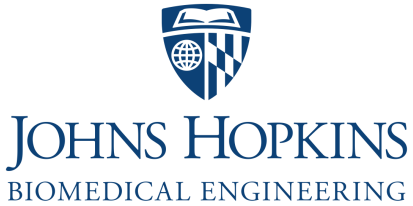
# Paradoxical Performance for Monetary Incentives

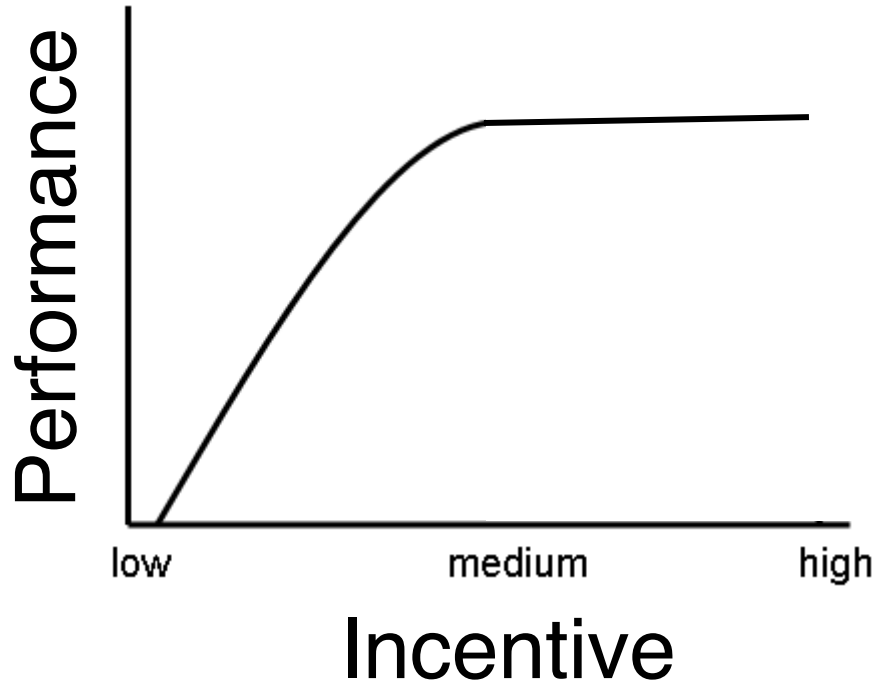
Vikram S. Chib



Donald's
OPEL
Coca-Cola

# Behavioral Responses to Incentives

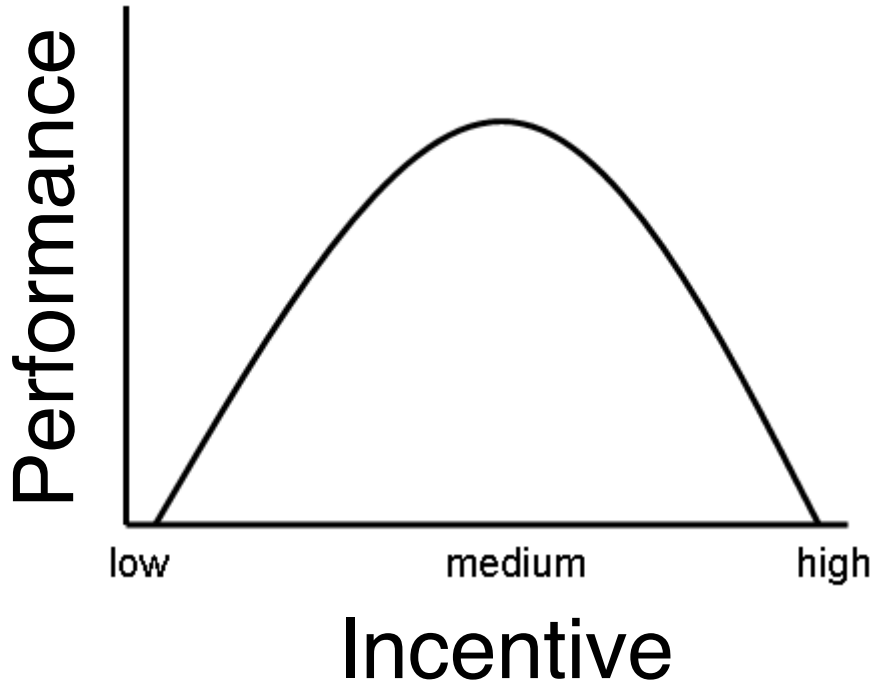
| + | | + | | + |
|---|---|---|---|---|
| $$$ Incentives | ⇒ | Effort / Motivation | ⇒ | Performance |




(Lazear, 2000)

# Behavioral Responses to Incentives

| + | | + | | + / - |
|---|---|---|---|---|
| $$$ Incentives | ⇒ | Effort / Motivation | ⇒ | Performance |



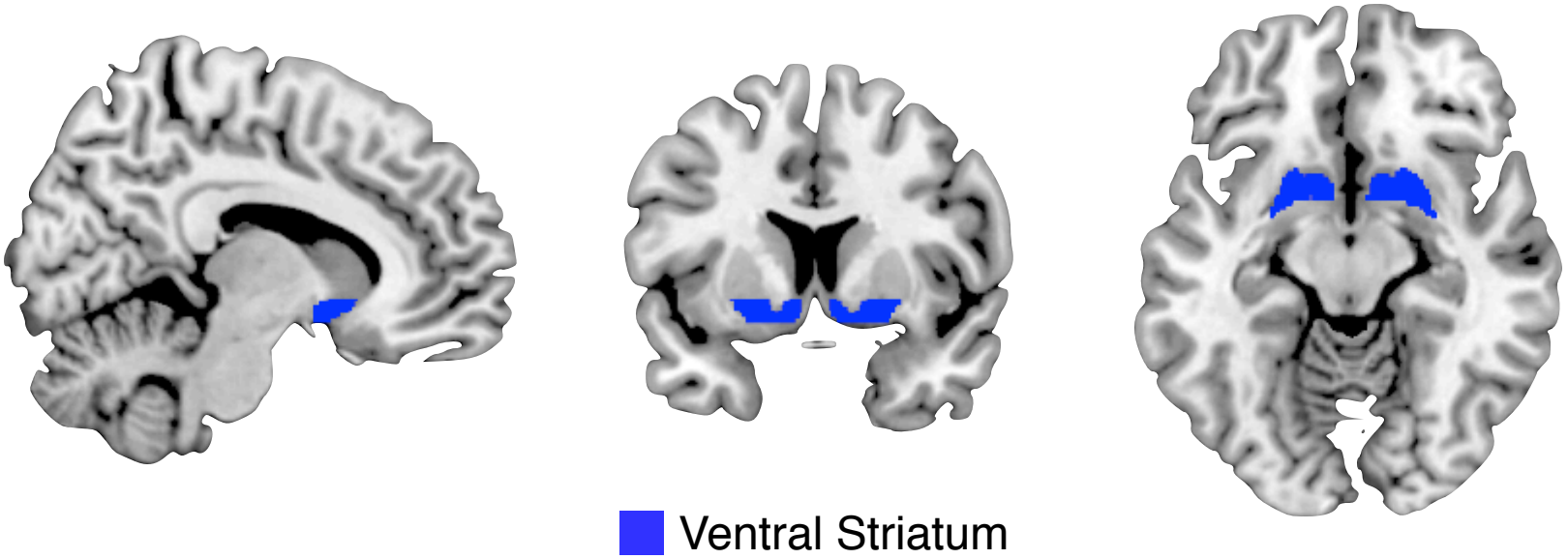

(Ariely et al., 2009)

# Psychology and Neuroscience of "Choking Under Pressure"

- "Overmotivation" hypothesis (Baumeister, 1984; Beilock et al., 2004; Mobbs et al., 2009)

- Poor neuroscientific understanding of skilled-task performance for incentives

# Ventral Striatum (vSTR)




ventral striatum = nucleus accumbens + ventral putamen

(O'Doherty et al.,2003; Haber et al., 2000; Haber and Knutsen., 2010)

# Ventral Striatum:
# Neural Interface Between Motivation and Action

- Encoding of rewards and punishments (Knutson et al., 2000; Yacubian et al., 2006 ; Tom et al., 2007)

- Regulation of instrumental motor responses (Tanaka, et al., 2008; Tricomi et al., 2009; Wunderlich et al., 2012)

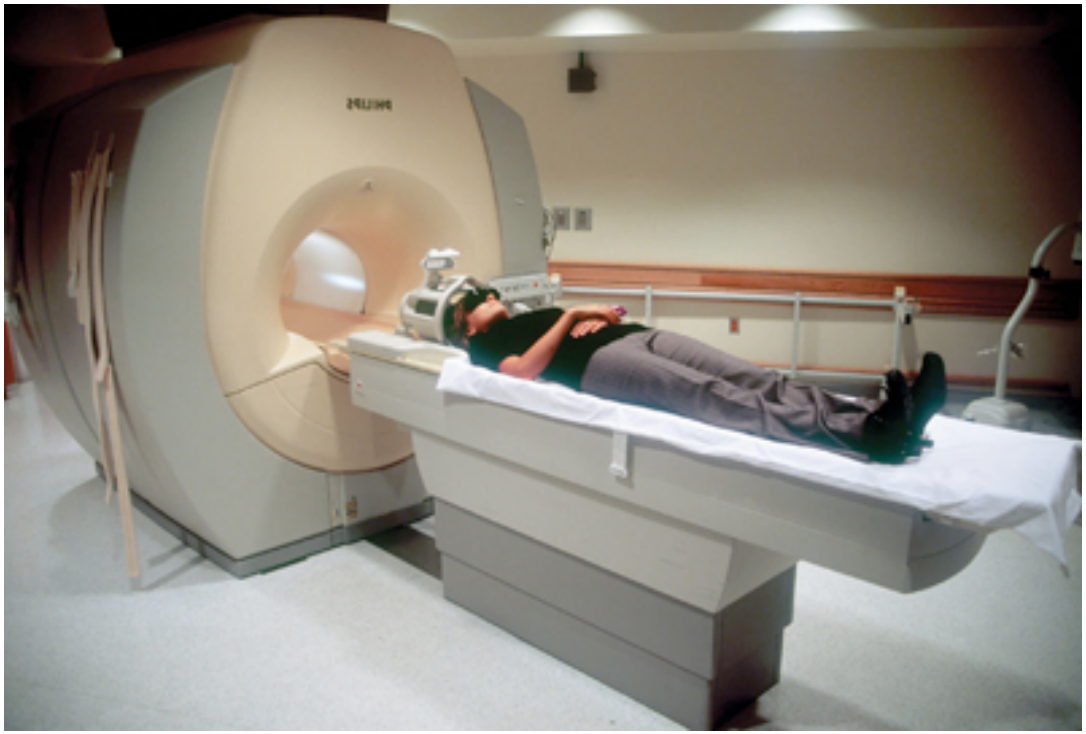
- Mediates the effects of rewards on increases in motor effort (Kurniawan et al., 2010; Pessiglione et al., 2007; Schmidt et al., 2012)

What are the neural mechanisms underlying paradoxical performance for incentives?

