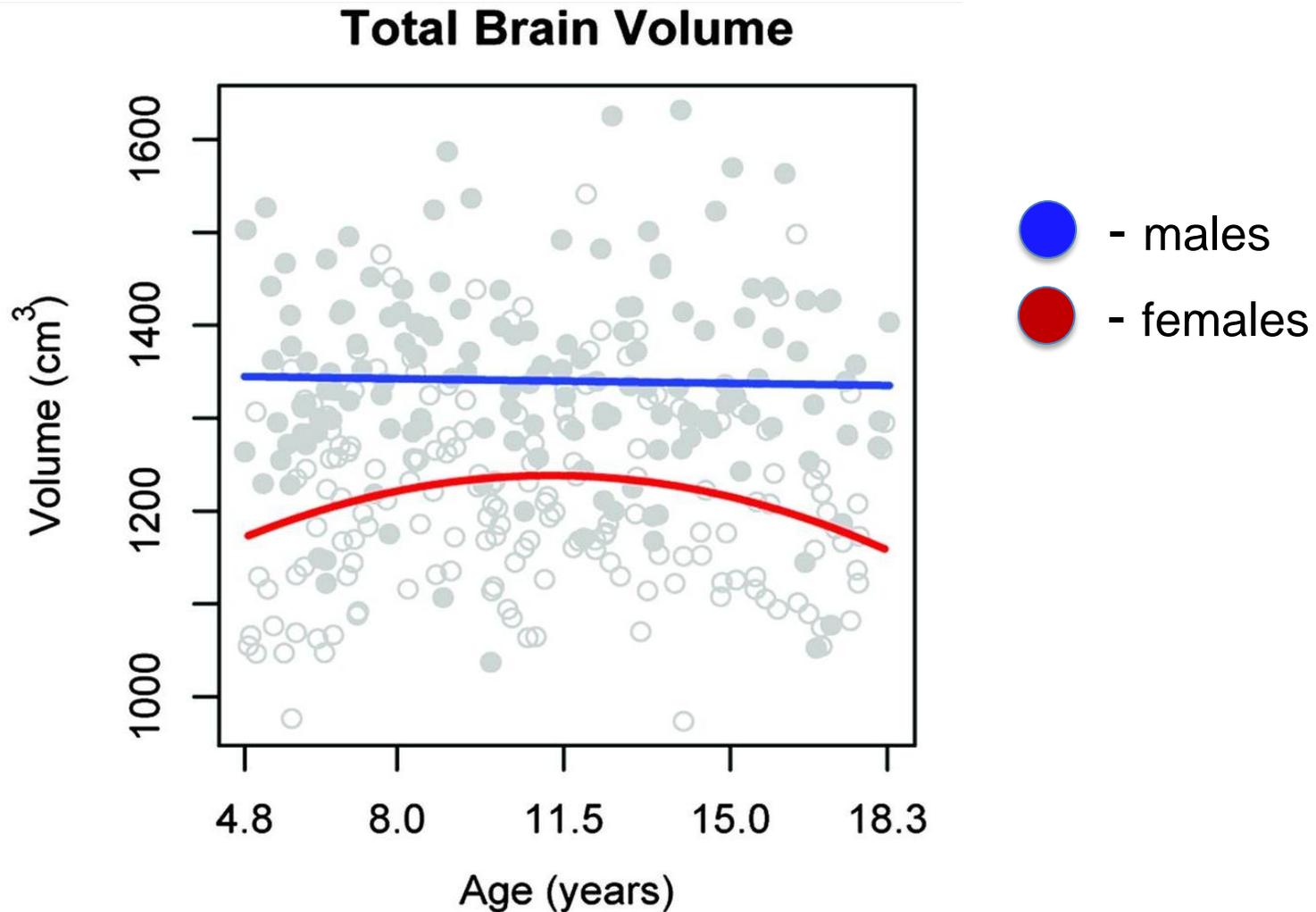
Adolescent Brain Changes Underlie Many Typical Teen Behaviors

“Teenage brains. Beautiful brains. Moody. Impulsive. Maddening. Why do teenagers act the way they do? Viewed through the eyes of evolution, their most exasperating traits may be the key to success as adults.”



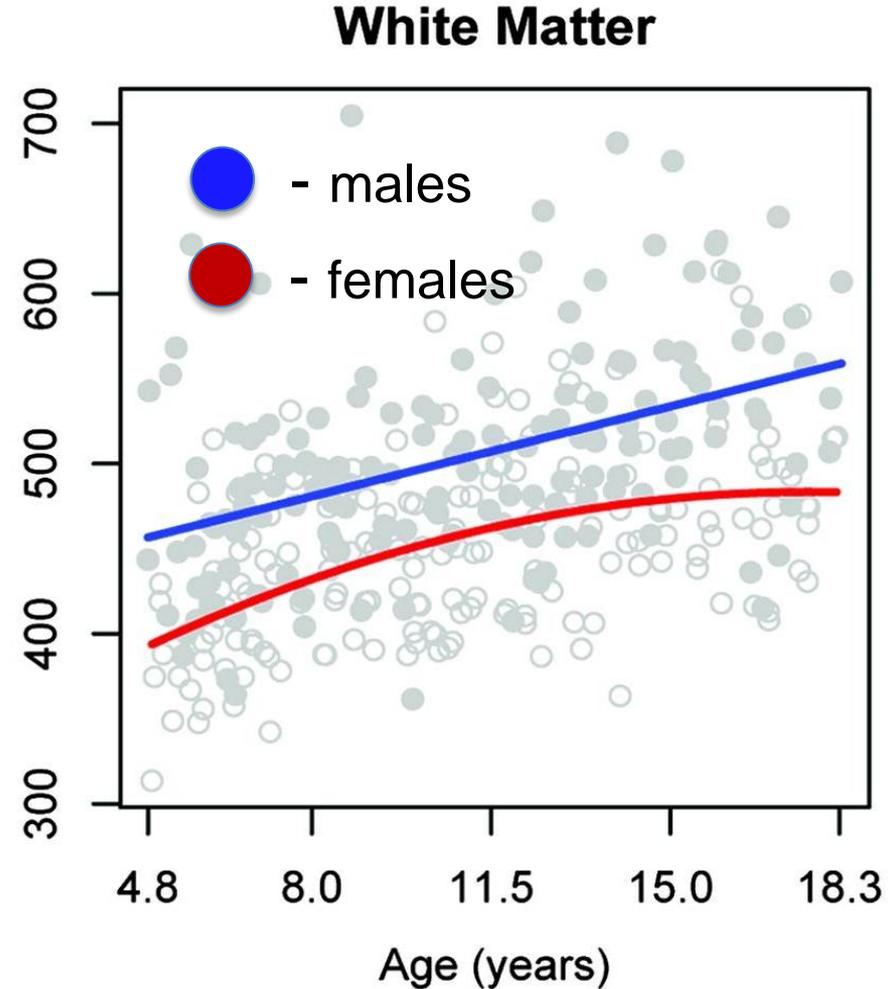
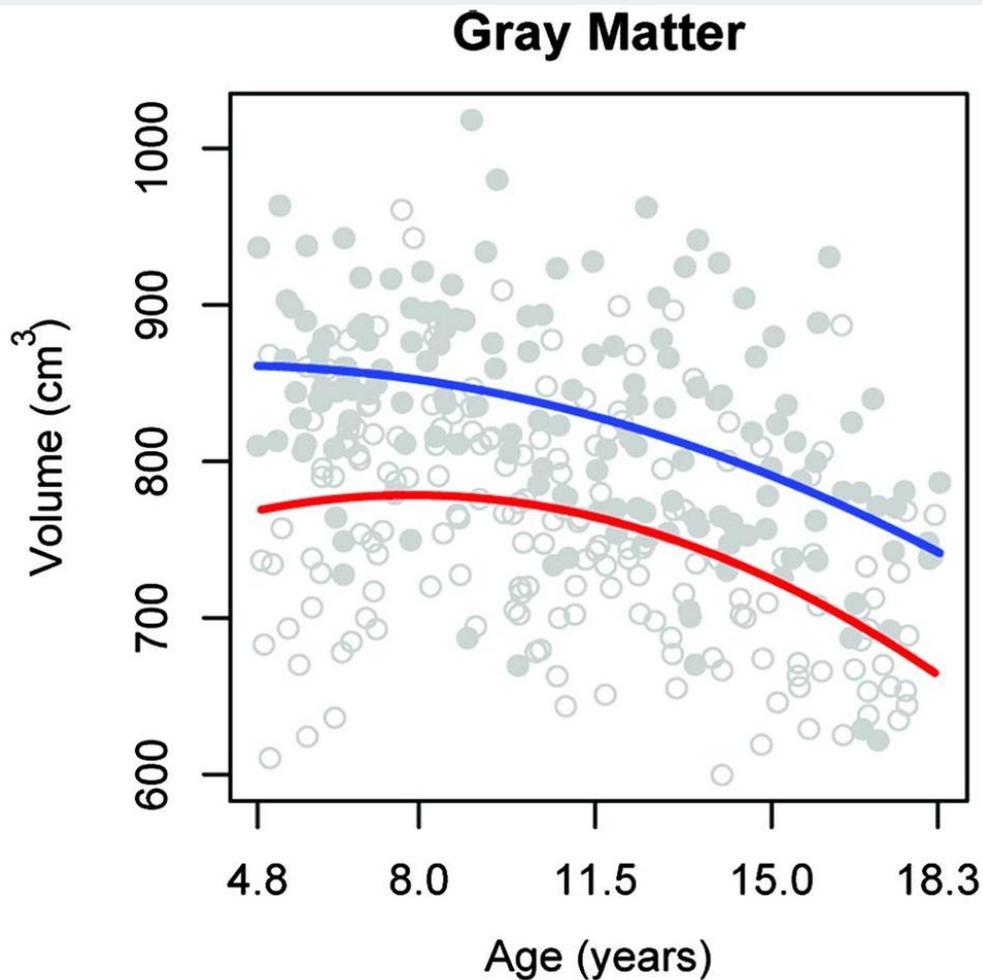
David Dobbs
The beautiful teen brain.
National Geographic
October 2011

