Drug abuse liability is associated with higher reward-sensitivity: An fMRI study using the Monetary Incentive Delay task

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Drug abuse is a major public health concern and determining which individuals are at risk based on personality dimensions is critical research question. Sensation seeking (SS) is a biologically based personality trait marked by a tendency to seek out and engage in novel and varied experiences to maintain an optimal level of arousal -- even if those experiences involve significant risk (Zuckerman, 1994; 2005). The Sensation seeking scale includes several personality dimensions including: reward seeking, boredom susceptibility, and impulsivity. Individuals classified as high sensation seekers are vulnerable to drug abuse and other risky behaviors that may result in poor health outcomes. The goal of this research project is to examine the contribution of reward seeking and impulsivity dimensions of Sensation Seeking to differences in behavior and brain activation using the Monetary Incentive Delay (MID) task and fMRI.

The MID task was adopted from Bjork et al. (2004) and involved responding to a target within a limited time window in order to receive monetary rewards or avoid monetary losses. The task involved presentation of a cue for 1500 msec indicating the value of a potential loss or win (lose $5, lose $.50, neutral – neither win nor lose, win $.50, win $5). Subjects were to respond as quickly as possible with a button press to the ensuing target in order to either avoid losing or be successful at receiving the amount indicated by the cue. The cue was followed by the target (white box), which was displayed for a variable duration (generally in the range of 200 to 250 msec, but with a maximum of 360 ms) in order to keep each subject's performance at approximately 66% accuracy. If the subject responded within the target time window, a feedback screen (displayed for 1500 msec) displayed a check mark and also indicated the running total of money earned. If the response was incorrect, a red X appeared.

Sixteen individuals classified as low-risk (Low SS) or high-risk (High SS) in terms of drug abuse liability have completed the MID task in the MRI scanner. Low-risk individuals (n=9) scored in the bottom quartile of the 11 sensation seeking items from the ZKPQ (Zuckerman et al, 1993) and in the bottom quartile of the 8 impulsivity items of the ZKPQ. High-risk individuals (n=7) scored in the top quartile of sensation seeking, impulsivity, or both sensation seeking and impulsivity.

Overall, individuals are expected to be most highly motivated to respond quickly when the values at stake are high, but not as motivated to respond quickly during neutral trials or when the values at stake are low. High reward sensitivity should be indexed by a greater difference in reaction time for high value trials (i.e., either win $5 or avoid losing $5) as compared to neutral or low value trials.

Preliminary analyses of behavioral data indicate that high-risk individuals are more motivated to receive rewards or avoid losses compared to low-risk individuals. In Figure 1a, the high-risk group shows a more pronounced incentive function in which reaction time for each incentive value is expressed relative to reaction time on neutral trials. In other words, high-risk individuals were more motivated to respond within the allotted time window to receive rewards or avoid losses than were low-risk individuals, who show a flatter incentive function. However, high-risk individuals do not seem to be more sensitive to rewards than to losses.

In terms of brain activation, however, high-risk individuals may indeed be more sensitive to rewards than low-risk individuals, depending on the brain region. One component of the analysis isolated brain regions that were modulated by motivated behavior such that the most activation corresponded to the high-value conditions and the least activation corresponded to the neutral condition, reflecting the behavioral incentive functions. This analysis revealed widespread activation that included right anterior cingulate cortex (Figure 1b) and the bilateral ventral striatum / nucleus acumbens (Figure 1c) which is commonly reported in fMRI studies of the MID task (Bjork et al., 2004; Knutson, 2005). As shown in Figure 1b, high-risk individuals showed greater activation in the right anterior cingulate cortex for the high-reward condition as compared to low-risk individuals. In the left and right caudate (Figure 1c), however, high-risk and low-risk individuals showed comparable activation for high rewards, but low-risk individuals showed more activation (albeit below baseline) for avoiding losses. However, these group differences do not reach significance in this preliminary analysis.

By studying this reward seeking behavior with fMRI, we hope to learn what neural correlates are driving the reward seeking behavior which in turn drives risky decision making behavior. Gaining a better understanding of the motivation for reward seeking, we may be able better target the specific underlying behaviors leading to drug abuse. In addition, discovering the neural correlates driving this behavior may lead to more effective therapies, interventions and prevention strategies for drug abuse.

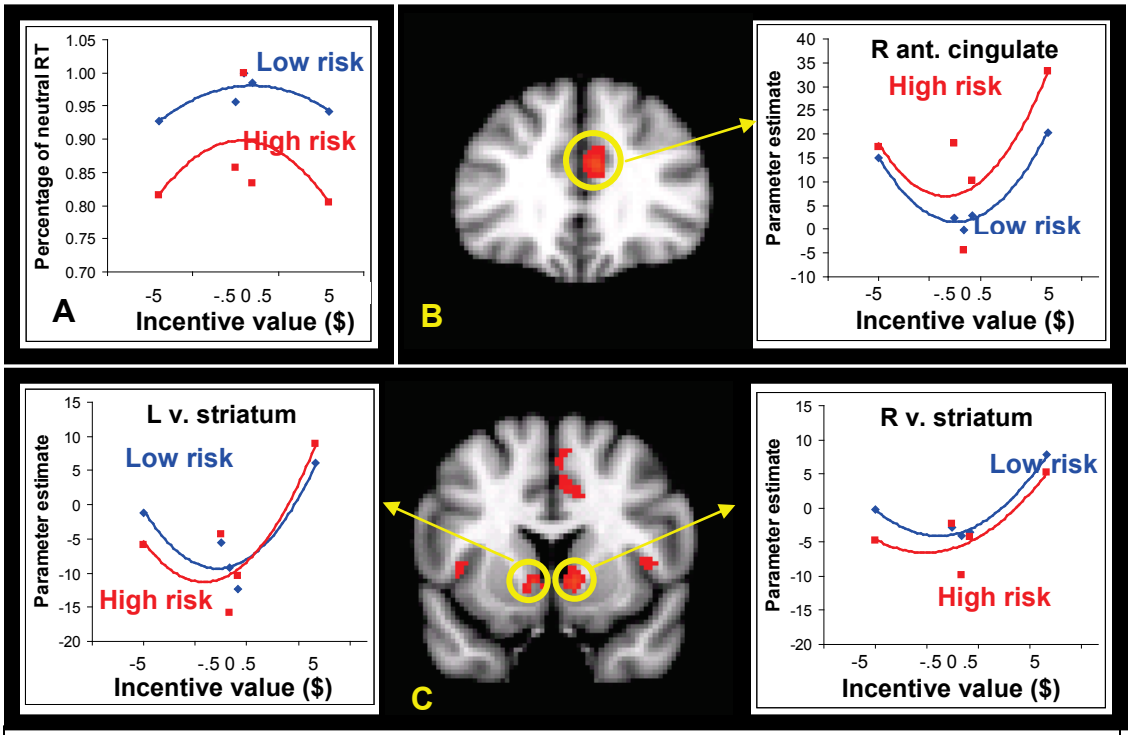

Figure 1. (A) Performance on the MID task for individuals classified as high-risk versus low-risk for drug abuse vulnerability. Brain activation ($p < .0005$) in (B) the right anterior cingulate cortex and (C) the bilateral ventral striatum that was associated with greater activation for high positive or negative incentive values. The parameter estimate reflects fMRI signal greater for each incentive value relative to visual fixation. fMRI signal is plotted as a function of risk status.