An fMRI Study of Reward Processing and Adolescent Alcohol Use

Sara E. Langworthy[1], Ruskin H. Hunt[1], Stephen M. Malone[2] & Kathleen M. Thomas[1]

[1]Institute of Child Development, University of Minnesota, [2]Department of Psychology, University of Minnesota

Human Brain Mapping Conference, June 6-10, 2010, Barcelona Spain

Introduction

Adolescence is often characterized by an increase in risk-taking behaviors and substance use. Researchers have hypothesized that differences in reward processing mechanisms in the brain may be partly responsible for the increased risk taking behaviors seen in adolescence (Galvan et al., 2006). Previous studies have found that adults and adolescents show similar patterns of activation in the nucleus accumbens (NAcc) during high reward conditions (Bjork et al., 2004). However, patterns of orbitofrontal cortex (OFC) activity have been shown to be less mature in adolescents during reward conditions, implicating prefrontal immaturity in increased risk-taking behaviors (Galvan et al., 2006) and substance use in adolescence. In this study, we hypothesized that there may be differential recruitment of the NAcc and OFC as a function of teen alcohol use.

Participants

- Interviewed about alcohol consumption using the revised CIDI Substance Abuse Module
  - **Drinkers** - individuals who reported any past alcohol consumption
  - **Gender Matched Controls** – individuals who reported no alcohol consumption

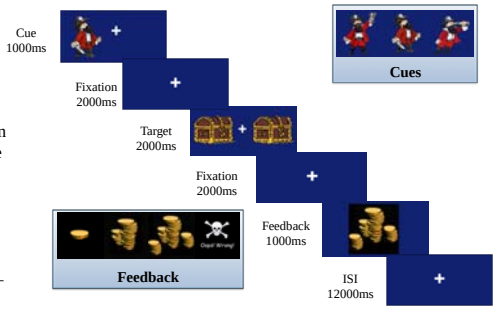
Drinkers
- n = 13
- Mean age = 16.04 years
- 6 male, 7 female

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

Methods

Pirate Reward Task

- Three levels of reward associated with three different cues
- Participant required to press right or left button depending on which side of the screen the cue appeared
- Feedback indicated amount of reward gained (small, medium, large)
- Participant not explicitly told the cue-feed back associations – implicit learning task

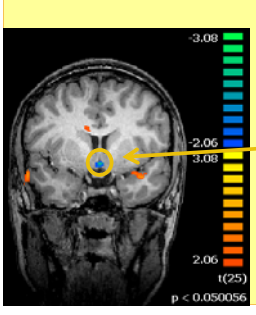


Data Acquisition

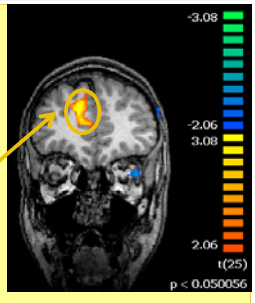
- Siemens 3T Trio scanner
- Whole brain EPI BOLD images
  - TR = 2000ms, TE = 28ms, Matrix = 200 x 200, Flip Angle = 90^0, 4mm slice thickness, 34 axial slices, 182 repetitions
- T1-weighted anatomical MPRAGE images
  - TR = 2530ms, TE = 3.65ms, Matrix 256 x 256, FOV = 256, 1mm slice thickness, 240 sagittal slices

Overall

Analysis Parameters
- Cluster threshold of at least 6 functional voxels
- Color scale reflects p = 0.05 to p = 0.005

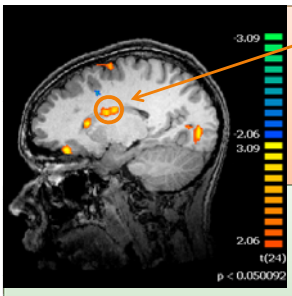


Task Related Activation
- Greater activation for anticipation of large versus small reward targets in the right medial frontal lobe (Talairach: 14, 41, 25; t = 2.602, p < 0.05)
- Activation for anticipation of small reward targets and deactivation for anticipation of large reward targets in nucleus accumbens (Talairach : 0, 4, -6; t = -2.759, p < 0.05)