Overall Brain Size Changes Little During Adolescence



National Institutes of Health magnetic resonance imaging study of normal brain development (*Cerebral Cortex*, 2012)

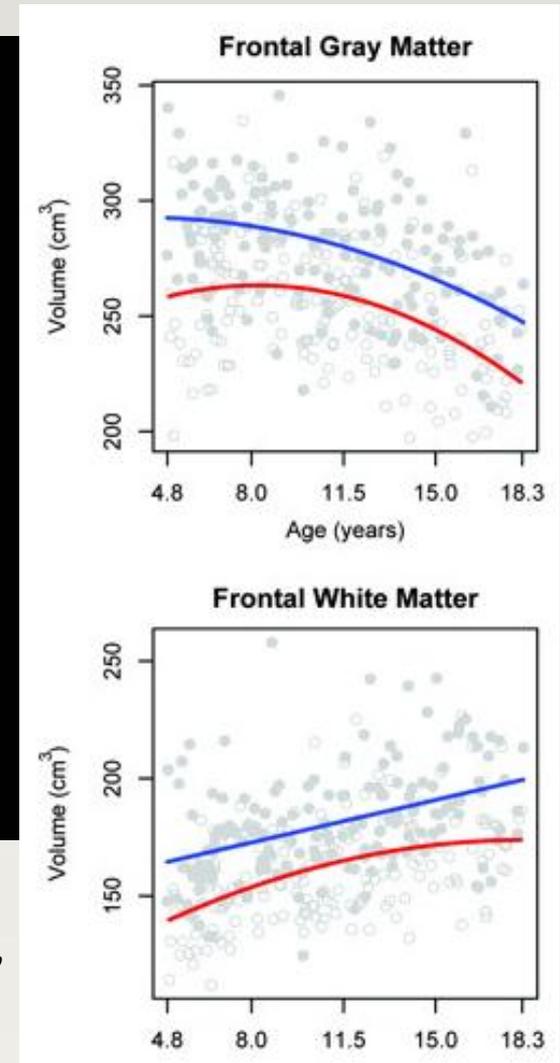
Changes Occur Within And Between Circuits



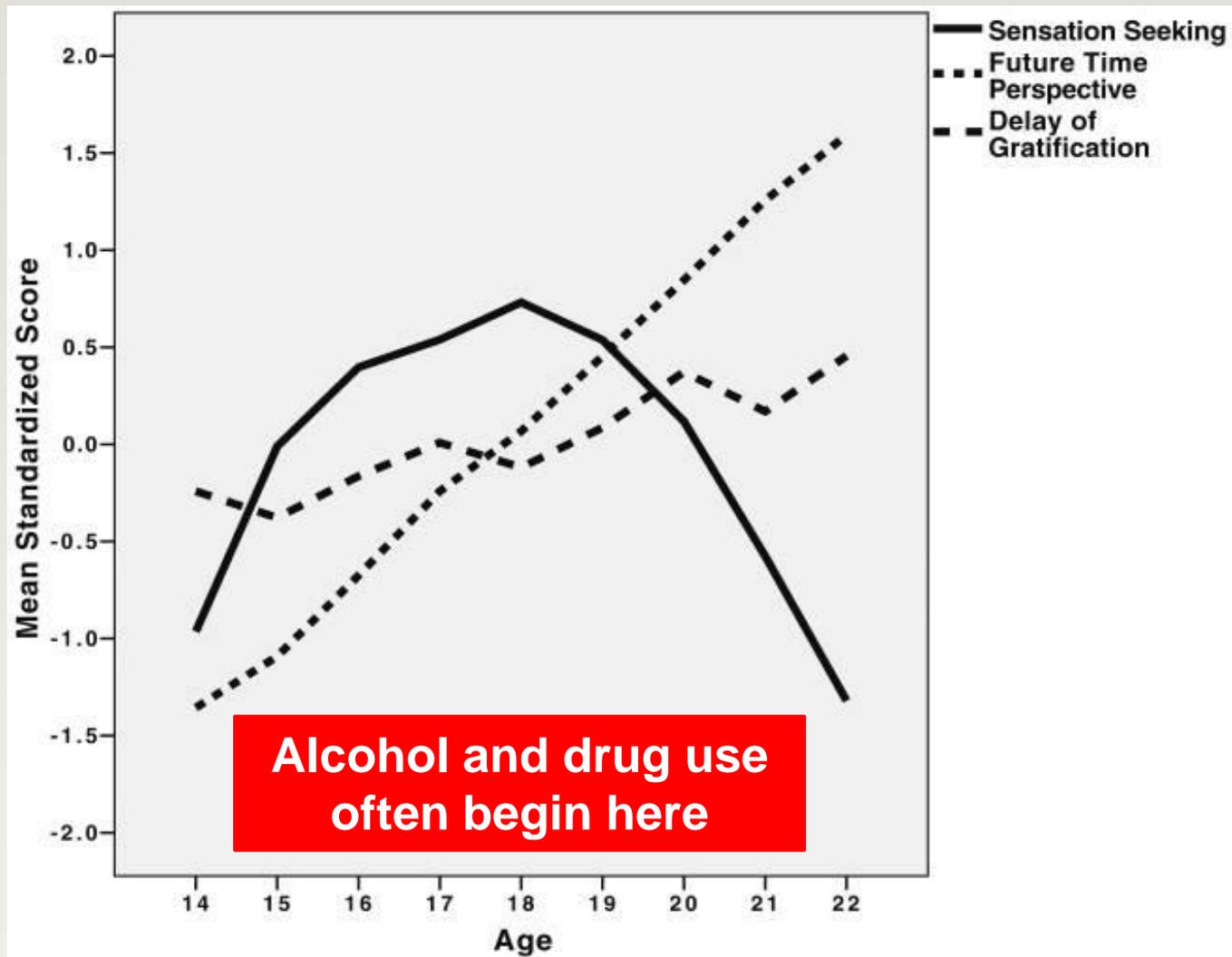
Frontal Lobe Changes During Adolescence



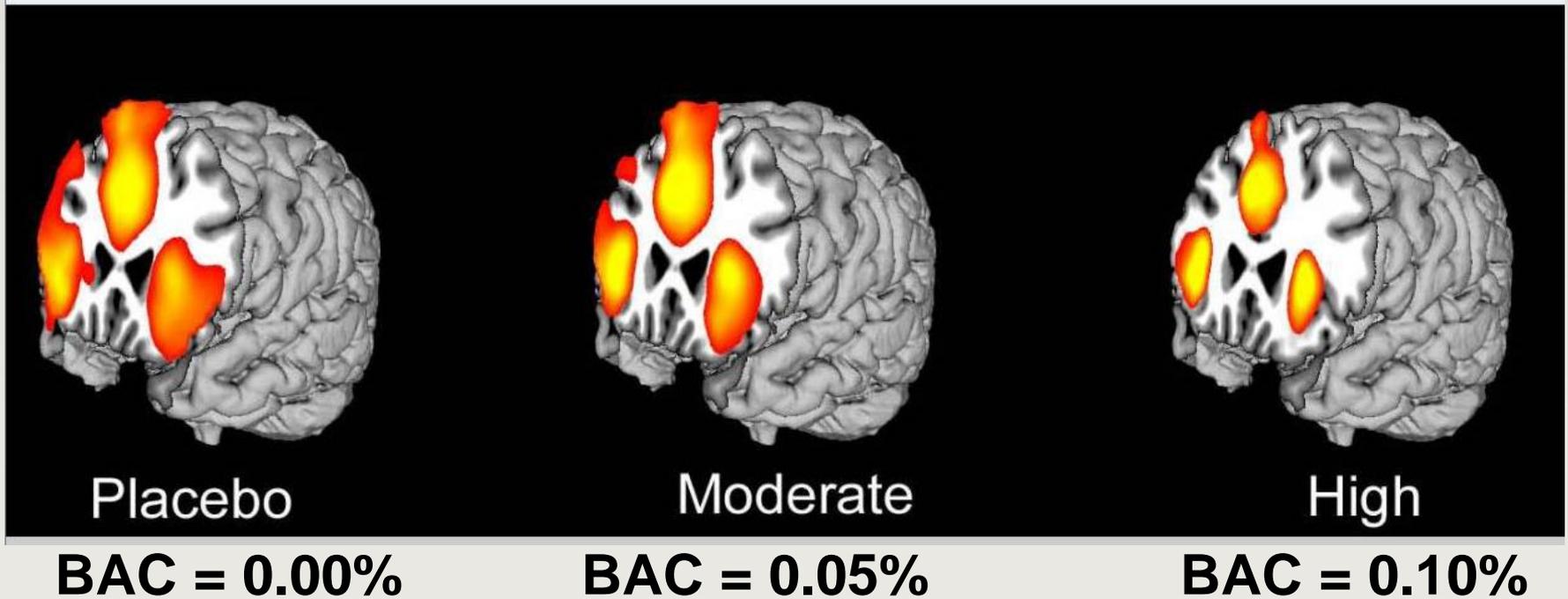
- Planning, decision-making, impulse control, memory, language, processing social cues



