An fMRI Study of Reward Processing and Adolescent Alcohol Use

Sara E. Langworthy1, Ruskin H. Hunt1, Stephen M. Malone2 & Kathleen M. Thomas1
1Institute of Child Development, University of Minnesota, 2Department 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

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-feedback 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°, 4mm slice thickness, 34 axial slices, 182 repetitions
- TI-weighted anatomical MPRAGE images
- TR = 2530ms, TE = 3.65ms, Matrix 256 x 256, FOV = 256, 1mm slice thickness, 240 sagittal slices

Overall

Anticipation of Target

- Drinker group showed different areas of focal activation for the orbitofrontal cortex and nucleus accumbens (Talairach: 0, 7, -7; t = -3.608, p < 0.005)
- Controls show no difference in the caudate nucleus (Talairach: -17, -5, 11; t = -3.518, p < 0.005), the left (Talairach: -16, 35, -11; t = -4.269, p < 0.005) and right (Talairach: 28, 34, -13; t = -2.967, p < 0.05) orbitofrontal cortex

Behavioral Results

- No accuracy or reaction time differences between groups

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.