# Task Requirements

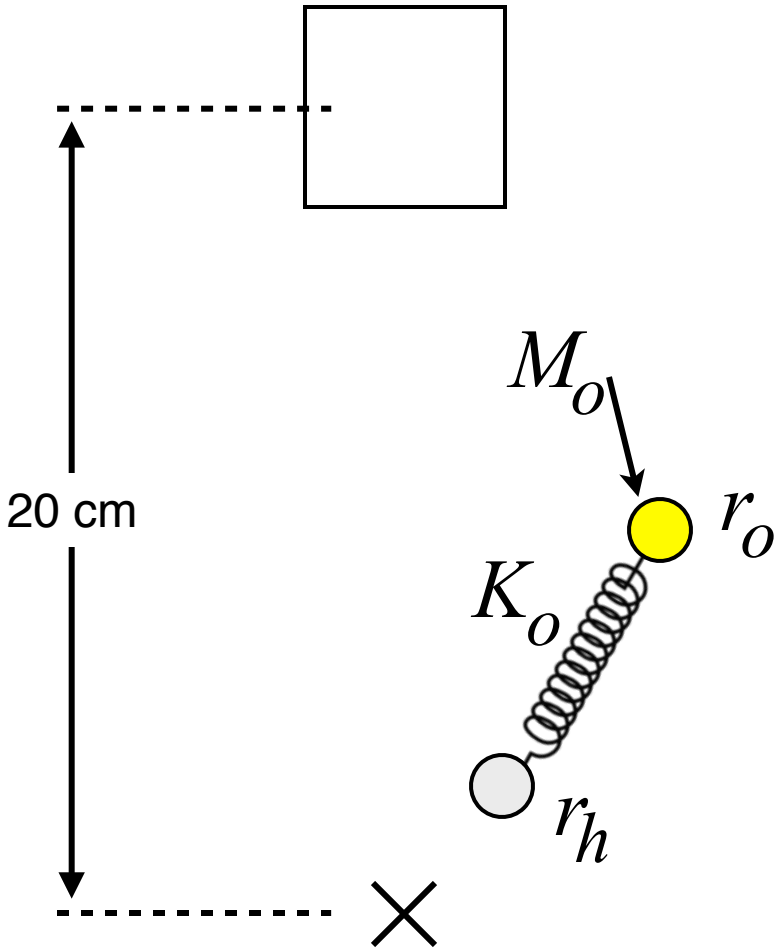
- Novel to subjects
- Standardizable difficulty across subjects

# MRI Setup



Infrared cameras track subjects' reaching movements in the scanner.

# Control of a Spring-Mass System




$$M_o\ddot{r}_o + K_o(r_o - r_h) = 0$$

$r_h$ hand position

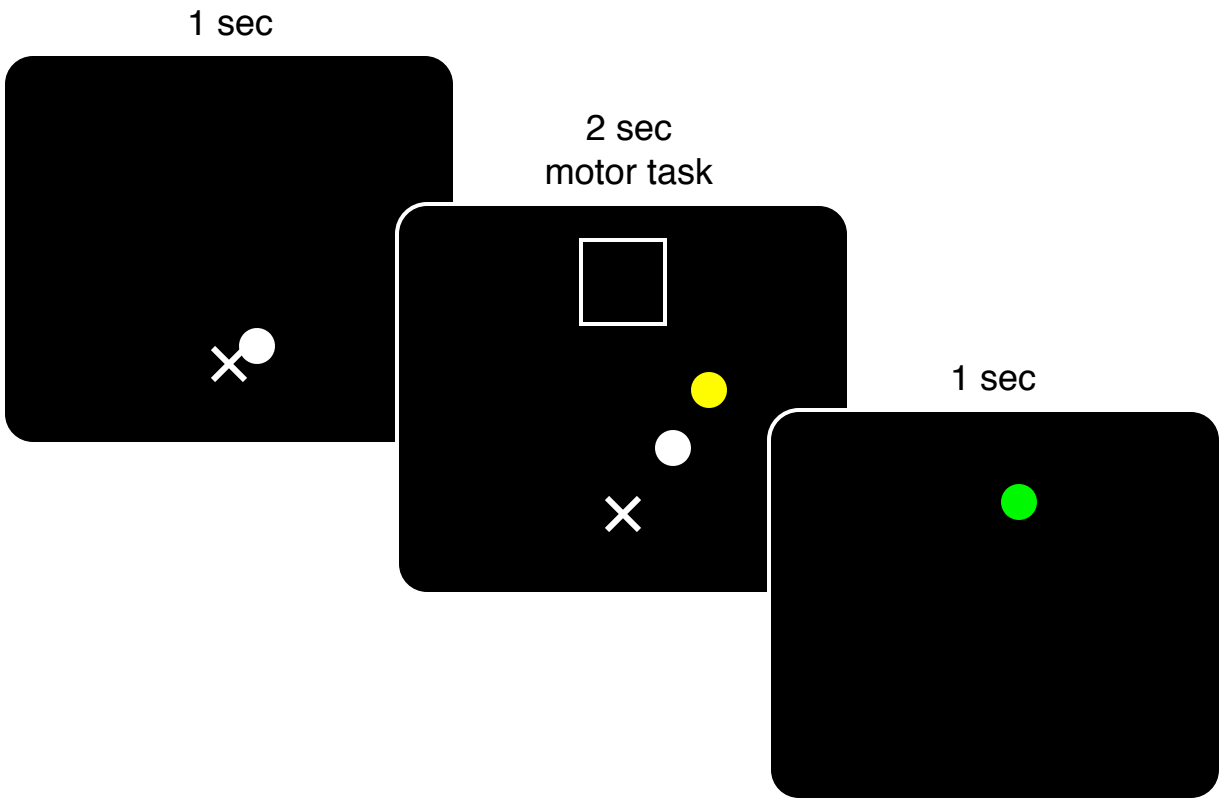
$r_o$ mass position

$M_o$ Object Mass

$K_o$ Object stiffness

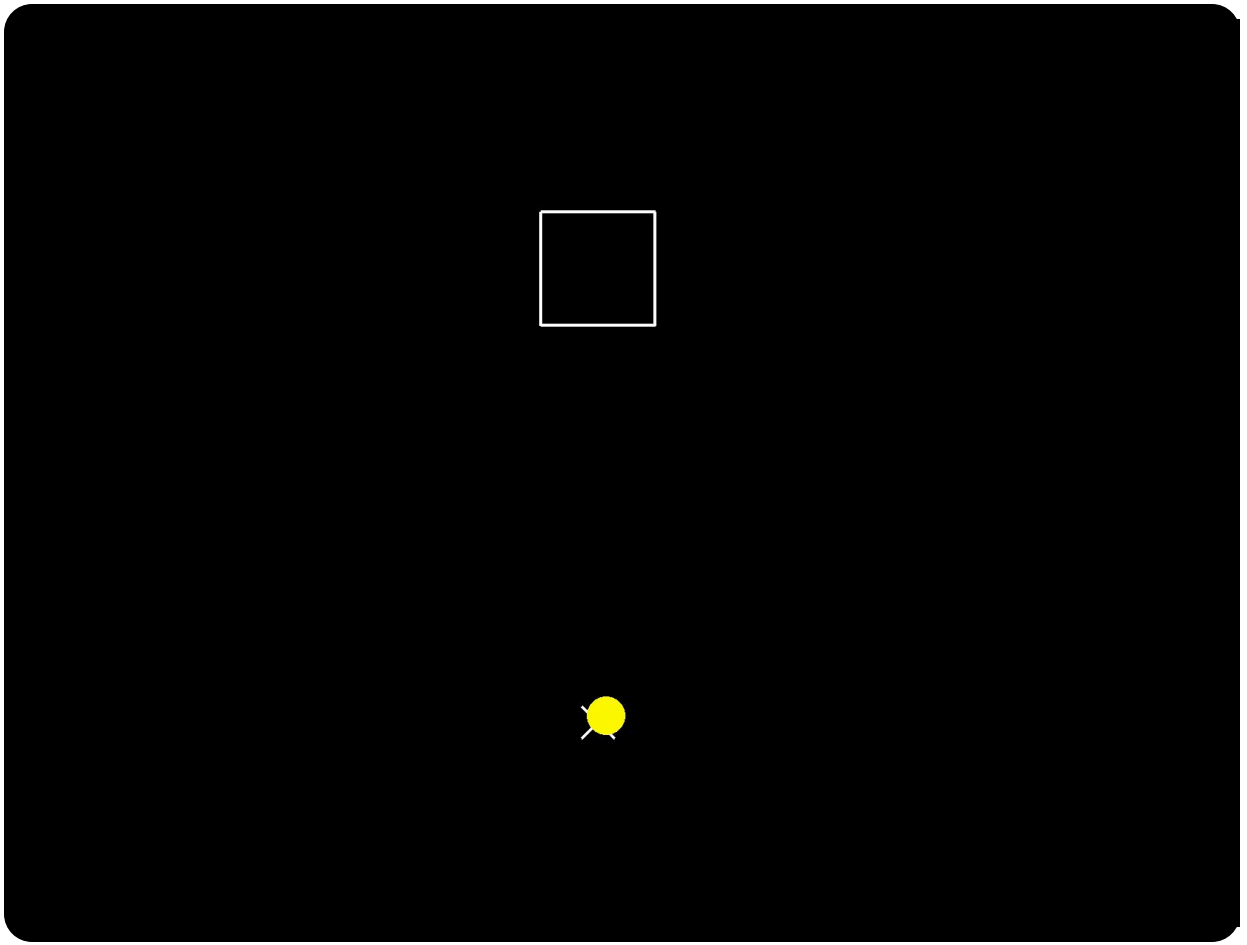
(Chib et al., 2012)