Adolescence Is Risky Business



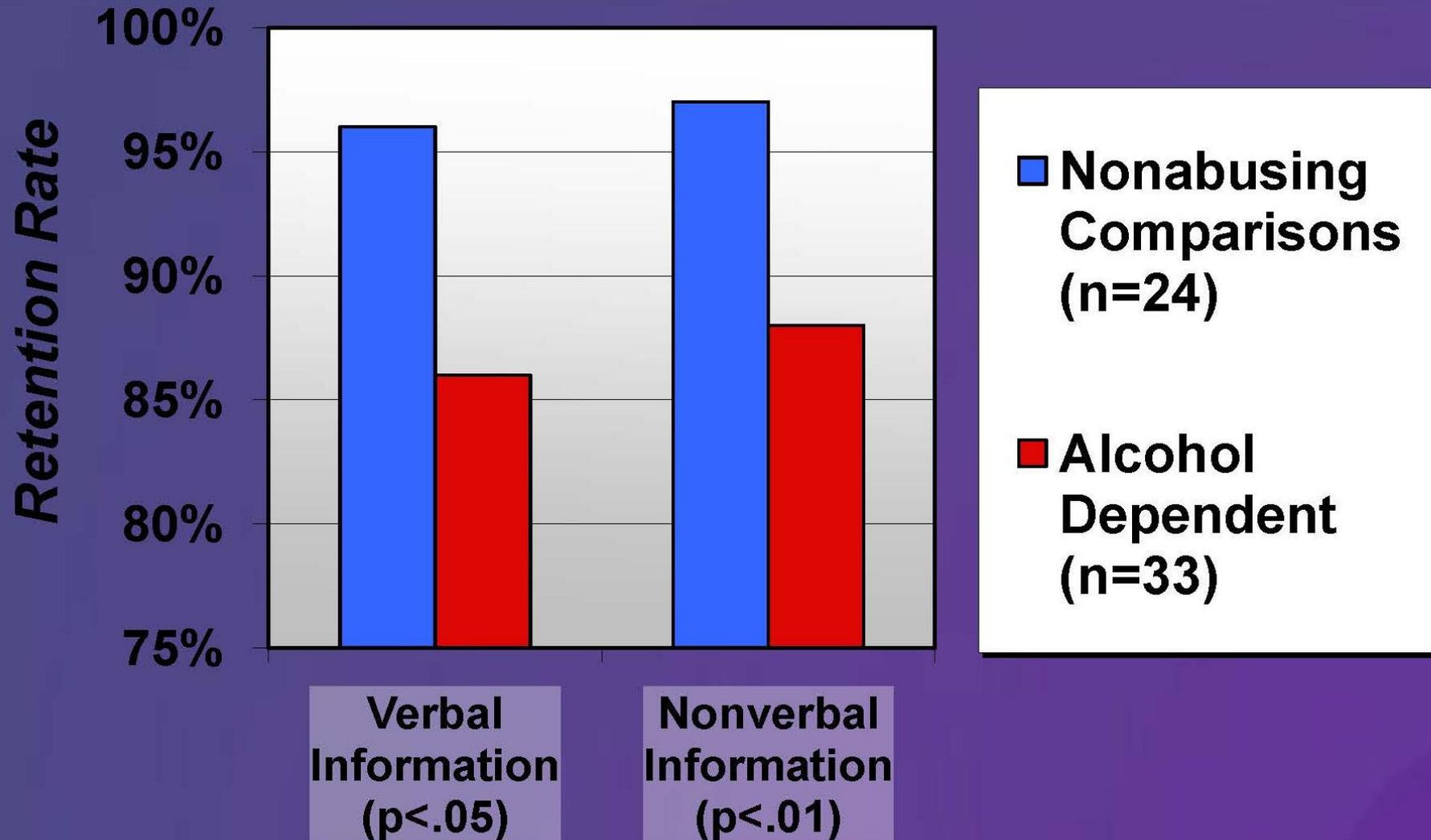
Acute Intoxication Impairs Executive Function and Disrupts Frontal Lobe Activity



Alcohol increased reaction time and false alarm errors in a dose-dependent manner in a Go/No-Go task (N = 51, mean age 24.5). **FMRI analyses showed alcohol decreased activity in anterior cingulate, lateral prefrontal cortex, insula and parietal lobe regions** during false alarm responses to No-Go stimuli.

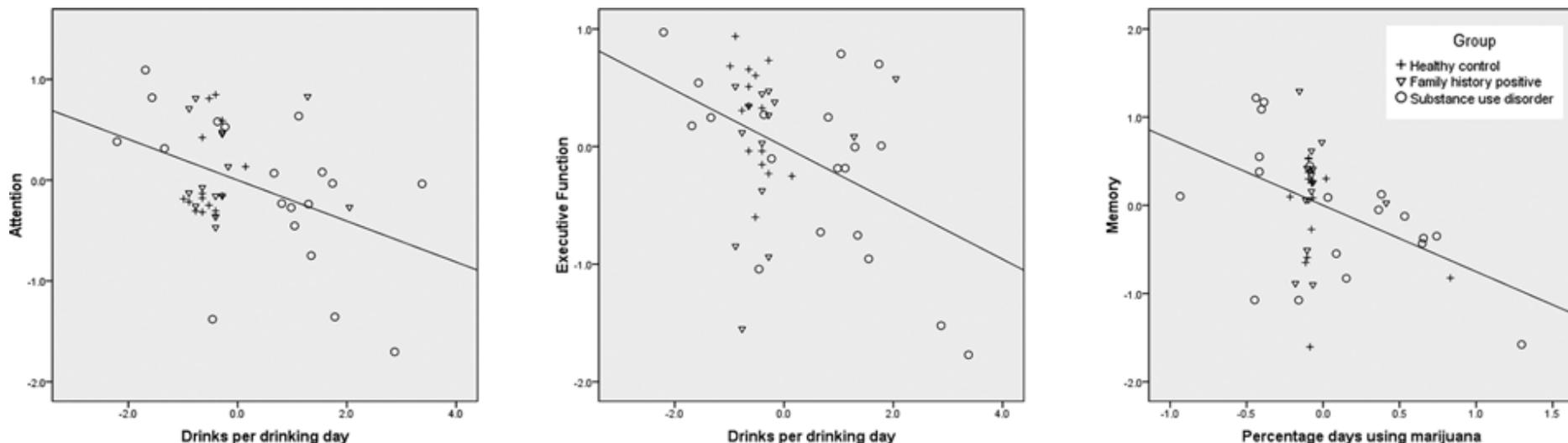
Anderson et al. (2011). Imaging of cognitive control during acute alcohol intoxication
Alcoholism: Clinical and Experimental Research. 35(1): 156–65.

Cognitive Impairments in Alcohol-Dependent Teens 3 Weeks Into Inpatient Treatment



Relationship Between Levels of Alcohol and Marijuana Use and Measures of Cognitive Function in Adolescents

As the number of drinks consumed per day goes up, performance on tests of attention, executive function, and memory go down. More days smoking marijuana equals poorer memory.

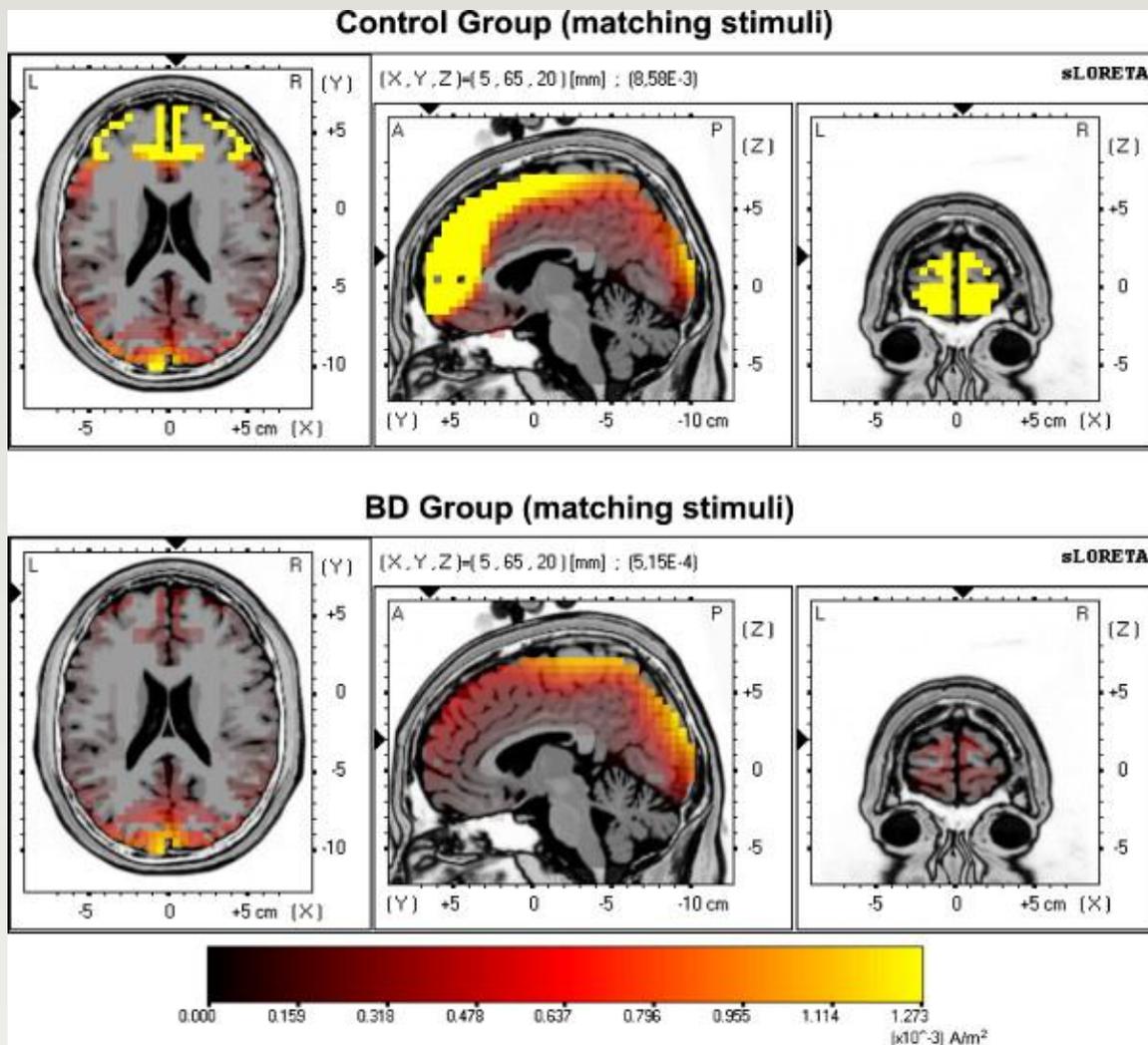


SUBJECTS: 48 adolescents (ages 12 to 18), recruited in 3 groups: a healthy control group (HC, $n = 15$), a group diagnosed with substance abuse or dependence (SUD, $n = 19$), and a group with a family history positive for alcohol use disorder (AUD) but no personal substance use disorder (FHP, $n = 14$).

