Volume of Nucleus Accumbens and Orbitofrontal Cortex is Related to Alcohol Use in Adolescents

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Introduction

Alcohol use has previously been linked to reductions in brain volume in reward processing circuits. Makris et al. (2008) reported reduced volume of nucleus accumbens and dorsolateral prefrontal cortex in adult alcoholics. During adolescence risk-taking behaviors and alcohol consumption increase (Steinberg 2005). De Bellis et al. (2000) found that adolescents who reported heavy alcohol consumption had smaller left and right hippocampal volumes compared to matched controls. Though there are reported cortical and subcortical volumetric differences related to heavy alcohol consumption, less is known about the impact of moderate drinking early in adolescence.

The current study used structural MRI to investigate neural correlates of alcohol use in adolescence. We hypothesized that early exposure to alcohol would be associated with morphological differences in both subcortical and cortical reward processing networks.

Participants & Measures

Gender-Matched Controls
n =13
Mean age = 15.63 years
6 male, 7 female

Drinkers
n =13
Mean age = 16.04 years
6 male, 7 female

Neuropsychological Testing

- ***BIS/BAS scale*** – measure of individual differences in motivational systems that support behavior and affect
- ***MPQ*** – measure of personality traits, including broad measures of positive emotionality, negative emotionality, and constraint
- ***Barratt Impulsivity scale*** – measure of motor, cognitive, and planning impulsivity
- ***IQ*** – vocabulary and matrix reasoning subtests of the Wechsler Abbreviated Scales of Intelligence

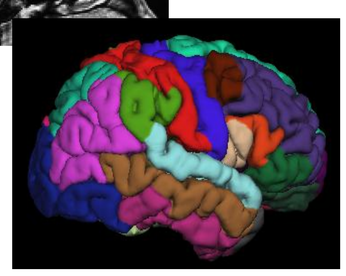
Alcohol Use Interview

- ***Revised CIDI Substance Abuse Module*** – semi-structured interview used to obtain detailed information about lifetime and past-year drinking behaviors, modified for use with adolescents
  - two **composite drinking variables (frequency/quantity of drinking, binge drinking)** created based on PCA analysis of lifetime and past-year drinking behaviors

Imaging Methods

Data Acquisition

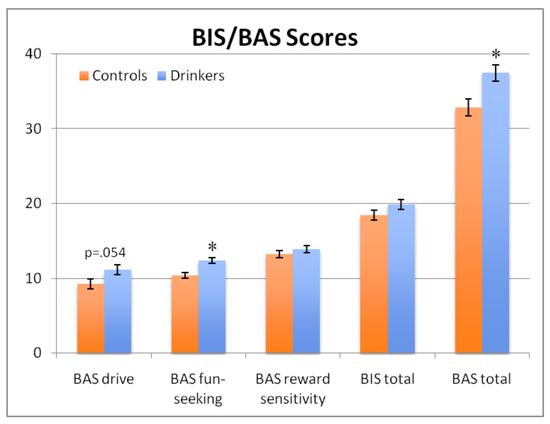
- T1-weighted anatomical MPRAGE images
  - TR = 2530ms, TE = 3.65ms
  - matrix 256 x 256, FOV = 256,
  - 1mm slice thickness, 240 sagittal slices.



FreeSurfer Analysis

- automated volumetric segmentation of subcortical and cortical structures (Fischl et al. 2004)
- volumetric measurements were corrected proportionally for intracranial volume (Jernigan et al. 1982)
- group analyses included age, gender (volume and thickness analyses), and IQ (thickness analyses) as covariates

Results: Neuropsychological Measures

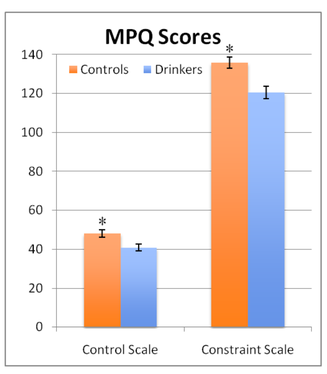


BIS/BAS

- **Drinkers** scored higher on drive (p=.054), fun-seeking (p=.002), and overall BAS scores (p=.01) than **Controls**