# Day 1: Training

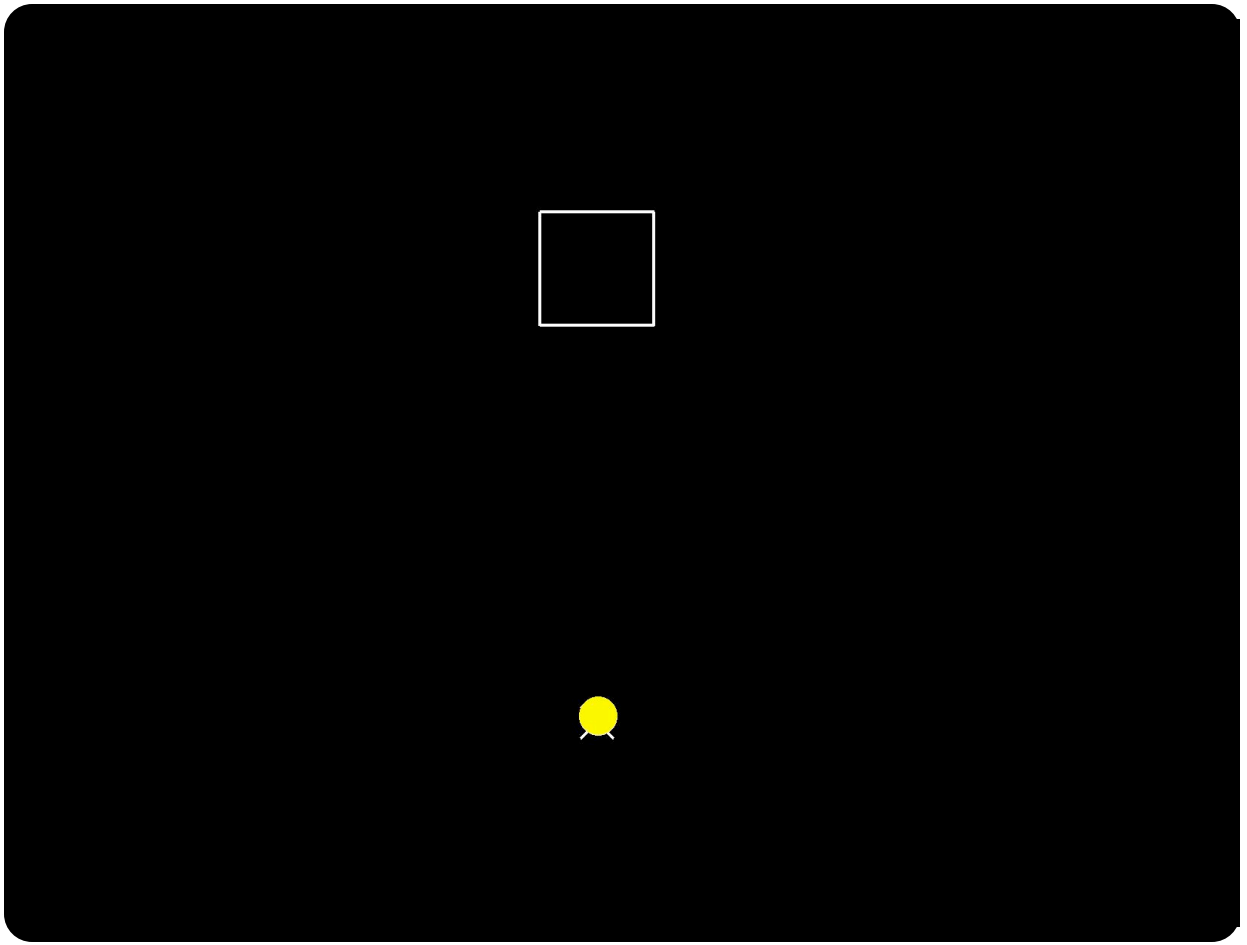



500 self-paced repeated movements

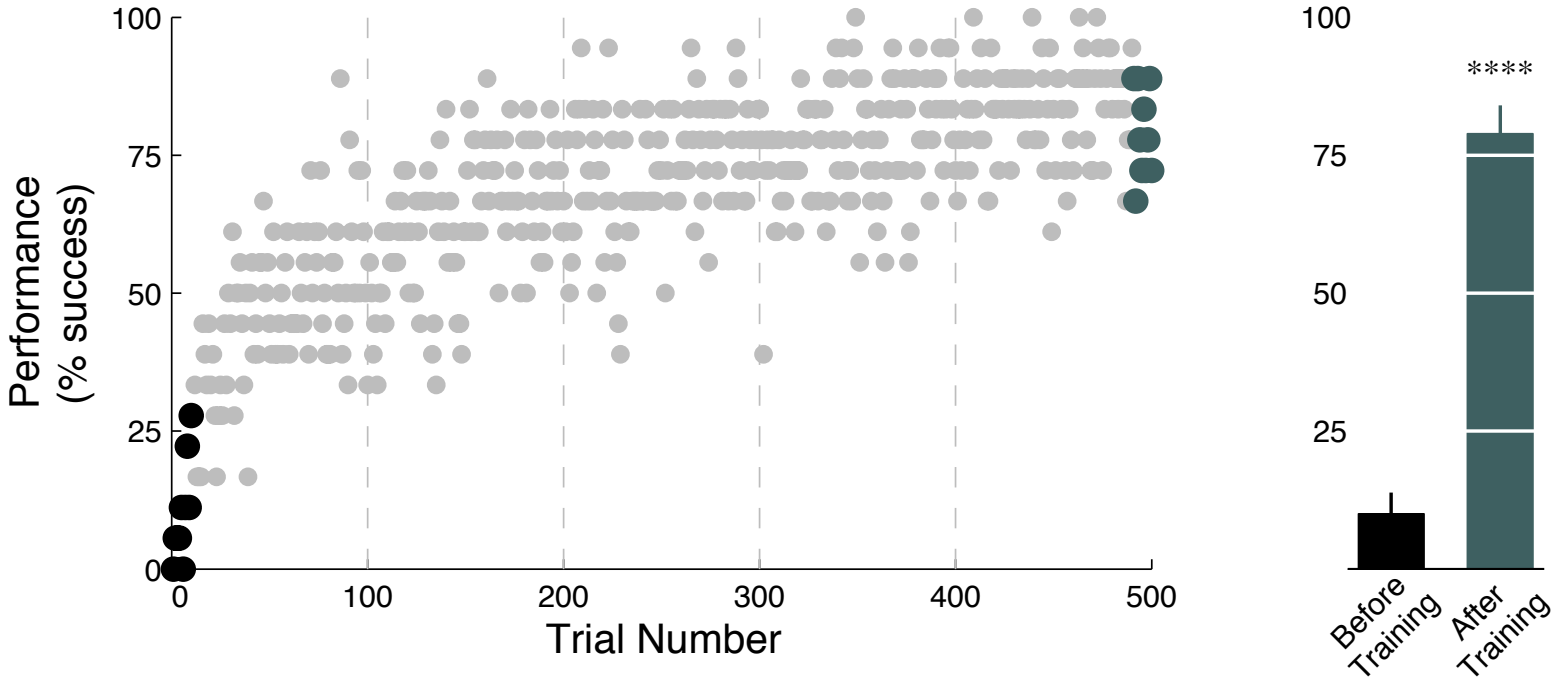
# Before Learning



# After Learning

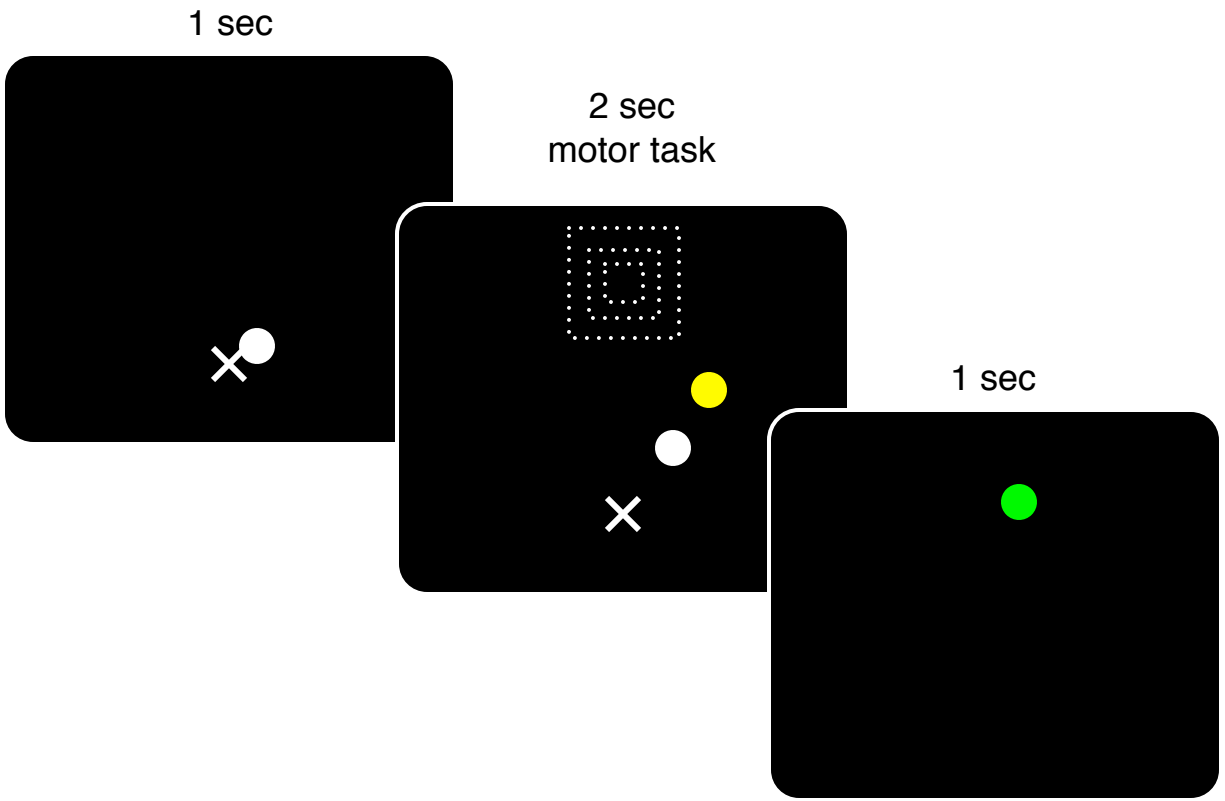


# Training Data



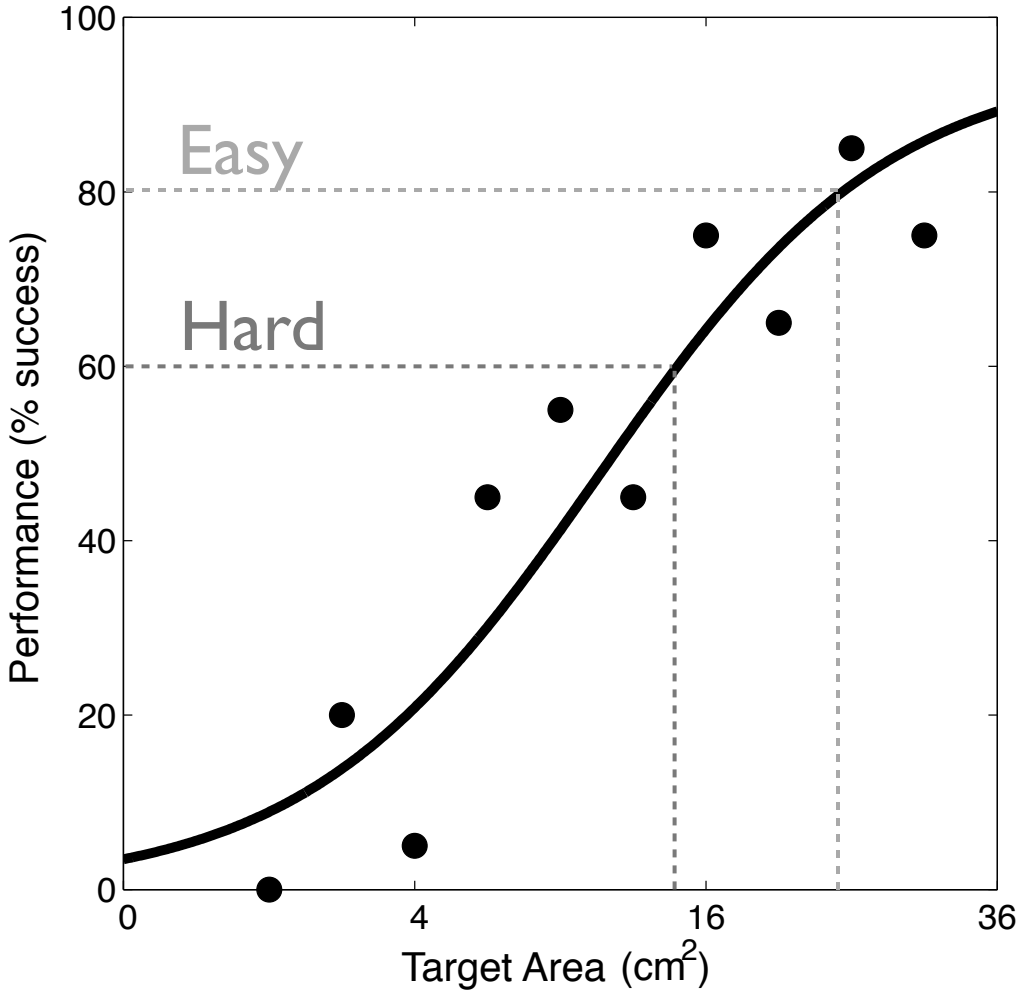