RESULTS: More drinks per drinking day predicted poorer performance on Attention and Executive Function composites, and more frequent use of marijuana was associated with poorer Memory performance. In separate analyses, adolescents in the SUD group had lower scores on Attention, Memory, and Processing Speed composites, and FHP adolescents had poorer Visuospatial Ability.

Thoma et al. (2011). Adolescent substance abuse: The effects of alcohol and marijuana on neuropsychological performance. *Alcoholism: Clinical and Experimental Research*, 35: 39–46.

Binge Drinkers Show Less Prefrontal Lobe Activity During Visual Working Memory



Subjects

- 53 controls
- 42 binge drinkers (BD)
- 18- to 20 years old

Average binge episodes last 2 weeks

- Controls = 0.2
- Binge drinkers = 2

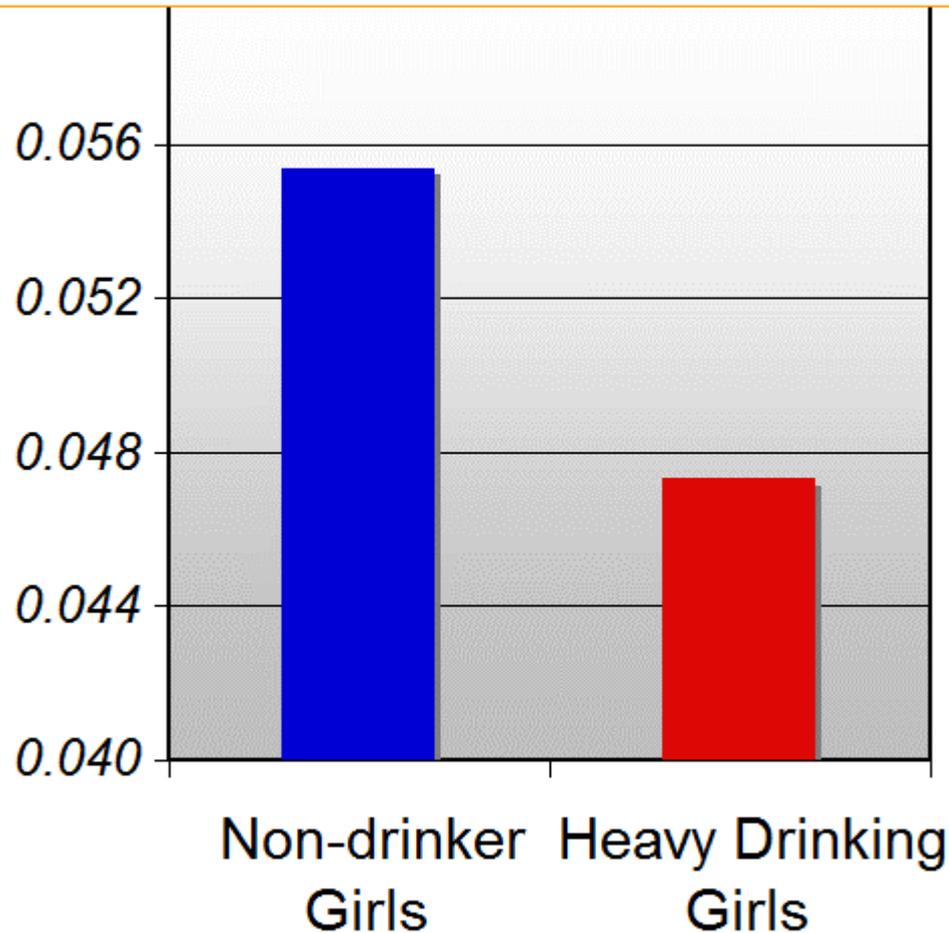
Technique

Low resolution brain electromagnetic tomography

Crego et al. (2010). Reduced anterior prefrontal cortex activation in young binge drinkers during a visual working memory task. *Drug and Alcohol Dependence*, 109, 45-56.

Heavy Drinking During Adolescence Associated With Reduced Frontal Lobe Volume

Ventral Prefrontal Volume

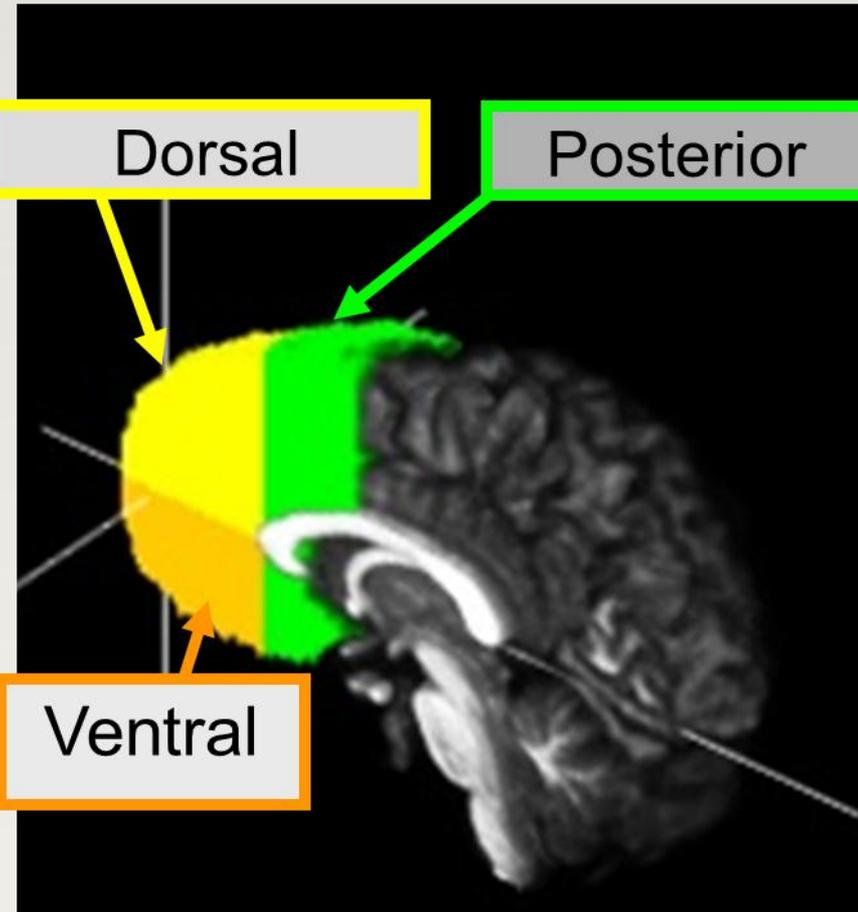


Prefrontal cortex:

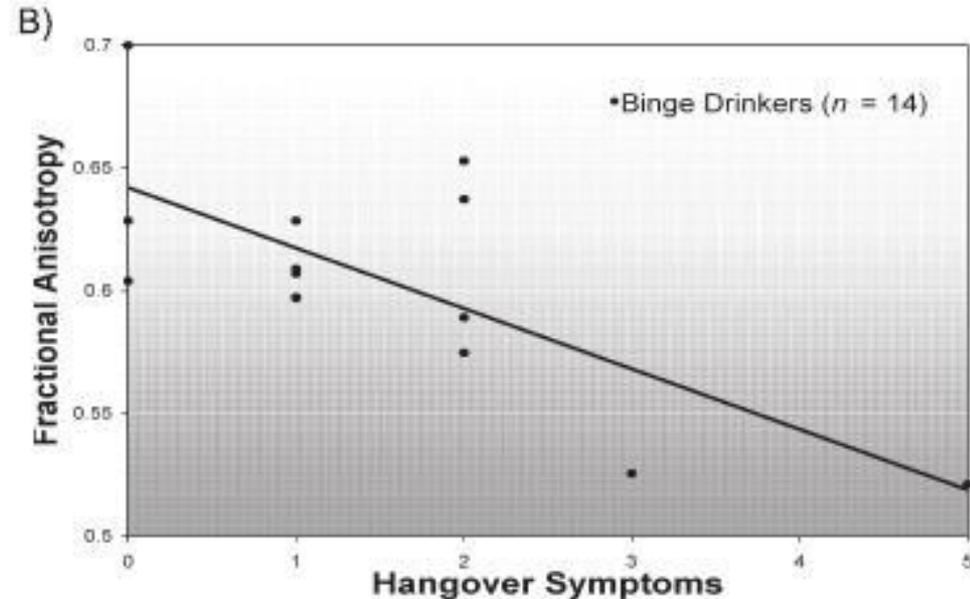
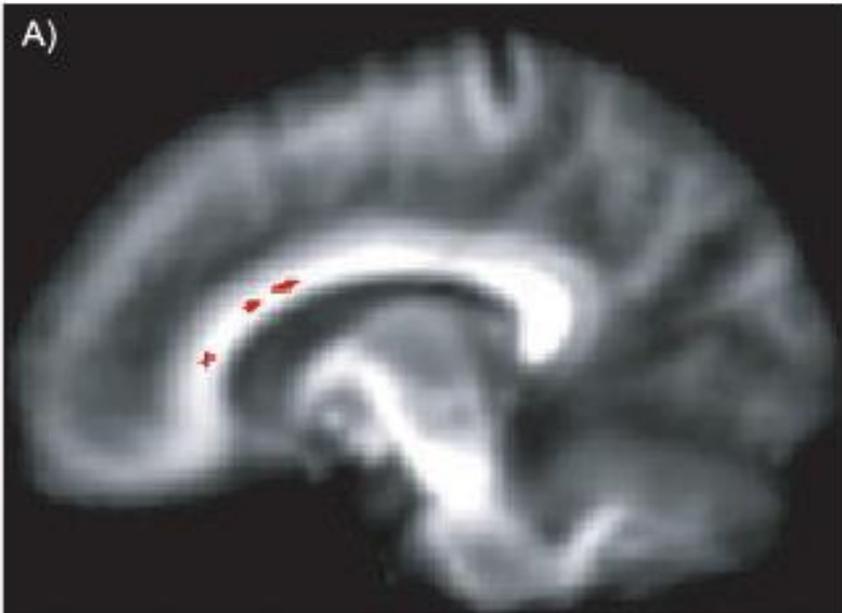
Dorsal