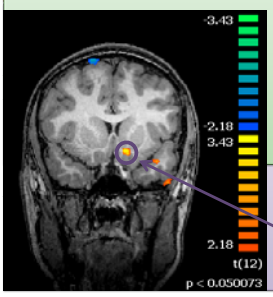


Behavioral Results
- No accuracy or reaction time differences between groups

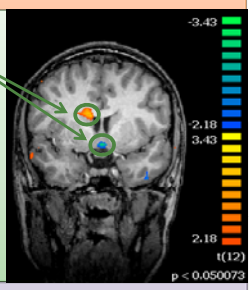
Anticipation of Target



Drinkers vs Gender Matched Controls
- Group differences in activation for anticipation of large versus small targets in the caudate nucleus (Talairach: 17, -5, 23; t = 2.979, p < 0.01)
- Drinkers show significantly greater activation during anticipation of large over small reward targets (t = 4.267, p < 0.005) whereas Controls show no difference in the caudate



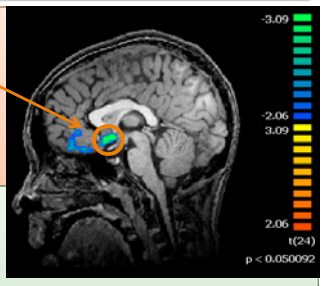
Drinkers
- In nucleus accumbens (Talairach: -1, 3, -5; t = -3.217, p < 0.01) Drinkers show greater deactivation for large than small reward target anticipation
- In the caudate (Talairach : 11, 4, 23; t = 4.269, p < 0.005), Drinkers show greater activation for large than small reward target anticipation

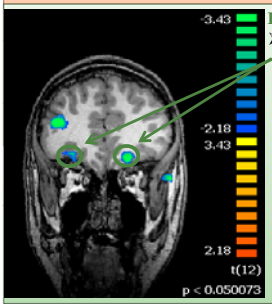


Gender Matched Controls
- In left nucleus accumbens,(Talairach: -10, 10, -9; t = 3.978; p < 0.005) Controls show greater activation for large than small reward anticipation

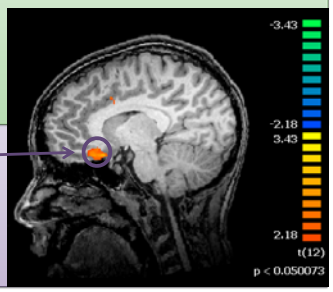
Anticipation of Receiving Reward

Drinkers vs Gender Matched Controls
- Group differences in activation in the nucleus accumbens (Talairach: 0, 7, -7; t = -3.608, p < 0.005)
- Drinkers show deactivation for anticipation of receiving a large reward in nucleus accumbens (t = -3.615, p < 0.005) whereas Controls show no difference





Drinkers
- Greater deactivation during anticipation of receiving a large rather than small reward in the nucleus accumbens (Talairach: 0, 8, -6; t = -3.518, p < 0.005), the left (Talairach: -16, 35, -11; t = -4.269, p < 0.005) and right (Talairach: 28, 34, -11; t = -2.967, p < 0.05) orbitofrontal cortex



Gender Matched Controls
- In the right orbitofrontal cortex (Talairach: 9, 25, -16; t = 3.201, p < 0.01) Controls show greater activation during the anticipation of large over small rewards

Conclusions

Overall, adolescents who had previously used alcohol showed greater deactivation during anticipation of large versus small rewards in the nucleus accumbens and the orbitofrontal cortex. Additionally, the Drinker group showed different areas of focal activation for the orbitofrontal cortex and nucleus accumbens than the Control group. Interestingly, the Drinker group showed significantly more activation of the caudate nucleus for large than small reward, whereas the control group did not show this pattern. The caudate nucleus has previously been associated with implicit learning processes in the brain (Thomas et al., 2004). These findings indicate that though reward centers in the brain seem to be less sensitive to large rewards for adolescent alcohol users, there are greater responses for large over small rewards in associative learning centers.

This research is supported by grants from the National Institutes of Health to The Center for Magnetic Resonance Research (BTRR-P41 RR008079 and P30N057091) , the MIND Institute, and National Institutes of Alcoholism and Alcohol Abuse to Stephen M. Malone (R21 AA17314)

spen0128@umn.edu http://education.umn.edu/icd/CDNLab/

Acknowledgements

Members of the Cognitive Developmental Neuroimaging Lab (CDN Lab), members of the Minnesota Center for Twin and Family Research (MCTFR), the Institute of Child Development (ICD) , the MIND Institute, the Center for Neurobehavioral Development (CNBD), the Center for Magnetic Resonance Research (CMRR), the Graduate and Professional Student Assembly (GAPSA) of the University of Minnesota, and the Graduate Students of the College of Education and Human Development (GradSEHD) of the University of Minnesota