Following training subjects are able to control the system.

# Day 1: Thresholding



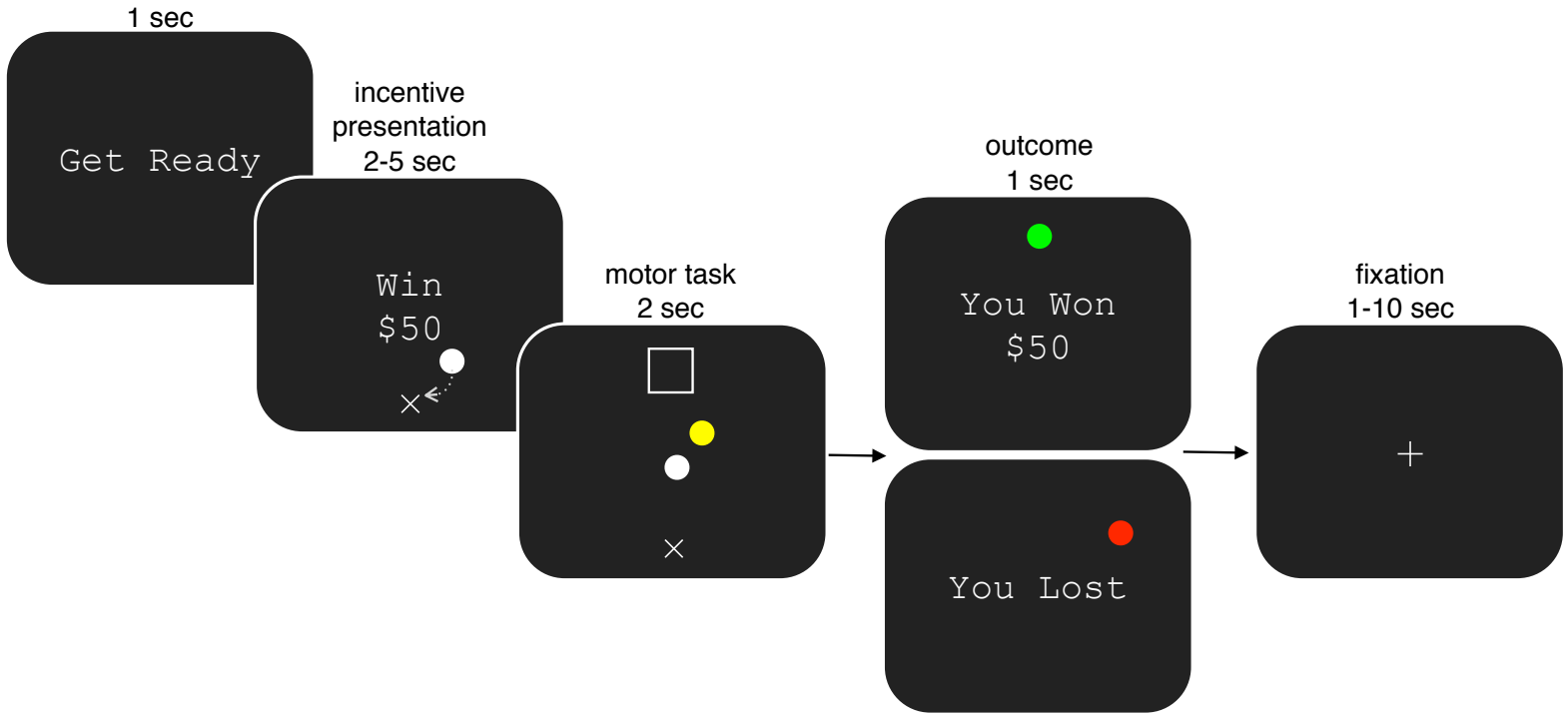

Varying target size

# Psychometric Function



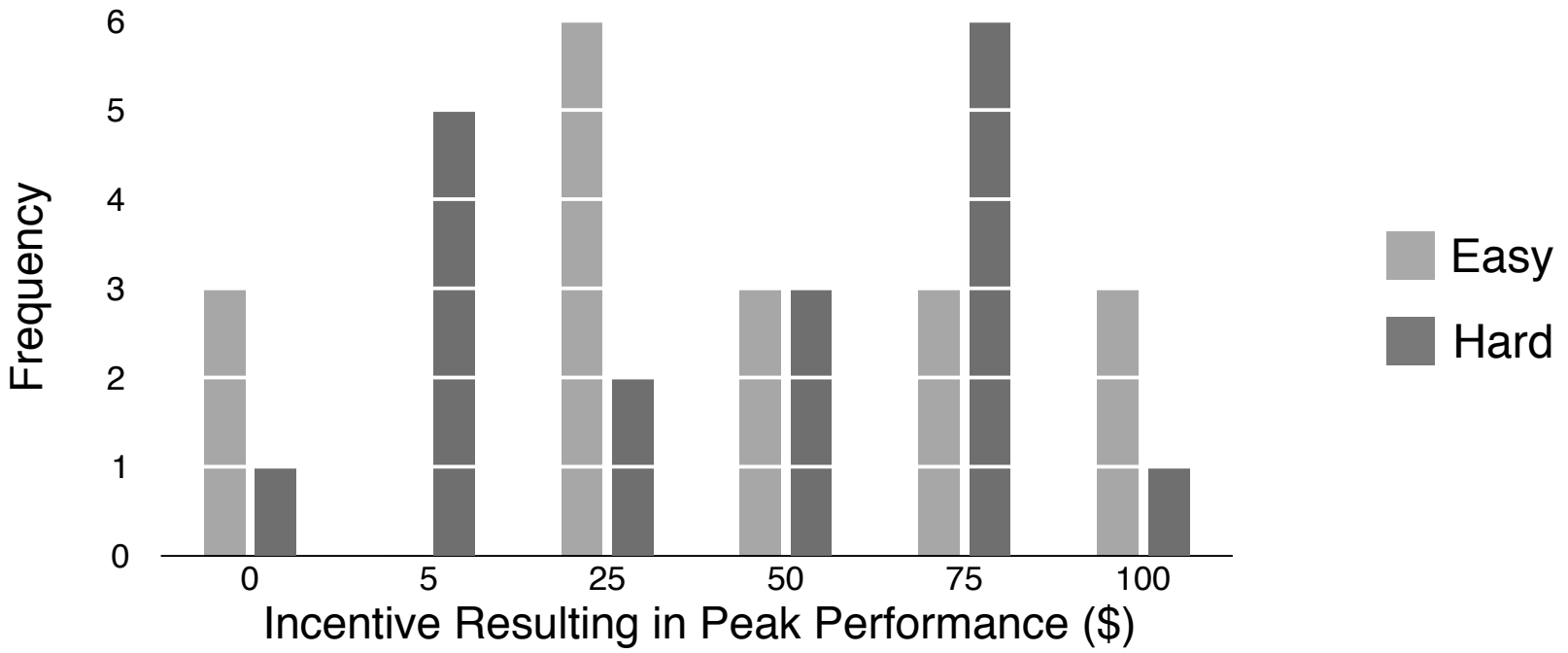

Difficulty levels were customized to individual subjects.