Posterior

Ventral

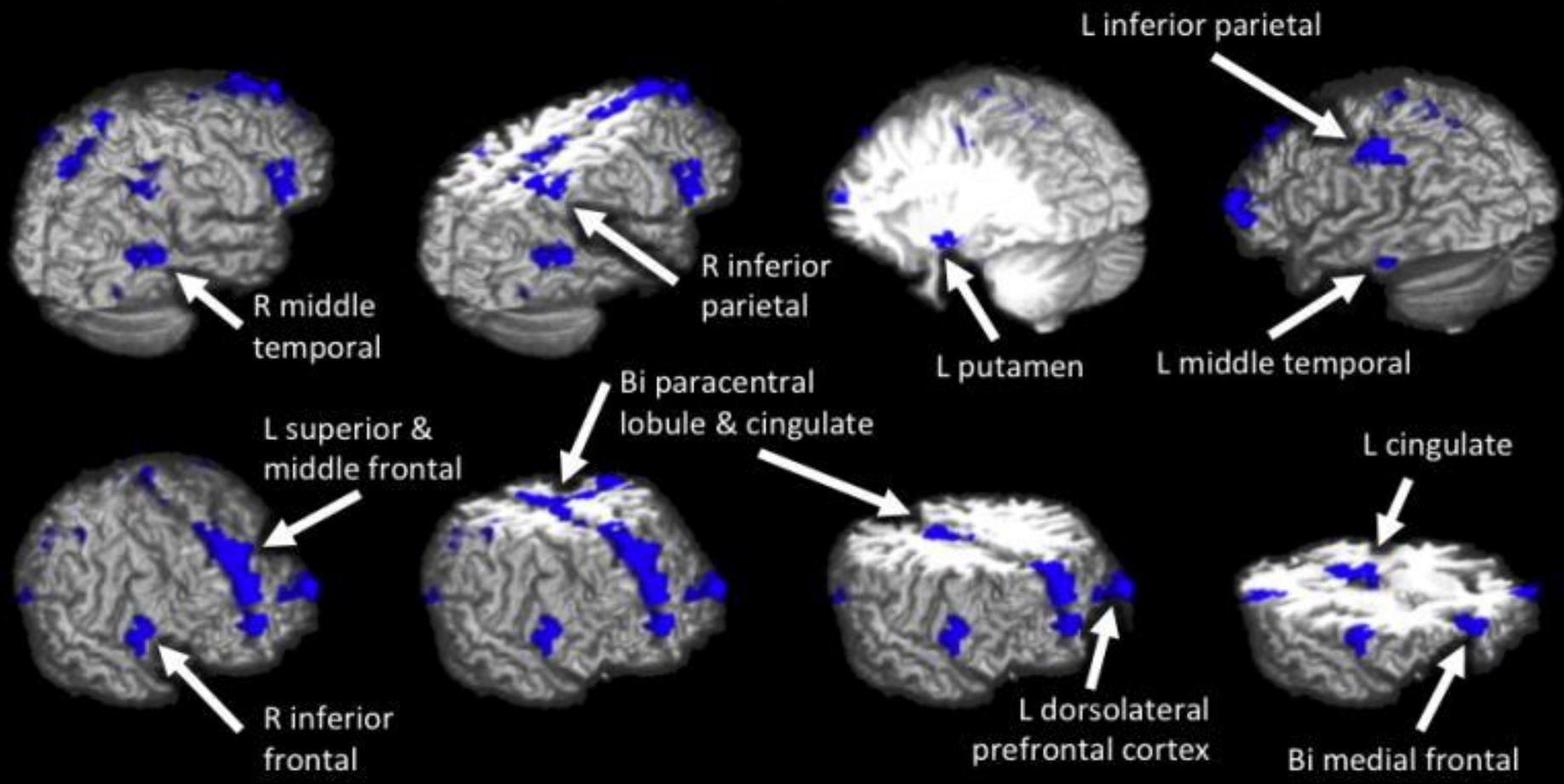


Binge Drinking During Adolescence Linked to Disrupted White Matter Tracts Connecting Brain Areas



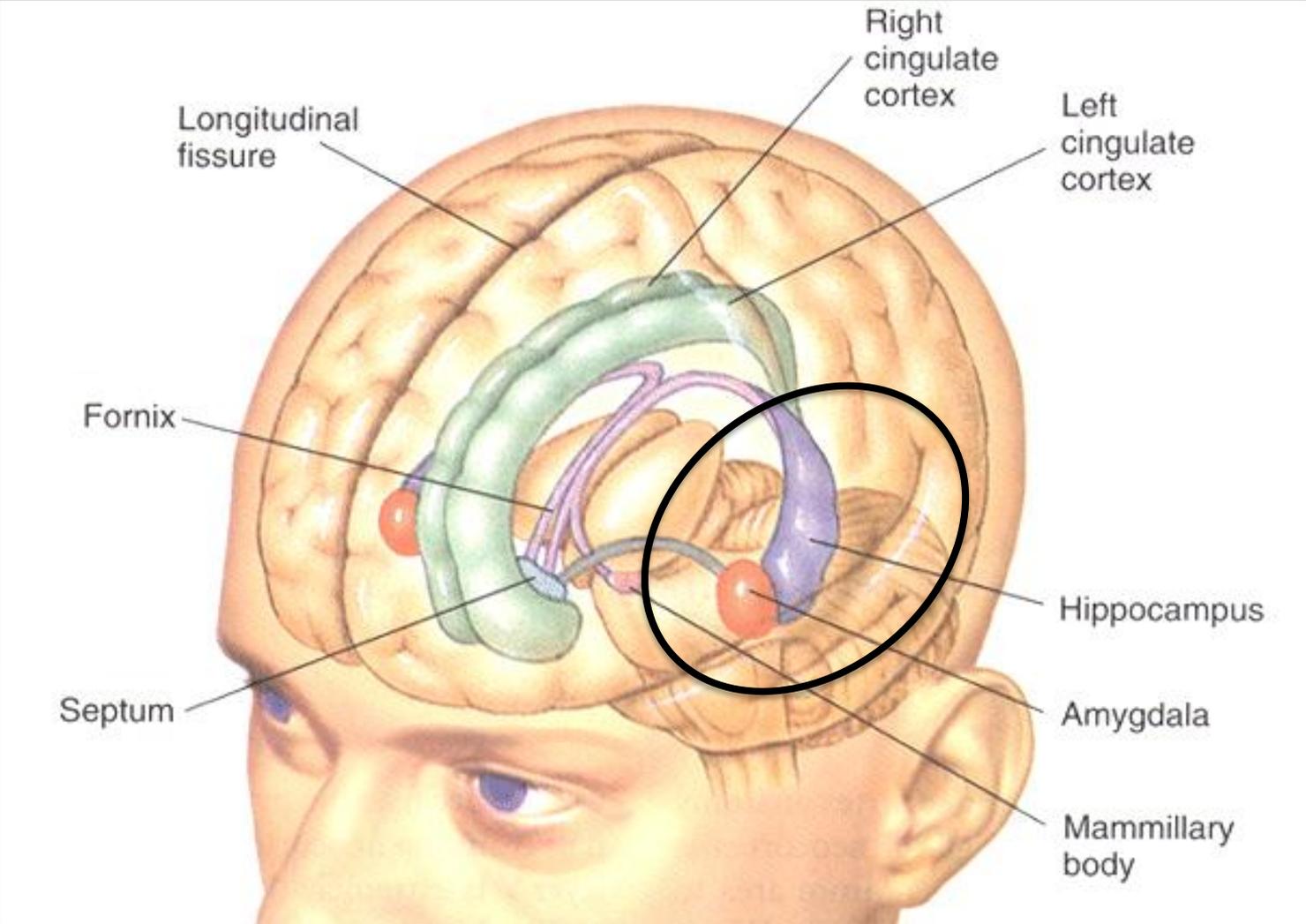
Binge drinking teens ($N = 14$, ages 16 to 19, average 15 drinks per month) with no history of alcohol use disorders had lower FA than controls ($N = 14$, age 16-19) in 18 white matter areas including the corpus callosum (above). Lower FA in six areas was linked to significantly greater lifetime hangover symptoms and/or higher estimated peak blood alcohol concentrations.