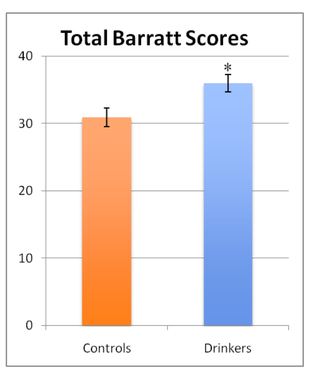
MPQ

- **Controls** scored higher on control (p=.011) and constraint (p=.003) scales than **Drinkers**



Barratt

- **Drinkers** had higher total impulsivity scores than **Controls** (p=.016)



Acknowledgments

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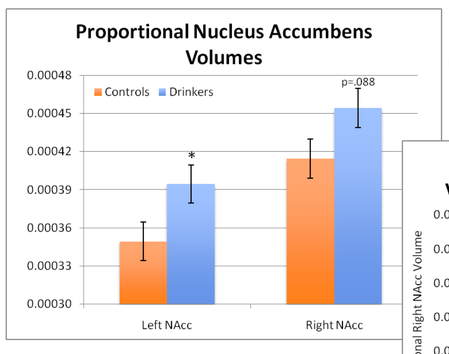
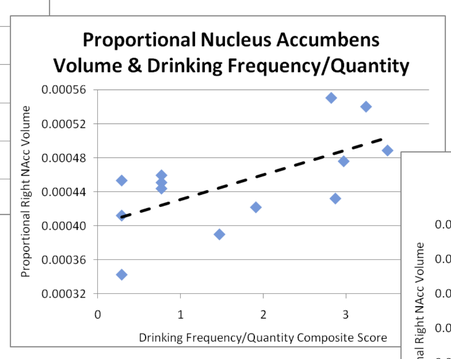
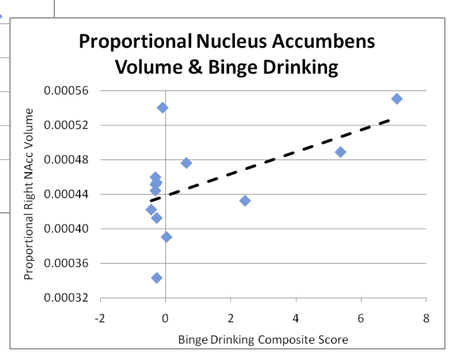
Results: Nucleus Accumbens



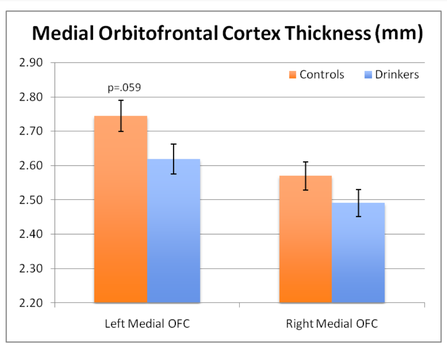
- **Drinkers** had larger proportional left (p=.051) and right (p=.088) nucleus accumbens volumes than **Controls**



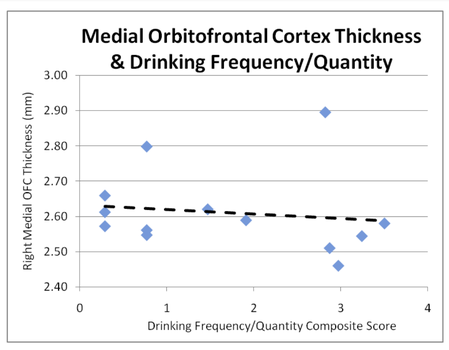
- Within the **Drinkers,** proportional right nucleus accumbens volume was predicted by frequency/quantity of alcohol use (t=2.328, p=.042) and binge drinking (t=2.223, p=.052)