# Day 2: Incentivized Motor Task (fMRI)



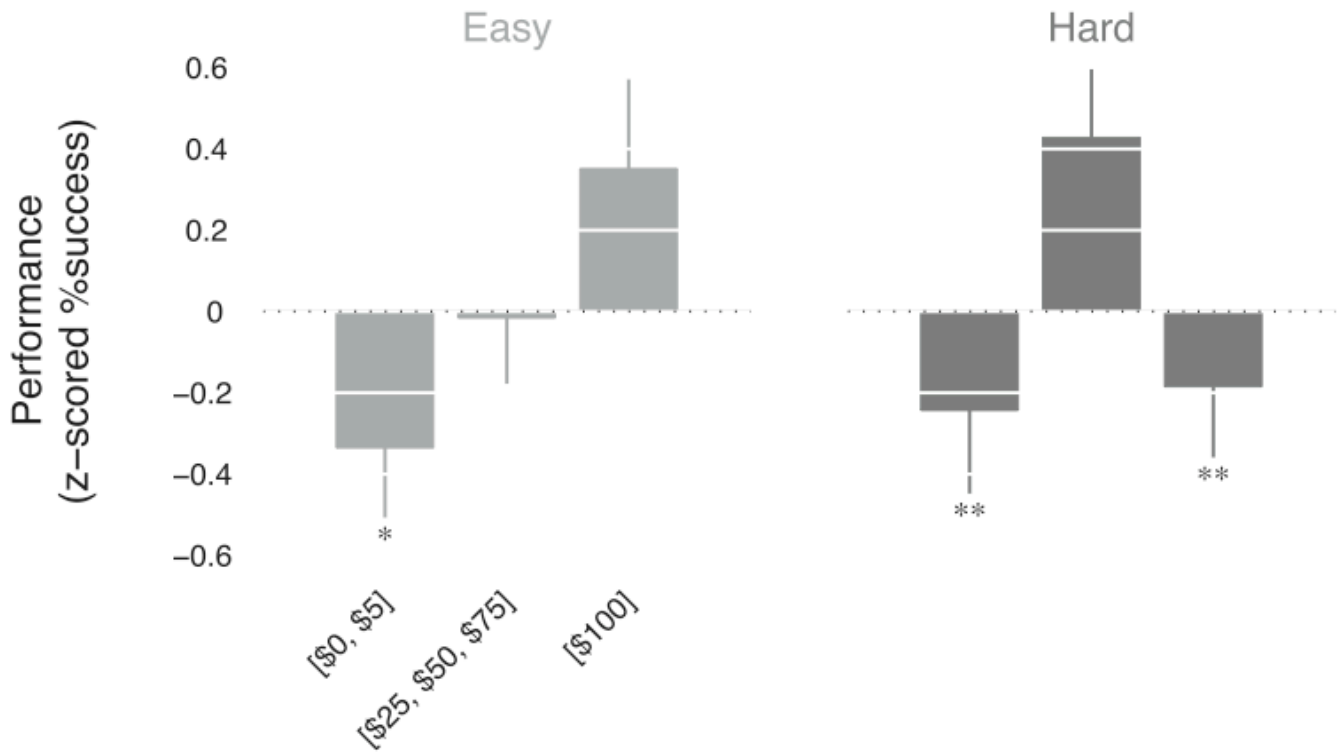

A random trial was selected and subjects were paid based on performance on that trial.

# Behavioral Performance




Subjects' performance peaked over the range of incentives.

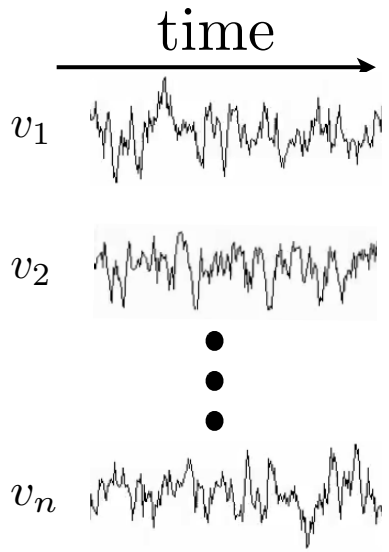
# Behavioral Performance




Subjects ‘choked’ in the hard difficulty condition.

# Overview of fMRI Methods

fMRI Scan

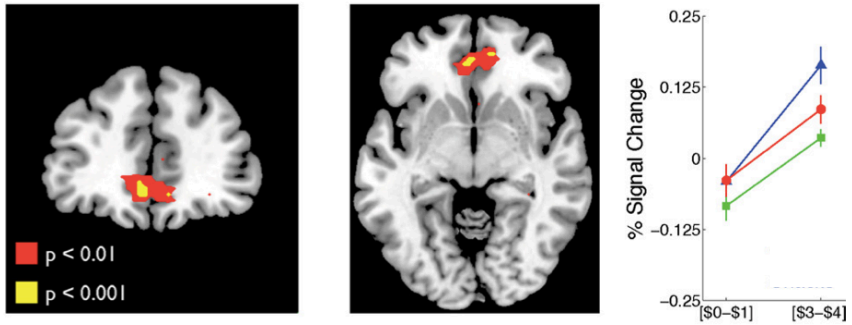



BOLD Signal

$y_{v,t}$

$$y_{v,t} = \alpha_v + \beta_{v,1} x_{1,t} + \beta_{v,2} x_{2,t} + \epsilon_{v,t}$$

General
Linear Model

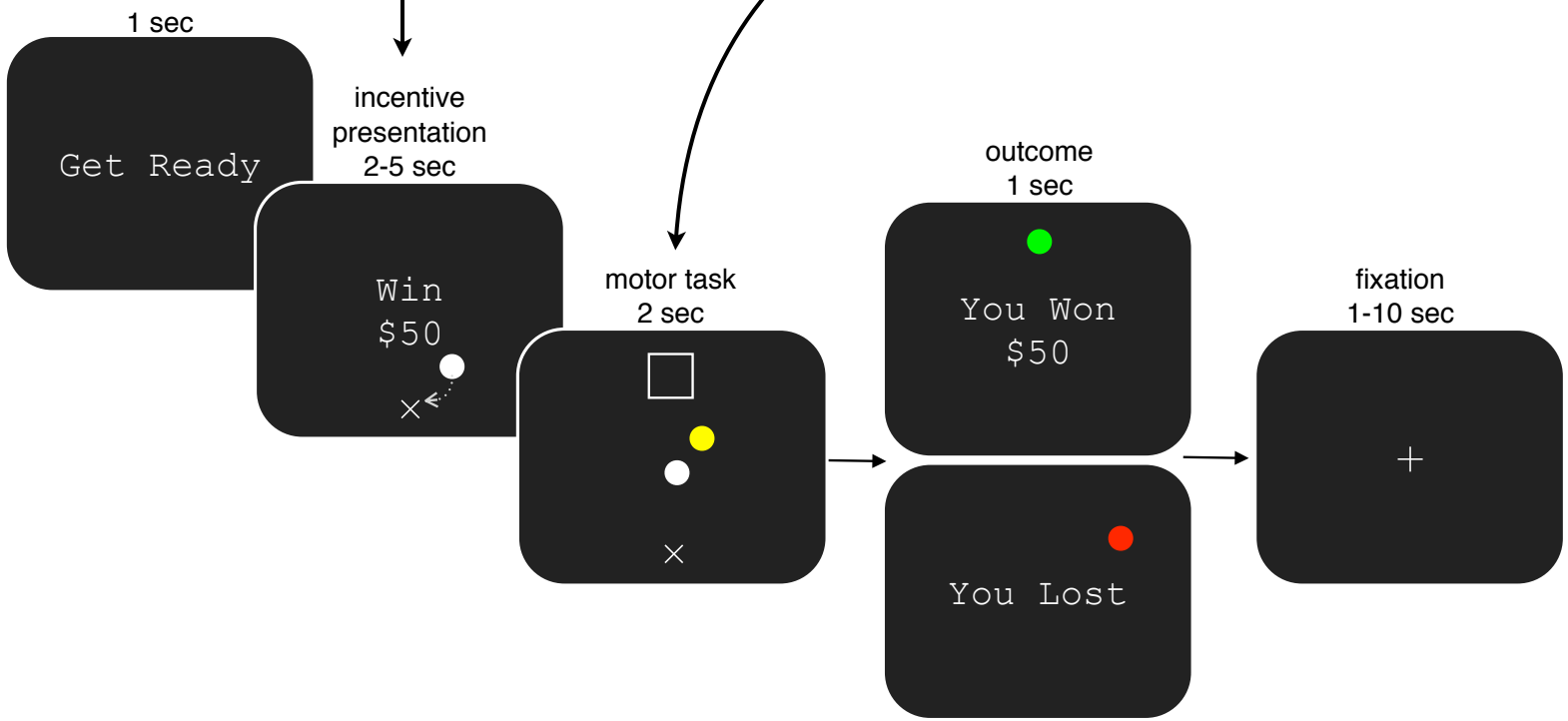



Statistical
Parametric Map

# Overview of fMRI Methods

For our experiment we generated a linear model of the form:

$$y_{v,t} = \alpha_v + \underline{\beta_{v,1} Present_t^{incent}} + \underline{\beta_{v,2} Score_t^{incent}} + \beta_{v,3} Miss_t^{incent} + \epsilon_{v,t}$$

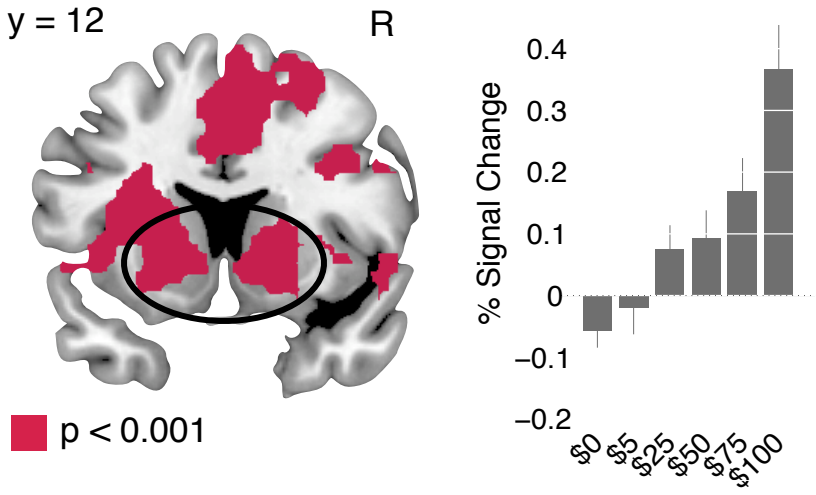


# Experiment Prediction

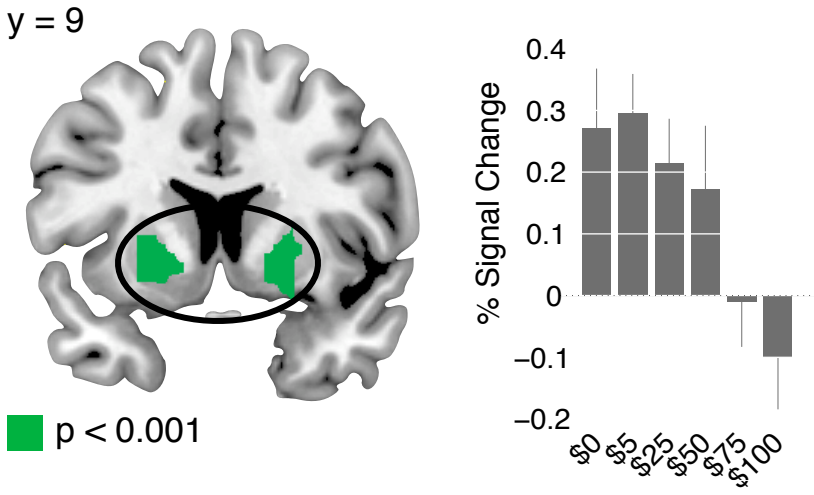
- The larger a subject's neural sensitivity to incentive the larger their performance decrements