Frontal Lobe Activity At Baseline Predicts Transition to Heavy Drinking in Teens

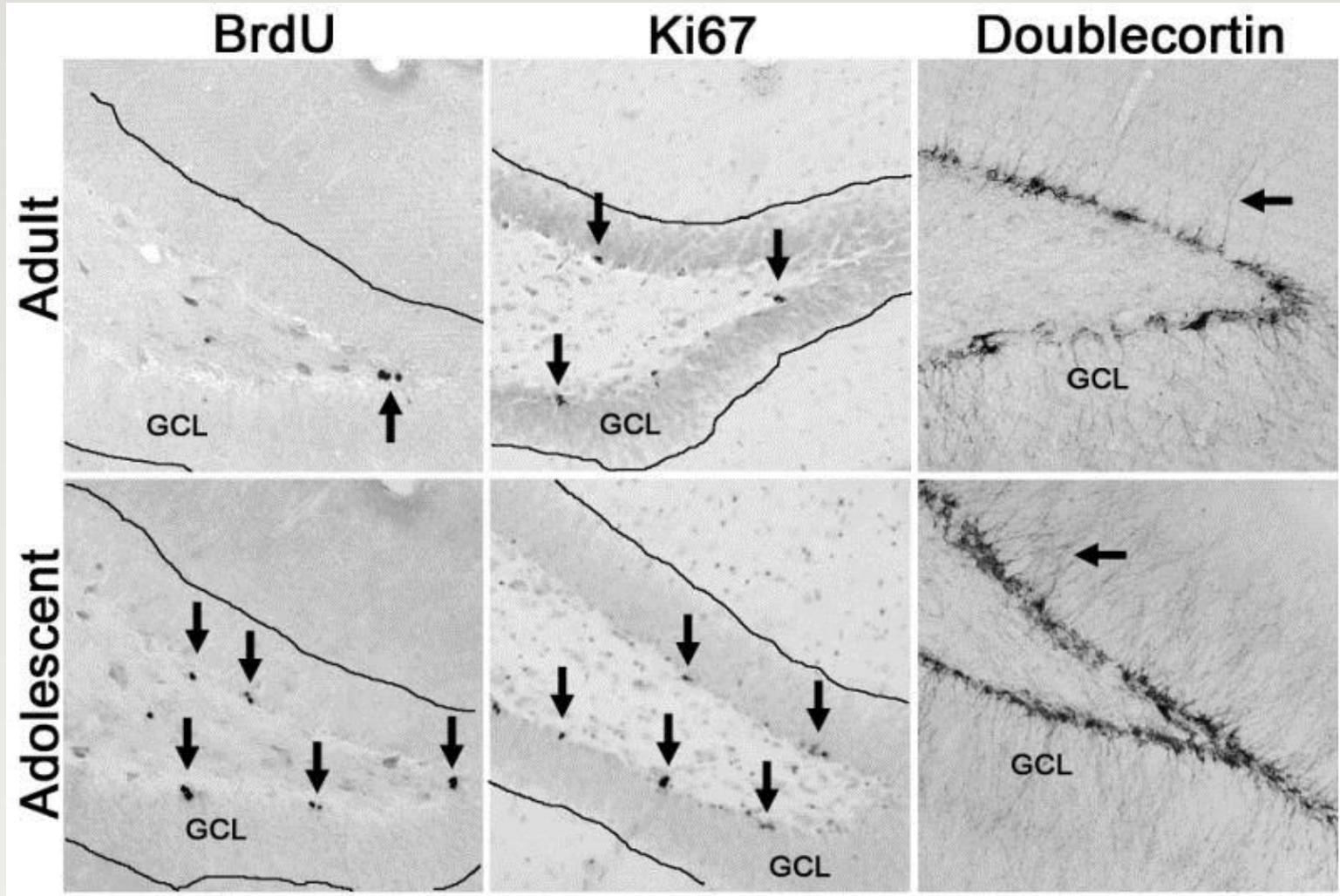


Differences in BOLD response during no-go trials at baseline between adolescents who transitioned into heavy alcohol use (TU; $n=21$) versus controls (CON; $n=17$). Areas in **blue** indicate where future users had significantly less BOLD response during inhibition (no-go) trials relative to baseline than non-users ($p<.01$, clusters $>864 \mu\text{l}$). In no region did TU show more no-go response than CON.

Hippocampus Creates Autobiographical Memories



Hippocampal Neurogenesis Peaks in Adolescence



He J, Crews FT. (2007). Neurogenesis decreases during brain maturation from adolescence to adulthood. *Pharm Biochem Behav.* 86:327–33.

Alcohol-induced Memory Blackouts



'Drunk and naked' in Cancun

By Gary Strauss, USA TODAY

CANCUN, Mexico — Shane Mahmood woke from a booze-induced fog with a half-inch stainless steel ring pierced through his lower lip.

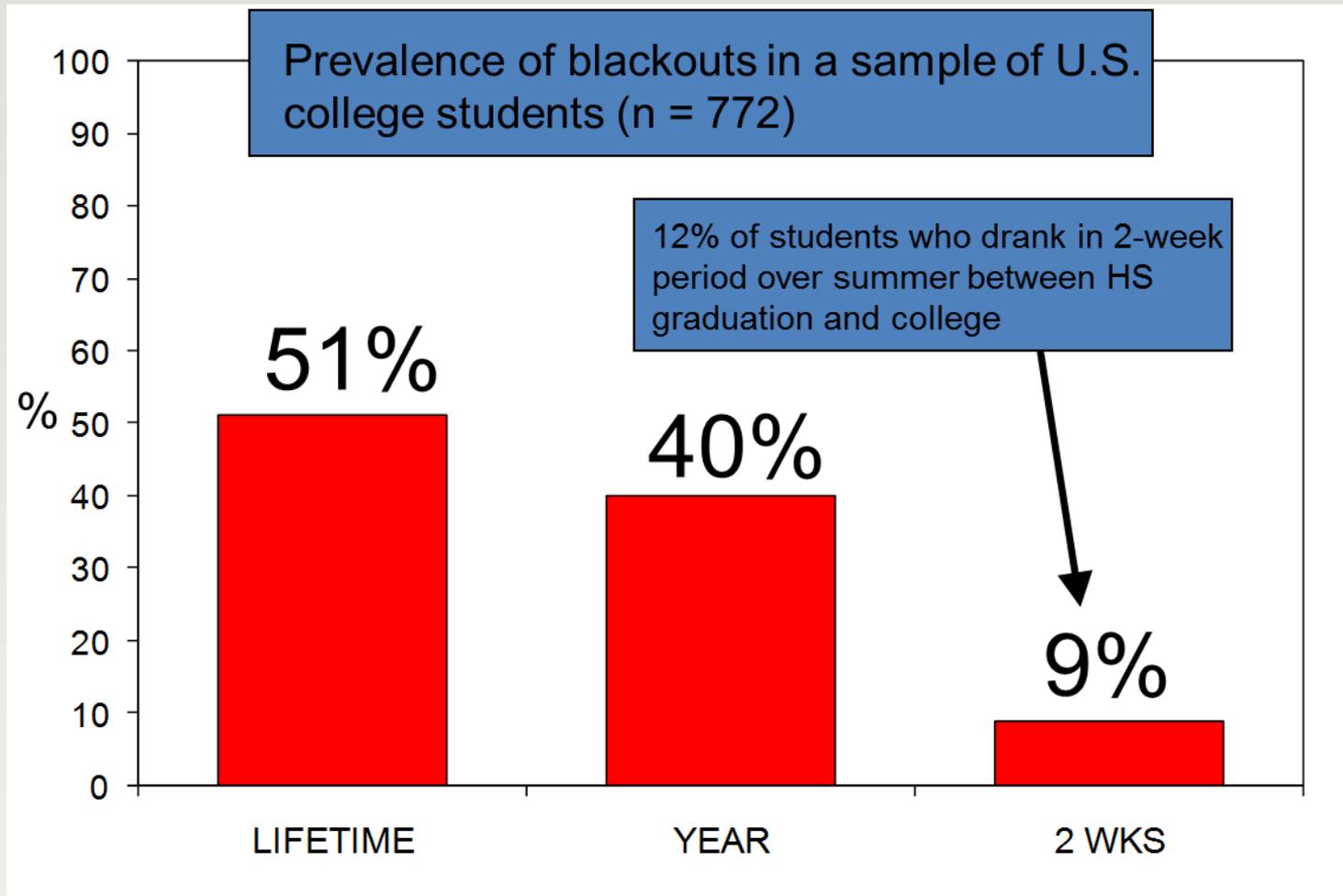


Shane Mahmood doesn't remember getting his lip pierced.

By Gary Strauss, USA TODAY

"I don't know how I got it or if it hurt when I did," says Mahmood, who was partying at disco La Boom with University of Washington pals when the predawn procedure apparently occurred. "I just remember beer and tequila before waking up and seeing it in the mirror."