Results: Orbitofrontal Cortex Thickness

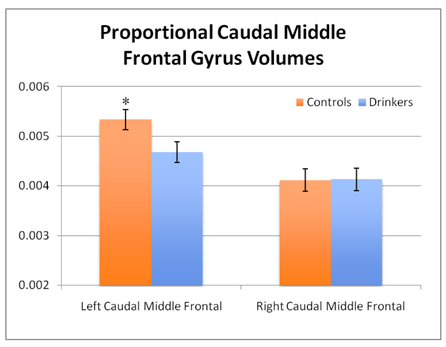


- **Drinkers** had reduced cortical thickness in left medial orbitofrontal cortex compared to **Controls** (p=.059)



- Within the **Drinkers**, left medial orbitofrontal cortex thickness was predicted by frequency/quantity of alcohol use (t=-2.283, p=.052)

Results: Dorsal & Lateral Prefrontal Cortices

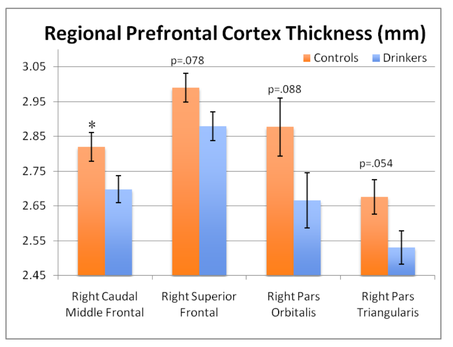


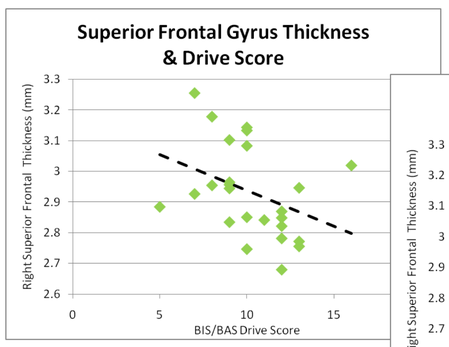
Volume

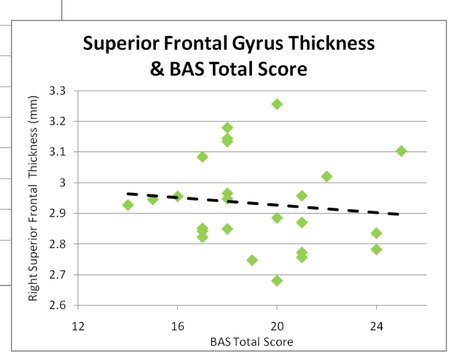
- **Drinkers** had smaller proportional left caudal middle frontal volumes than **Controls** (p=.037)

Thickness

- **Drinkers** had reduced thickness compared to **Controls** in right caudal middle frontal gyrus (p=.047), right superior frontal gyrus (p=.078), right pars orbitalis (p=.088), and right pars triangularis (p=.054)







Thickness

- In all **Adolescents**, right superior frontal gyrus thickness was predicted by BIS/BAS drive score (t=-2.662, p = .015) and BAS total score (t=-2.036, p=.055)

Discussion

Results suggest that alcohol use during adolescence is associated with increased volume in the nucleus accumbens and decreased volume and thickness in portions of the frontal cortex previously associated with reward processing in adolescents (Galvan et al., 2006). Furthermore, in adolescent drinkers more frequent consumption and binge drinking were related to more extreme volumetric differences in areas associated with reward processing. Drinkers also showed higher levels of fun-seeking and impulsive behaviors. Alcohol use in adolescence may affect the development of the nucleus accumbens and prefrontal regions associated with self-control and behavior regulation, contributing to higher levels of externalizing behavior observed in adolescent drinkers. However, it is unclear whether the morphometric differences observed in adolescent alcohol users predate initial consumption or are an effect of early substance use. The current sample was drawn from a larger study of alcohol use and reward processing in adolescent monozygotic twins. Future analyses will address changes in drinking behaviors and brain morphometry after a one-year follow-up.