# Neural Responses

Incentive Presentation

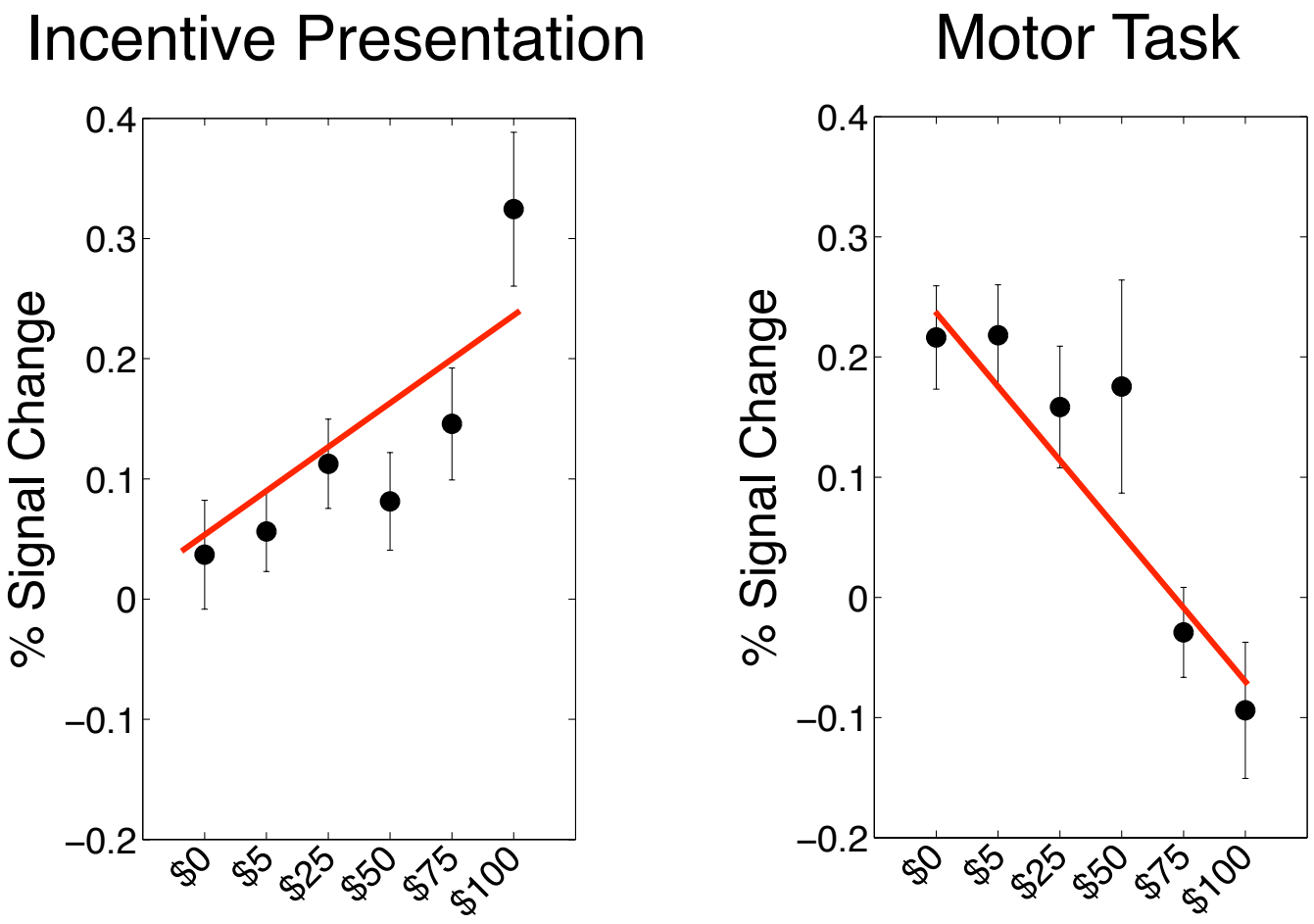



Motor Task



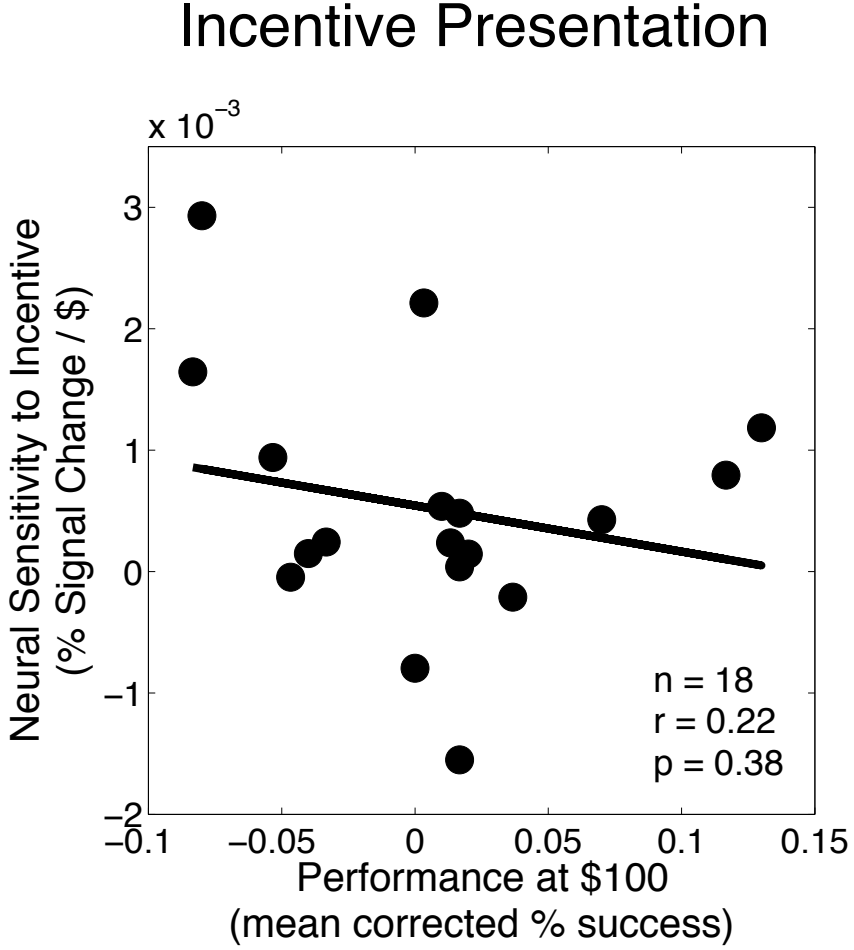

vSTR is activated at the time of incentive presentation and deactivated during motor performance.

# Neural Sensitivity to Incentive



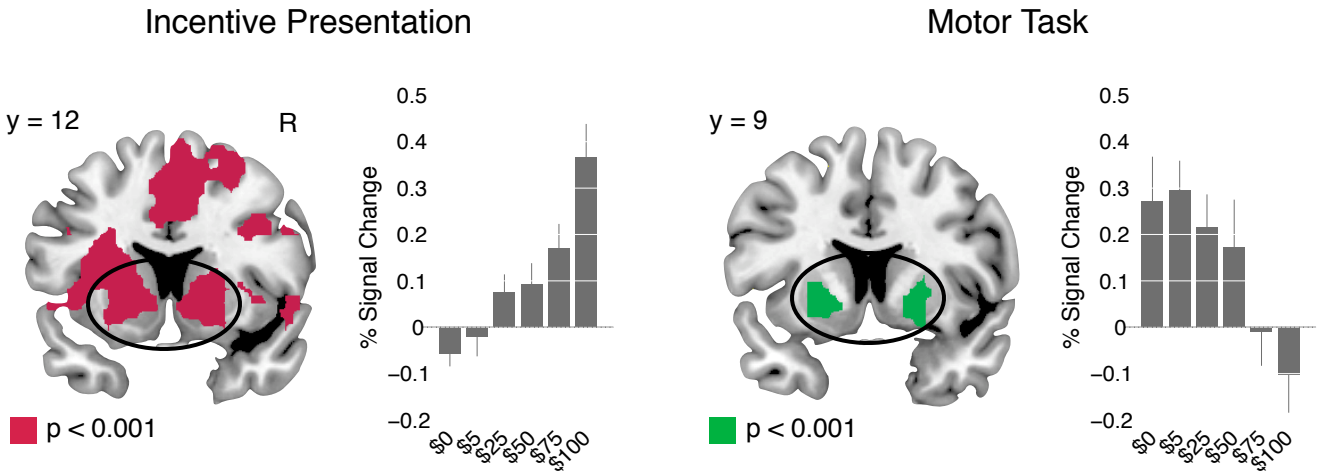

Units: %signal change/$

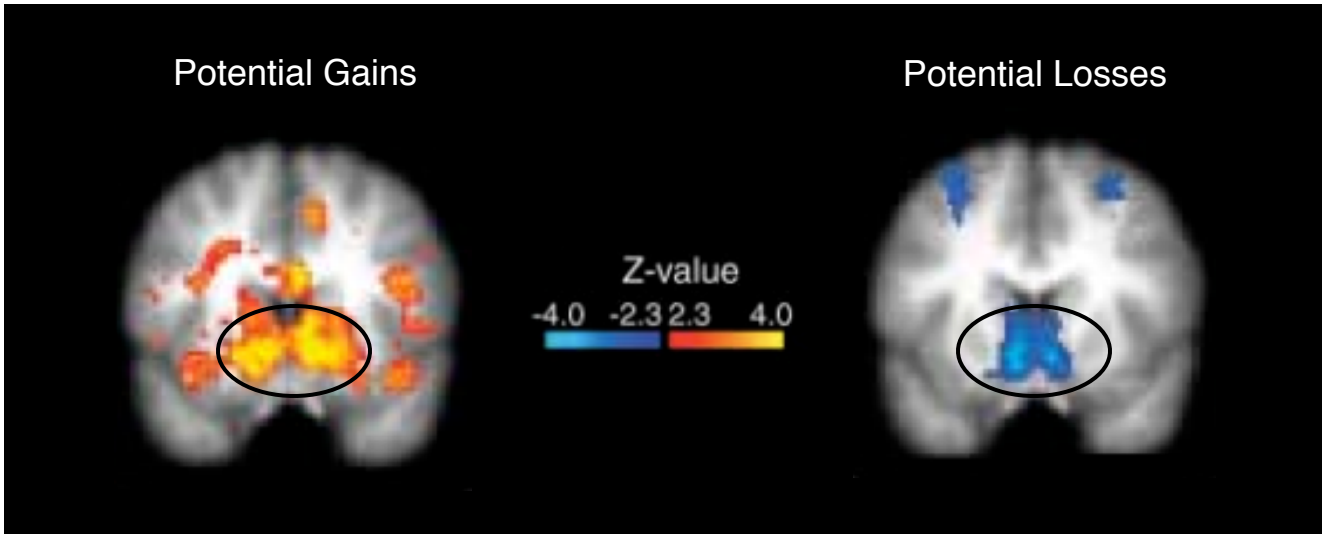
# Neural Responses and Performance




Neural sensitivity to incentive did not correlate with performance decrements.