Alcohol-induced Memory Blackouts Are Common Among Young Drinkers



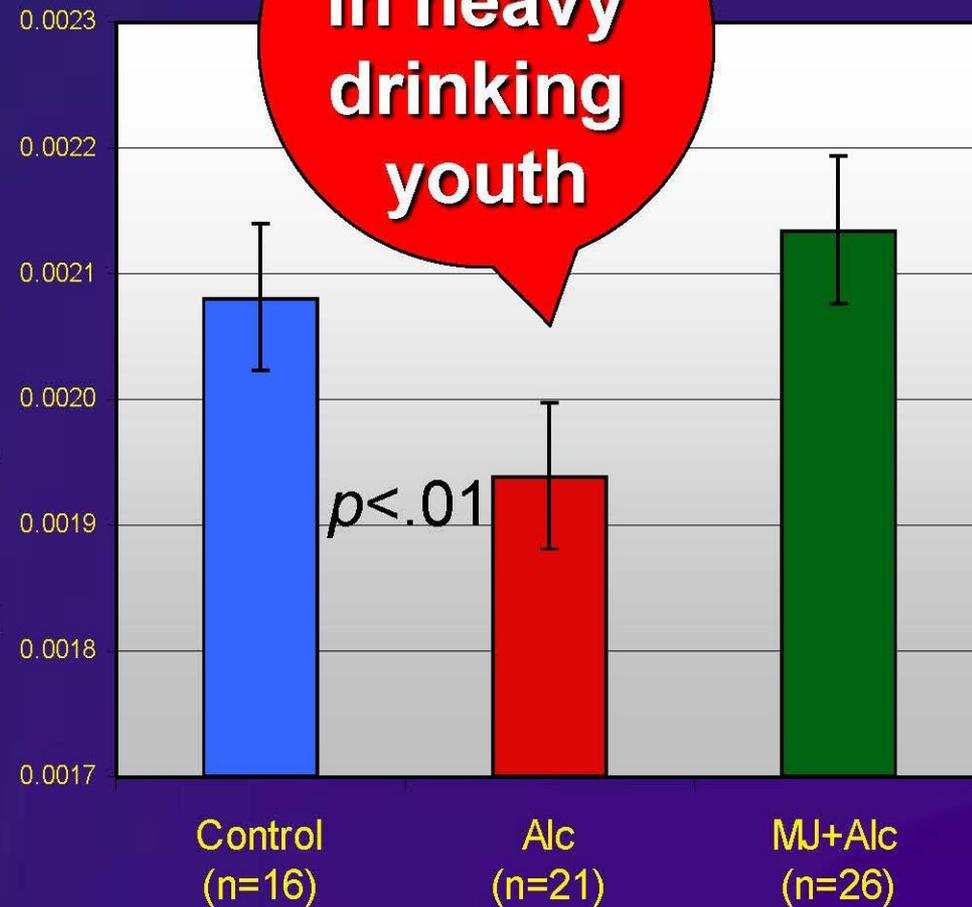
Left Hippocampus Smaller In Heavy-Drinking Teens

Hippocampal Volume



Right / Left

Left Hippocampus / Cranium Ratio



Reward (Monetary) Activates Ventral Striatum More Strongly in Adolescents Than Children or Adults

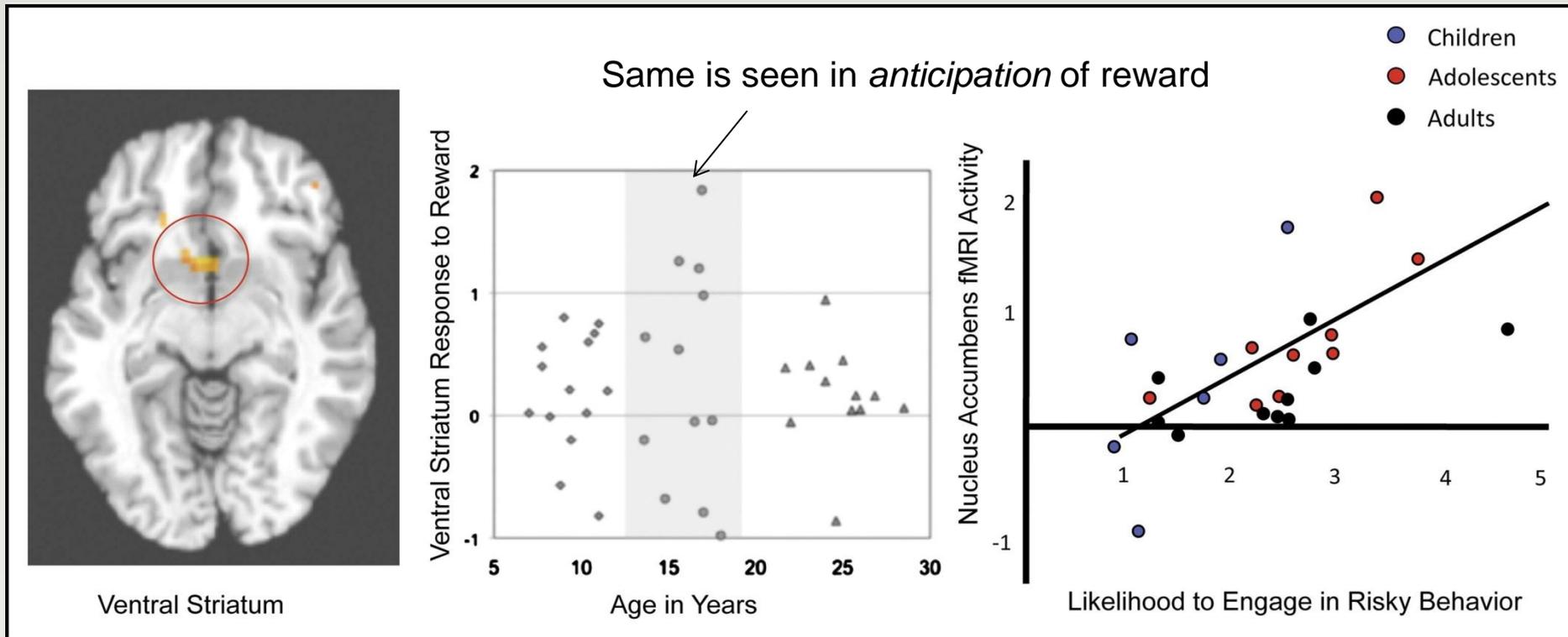


Figure. Ventral striatal activity to reward and association with risk-taking. Note: Ventral striatum (left) is activated with reward (middle) and correlated with risk-taking (right) (adapted from Galvan et al.⁶ and Galvan et al.¹⁶). Such findings could mean that adolescents are more motivated for reward and more reinforced by it.

Adolescent Alcohol Abusers Show Strong Reactions to Alcohol-related Cues Reflecting Strong Associative Learning

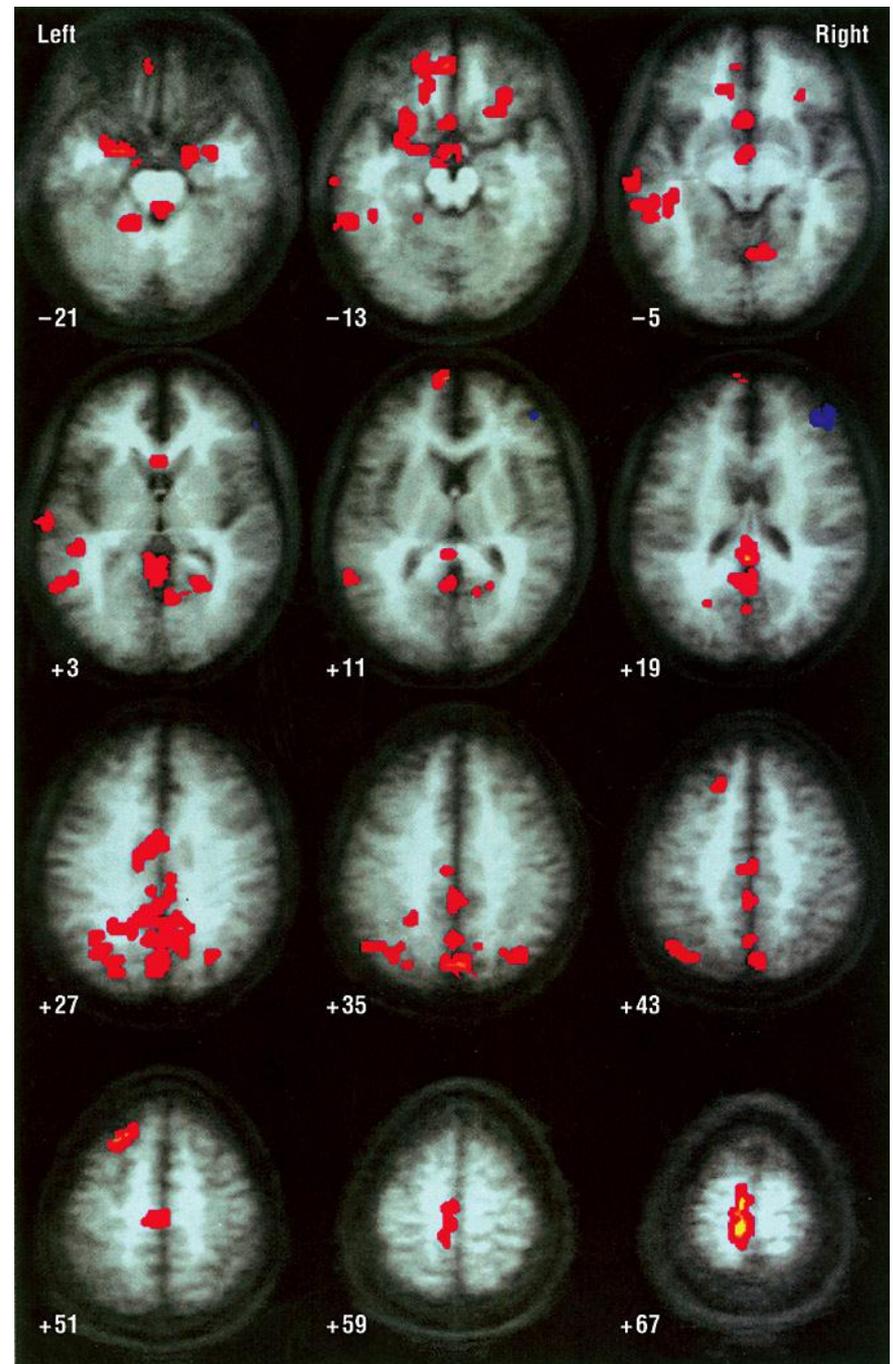
Functional magnetic resonance imaging (fMRI) results during alcoholic beverage picture trials relative to nonalcoholic beverage picture trials.

Greater activation in AUD subjects (red color) in the ventral anterior cingulate and subcallosal, prefrontal, orbital, and limbic regions, areas previously associated with reward and drug craving.

AUD group (N = 15) 6 girls 9 boys average age of 16, DSM abuse or dependence

Control group (N = 15) 6 girls 9 boys average age 16, low levels of previous use

Tapert, Susan. F. et al. (2003). *Arch Gen Psychiatry*. 60:727-735.



