



# Effects of risk-reward context upon the evaluation of monetary rewards

Evan M. Gordon<sup>1</sup>, Brent T. Warner<sup>1</sup>, Jonathan K. Smith<sup>1</sup>, & Scott A. Huettel<sup>1,2</sup>

<sup>1</sup>Brain Imaging and Analysis Center, <sup>2</sup>Department of Psychiatry, Duke University Medical Center  
[scott.huettel@duke.edu](mailto:scott.huettel@duke.edu) [www.biac.duke.edu](http://www.biac.duke.edu)



## 1 INTRODUCTION

A central component of decision making is the ability to accurately balance potential rewards against their associated risks. Single-unit and neuroimaging studies have demonstrated that the activity of reward systems in the brain, particularly of ventral dopaminergic systems, depends upon both reward magnitude and reward expectation.

We investigated, using functional magnetic resonance imaging (fMRI), how risk context influences the brain response to decisions involving rewards. Participants selected among virtual slot machines with different payoff schedules and played the selected machine for a block of trials. Three machines were used: the first high-risk/high-reward, the second was low-risk/low-reward, and the third gave no reward (perceptual/motor control). We evaluated whether risk context had an effect on brain activation when 1) subjects chose what machine to play on a given block, and 2) subjects received a large or small reward.

## 3 EXPERIMENTAL PARADIGM



## 2 METHODS

### Subjects

- Participants were 16 adults (mean age: 26y).

### Experimental task

- Subjects played virtual slot machines (~380 trials per session).
- Three machines were used:
  - High-Risk (Red); payoff schedule [\$3.00, 0.2; \$0.60, 0.15; \$0, 0.65]
  - Low-Risk (Blue); payoff schedule [\$3.00, 0.1; \$0.60, 0.65; \$0, 0.25]
  - Control (Black), which always paid \$0.
- The High-Risk and Low-Risk machines had identical expected value.
- At the beginning of each five-trial block, subjects chose which machine to play and had \$1.50 deducted from their earnings.
- On one-third of the blocks, subjects chose between the High- and Low-Risk machines (*Free Choice*).
- On another third of the blocks, subjects could choose one of the risky machines, but could not choose the other (*Constrained Choice*).
- On the remaining blocks, subjects were forced to choose the Control machine (*Control Choice*).

### Data acquisition using fMRI at 4.0T

- Images were acquired sensitive to BOLD contrast (i.e., T<sub>2</sub>\*-weighted).
- We used a spiral-in pulse sequence (TR: 1500ms; TE: 35ms).
- We acquired 34 axial slices (3.75\*3.75\*3.8mm voxels).
- Preprocessing steps (SPM99) included motion correction, slice timing correction, normalization, and spatial smoothing (8mm) using SPM99.

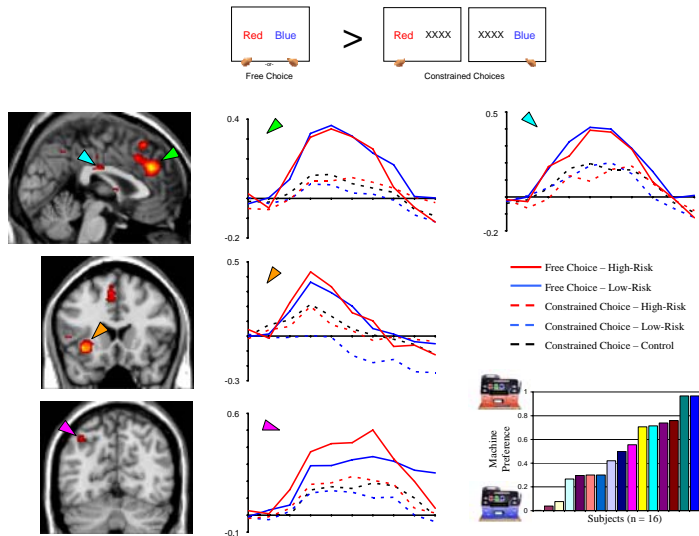
### Data Analysis

- We conducted multiple regression analyses using SPM2.
- Independent regressors were created for each task phase, categorized by decision made and/or reward received.
- Head motion parameters were included in the design matrix.
- Significance was assessed using second-order random-effects analyses.
- Significance is indicated by colormap with thresholds ( $p < .001$ ,  $p < .00001$ ).
- Time courses were calculated from the functional regions of interest (ROIs) derived from the random-effects analyses.

### Acknowledgments

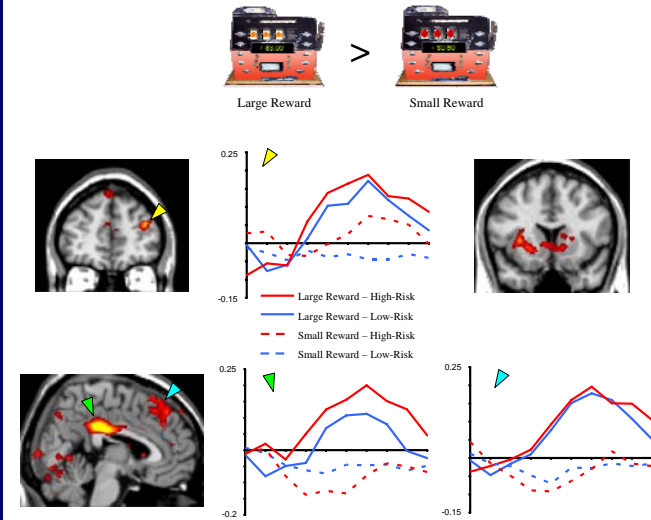
This research was supported by NIMH R01-070685 and by NINDS P01-41328.

## 4 CHOICE FREEDOM EFFECTS



Activation in frontomedian, posterior cingulate, anterior insular, and parietal cortices increased when subjects freely chose which machine to play.

## 5 REWARD EFFECTS



Reward magnitude influenced activation in lateral prefrontal, ventral striatal, frontomedian, and posterior cingulate cortices. Only large rewards evoked significant positive activation.

## 6 CONCLUSIONS

- Free selection of a risky slot machine was associated with increased activation in limbic and posterior parietal regions, when compared to constrained selection with similar perceptual and motor requirements.
- Activation in these regions did not scale with risk of the selected machine, save for a trend toward a correlation in parietal cortex.

- Reward effects were observed in limbic and lateral frontal regions, but there was no evidence that activation scaled with reward context.
- Further analyses will examine potential effects of individual differences in risk preference upon observed activation.