# Why does vSTR striatum deactivate?



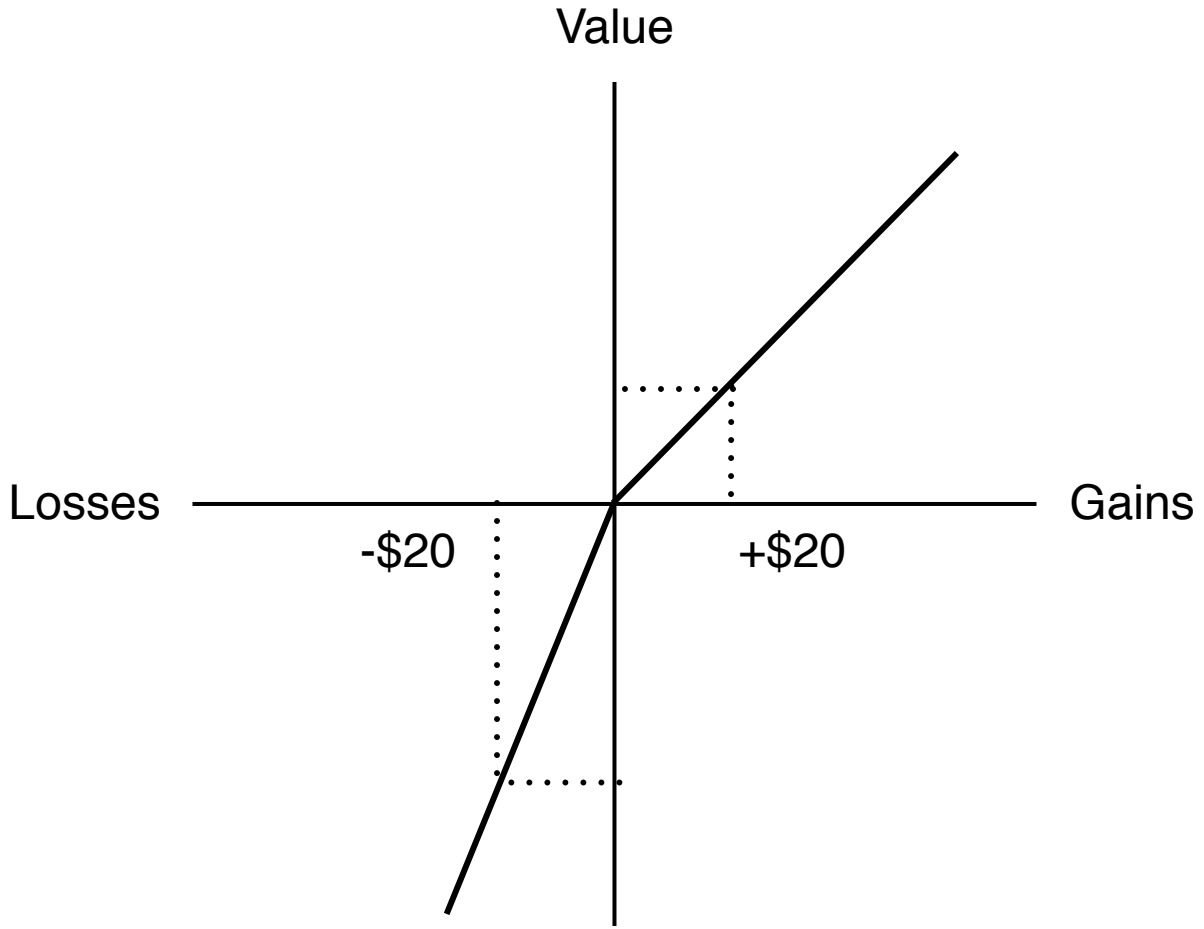




(Tom et al., 2007)

$$
\begin{aligned}
EV &= P_{gain}G + P_{loss}L \\
&= 0.5(22)+0.5(\text{-}20) \\
&= +\$1
\end{aligned}
$$

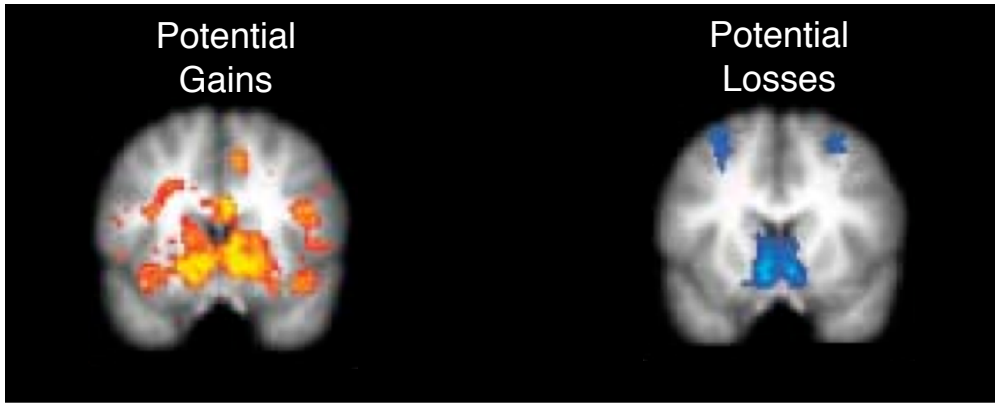
(Tom et al., 2007)

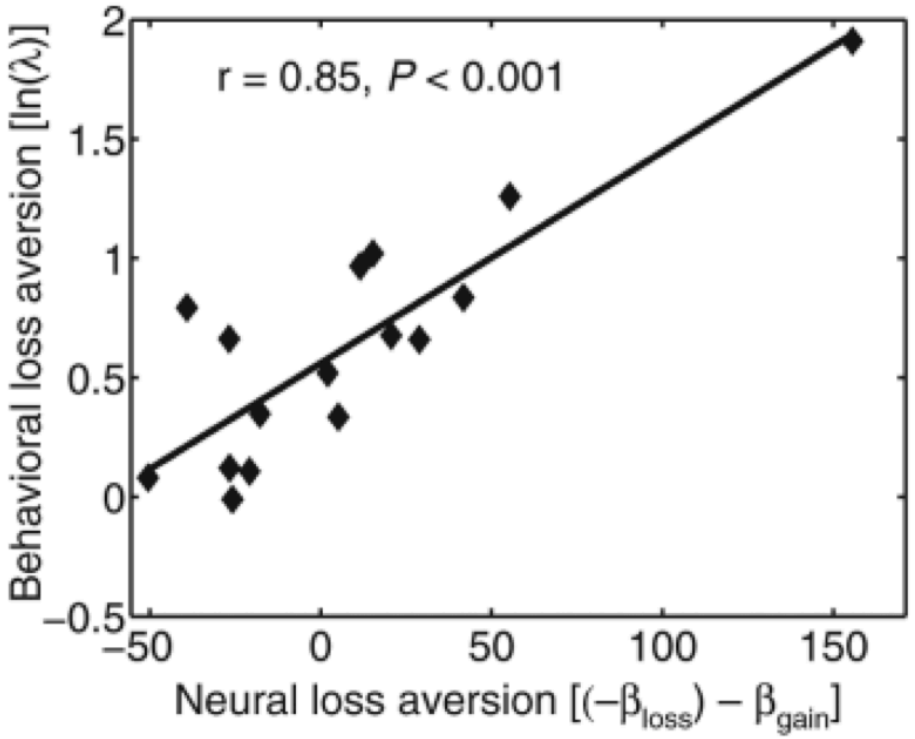
# Loss Aversion




Losses loom larger than gains. (Kahneman & Tversky, 1979)

# Loss Aversion




vSTR striatum activity predicts loss aversion.
(Tom et al., 2007)