Age of Drinking Onset and Dependence: Risk Goes Up as Age Goes Down

AGE	FHP* (%)	FHN** (%)
≤ 13	57	26
14-15	48	32
16-17	35	21
18-19	22	13
20	16	9
≥ 21	16	7

* FHP = Positive family history of alcoholism; ** FHN = Negative family history of alcoholism

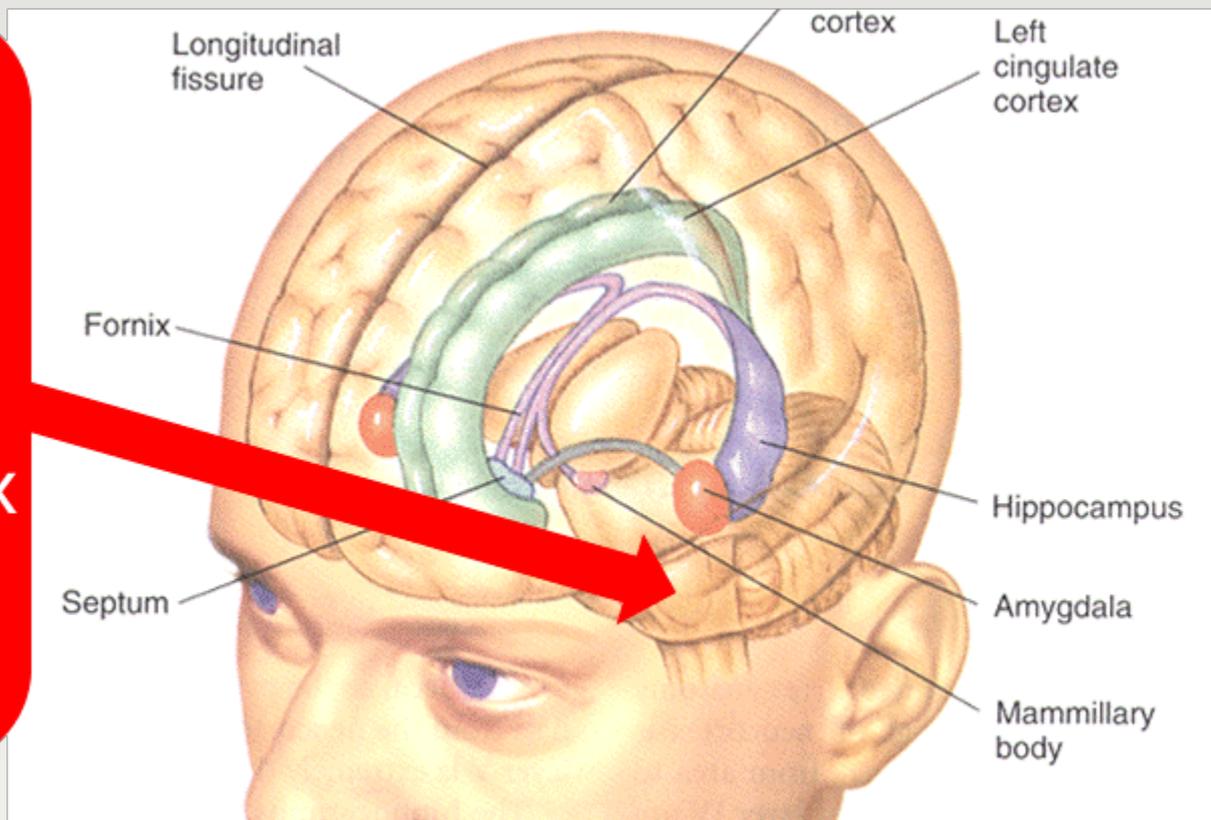
Grant BF & Dawson DA. Age of onset of alcohol use and its association with DSM–IV alcohol abuse and dependence: Results from the National Longitudinal Alcohol Epidemiologic Survey. *Journal of Substance Abuse*, 9:103–110, 1997.

Alcohol Can Be Deadly

Excessive alcohol and/or other CNS depressants can shut down brainstem areas involved in vital reflexes like breathing, gagging, and heart rate.

Alcohol

- Suppresses respiratory areas and other vital reflex centers
- Causes death



Alcohol Has a Narrow Safety Margin

Alcohol has a very small therapeutic index (TD_{50}/ED_{50})—
A toxic or deadly dose not much higher than a moderately
intoxicating dose.

Potentially fatal alcohol overdoses: How much alcohol?

If $ED_{50} = \sim .05\%$
And $TD_{50} = \sim .35\%$
Then $TI = \sim 7$

10 drinks in 2 hrs for
a 140 lb female

13 drinks in 2 hrs for
a 160 lb male

Posted 10/7/2004

Five binge-drinking deaths 'just the tip of the iceberg'

By Robert Davis, USA TODAY

This month has been deadly
for binge-drinking college
students.

Five underclassmen in four
states appear to have drunk
themselves to death, police
say, after friends sent their
pals to bed assuming that
they would "sleep it off."



HOME > NEWS > LOCAL

26 Teens Taken to Hospital for Alcohol Poisoning Ahead of Wiz Khalifa Concert at Jones Beach

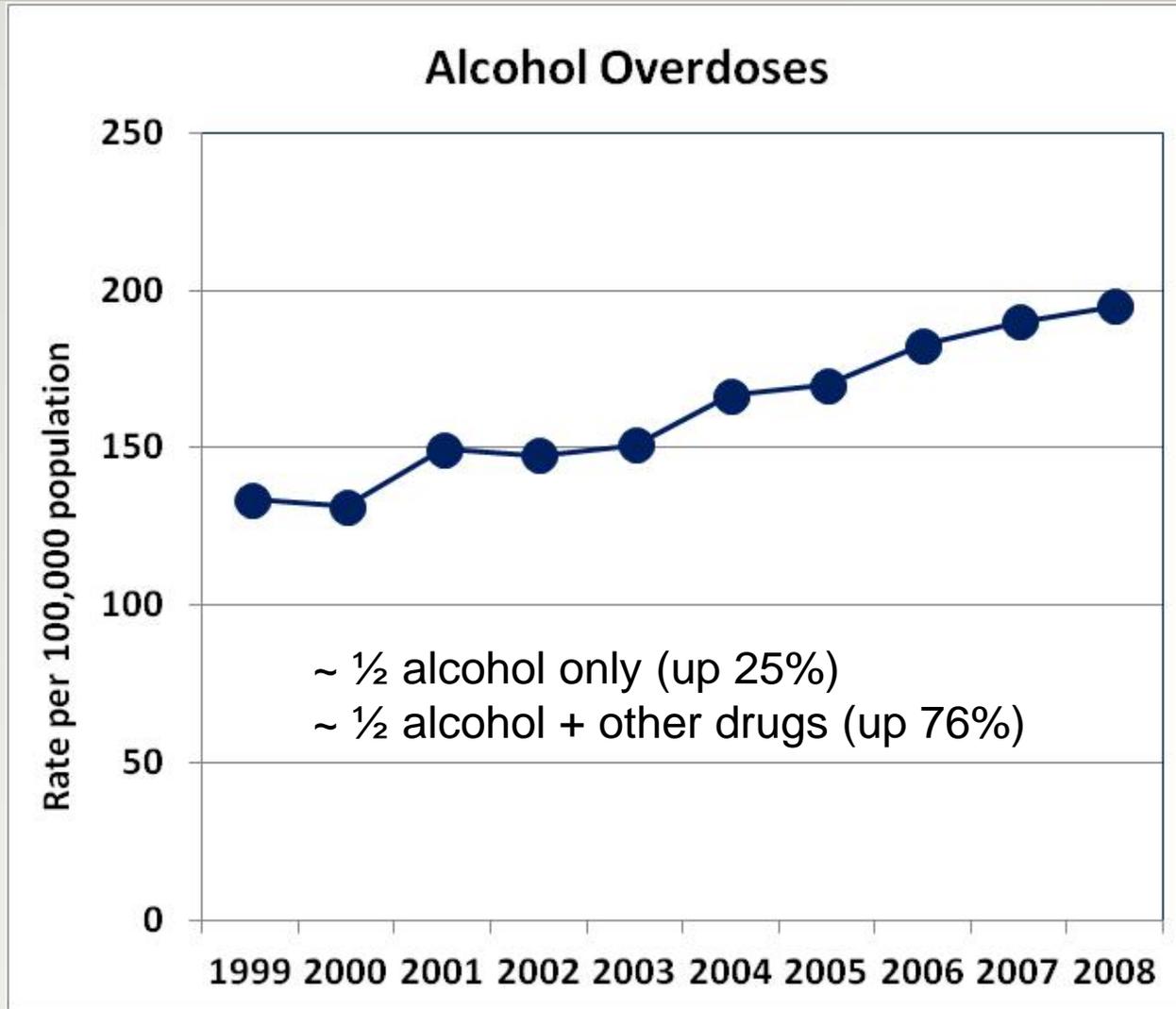
Twenty-six teenagers between the ages of 14 and 18 were taken from Jones Beach to Nassau University Medical Center in various stages of intoxication Thursday

Friday, Aug 3, 2012 | Updated 5:18 PM EDT



Getty Images

67% Increase In Hospitalizations Related to Alcohol Overdoses in 18 to 24 Year Olds Between 1999-2008



Summary

- **Adolescence represents a transition from dependence to relative independence.**
 - **Changes in the brain help drive us toward peers and away from relatives, which helps increase genetic diversity.**
 - **The brain absorbs new experiences with ease with an eye toward using these experiences to compete for mates and resources and to succeed in adulthood.**
 - **Short-term, alcohol disrupts brain function in ways that cause memory impairments, poor decision-making, risk taking, injuries, and death.**
 - **Long-term, alcohol can alter the trajectory of adolescent brain development and cause lingering cognitive deficits.**
 - **It remains unknown whether these deficits are permanent.**
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