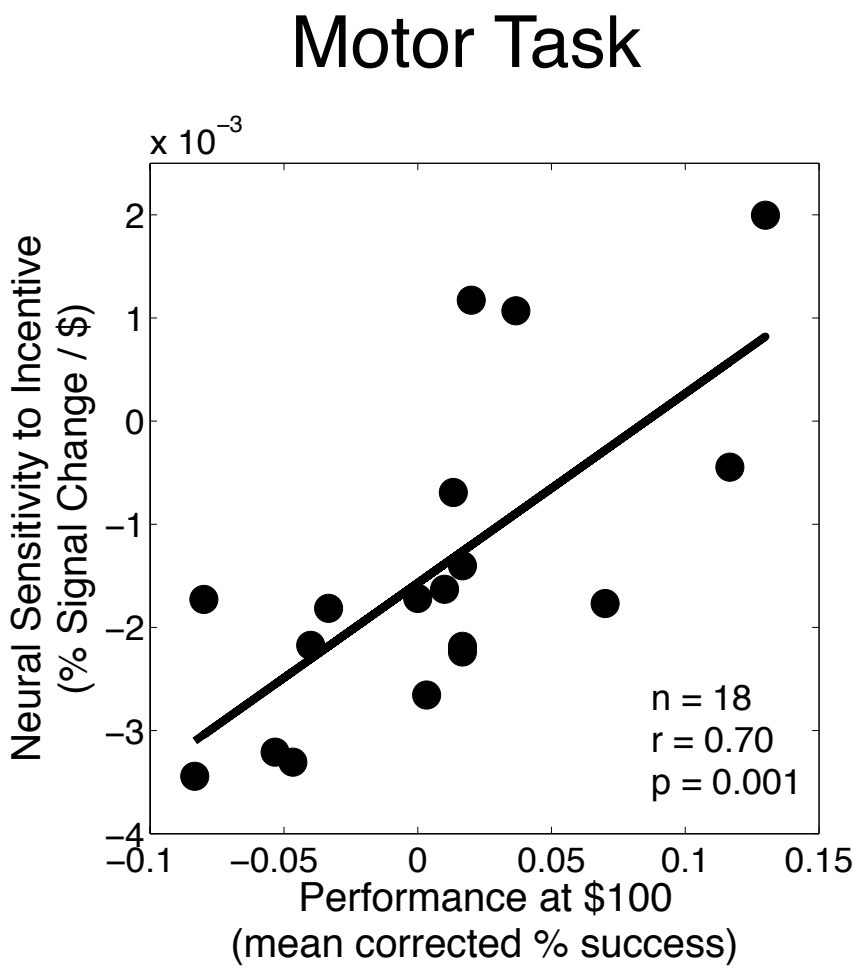
# fMRI Guided Predictions

1. vSTR deactivation predicts performance decrements

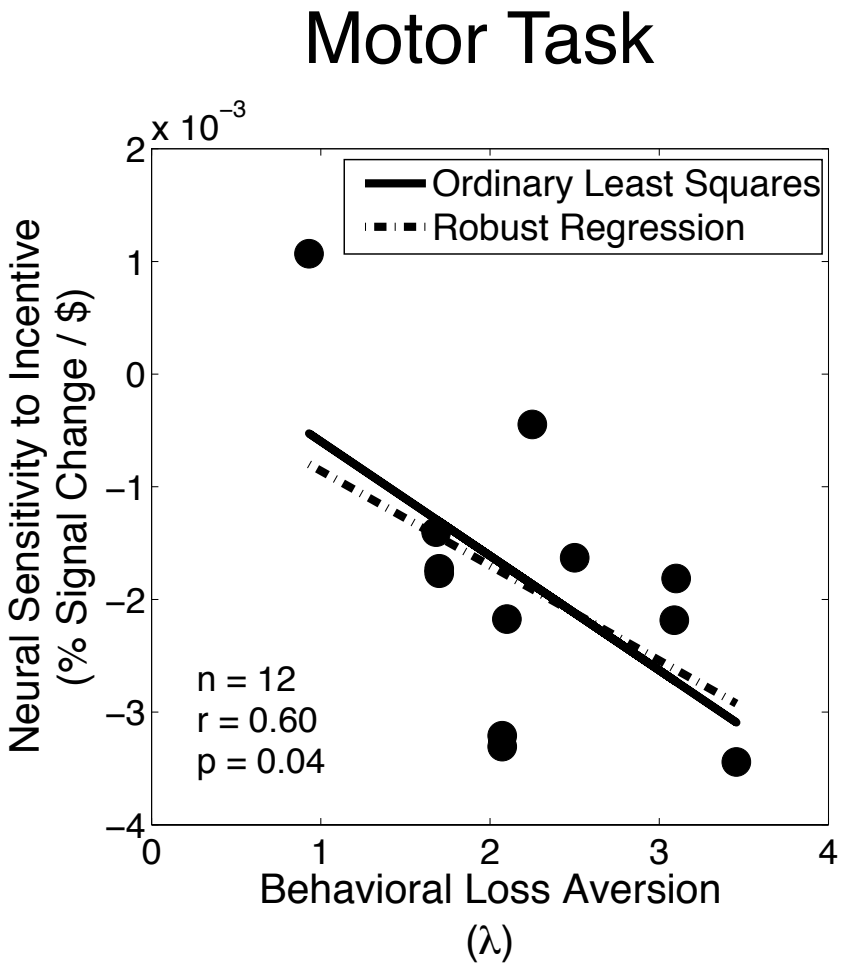
2. Activity in vSTR during the motor task is related to an individual's loss aversion

3. An individual's loss aversion is predictive of behavioral performance

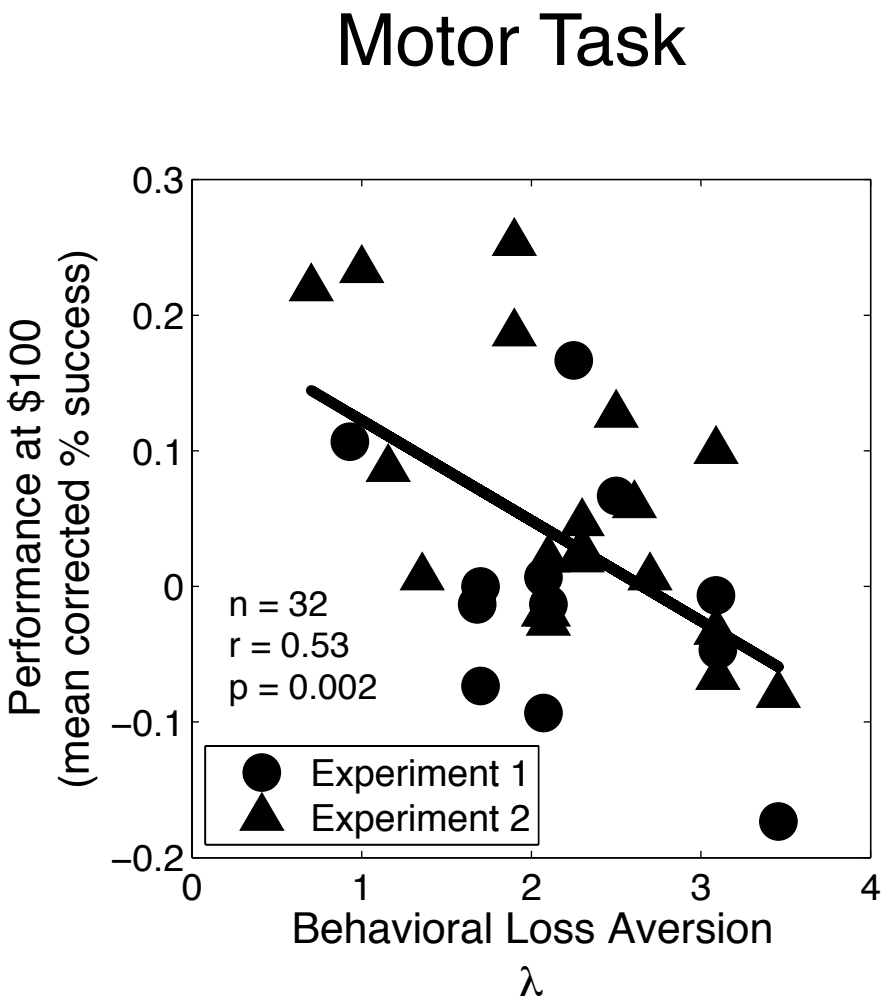
# 1. vSTR deactivation predicts performance decrements



# 2. Activity in vSTR during the motor task is related to an individual's loss aversion



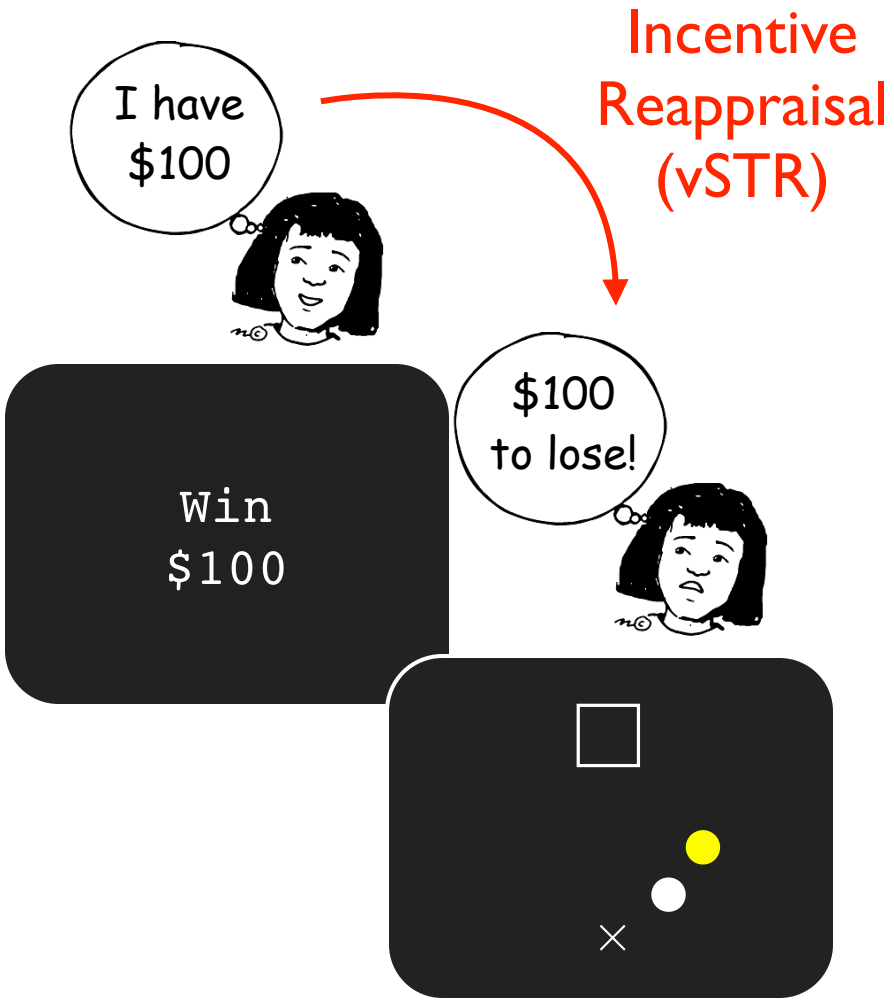
# 3. An individual's loss aversion is predictive of behavioral performance



# Summary of Results

- High incentive levels led to the paradoxical consequence of poor performance
- Rapid switching in vSTR response between incentive presentation and task performance
- vSTR deactivations and performance decrements are predicted by loss aversion

# Reappraisal of incentives during task performance



# Applications

- fMRI can inform theories in economics and psychology
- Incentive mechanism design
- Cognitive strategies to prepare for high stakes conditions (e.g., hazardous environments, education, rehabilitation)

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Questions?