Loss aversion and outcome-value encoding: A negative association between posterior insula activity and loss aversion coefficient

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Introduction

- People give different decision weights to gain and loss.
- Potential losses possess stronger psychological value than a potential gain with same objective value [1].

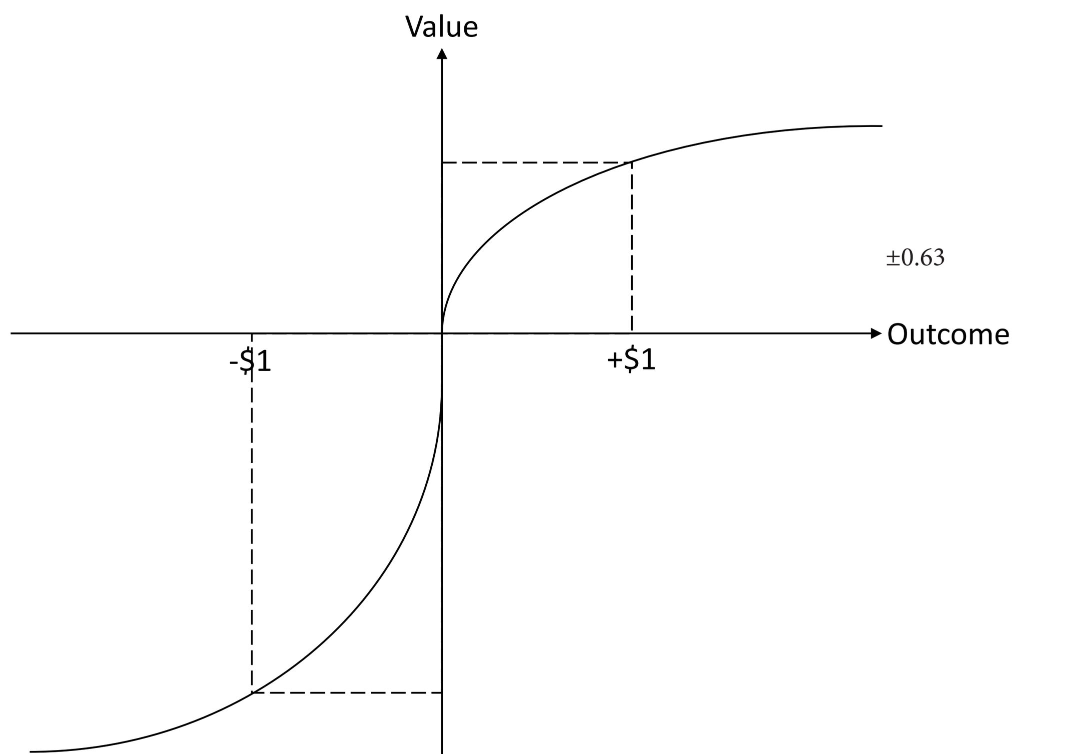


Figure recreated from Kahneman & Tversky (1979)

- Individual difference of loss aversion is linked to the activities at ventral striatum, prefrontal cortex, and amygdala during decision-making [2-3].
- Little has been done on how loss aversion may impact the encoding of outcome, which is important to reinforcement learning (RL).

Research Question

- How do people with different degree of loss aversion respond to gambling outcome differently in terms of neural activities?

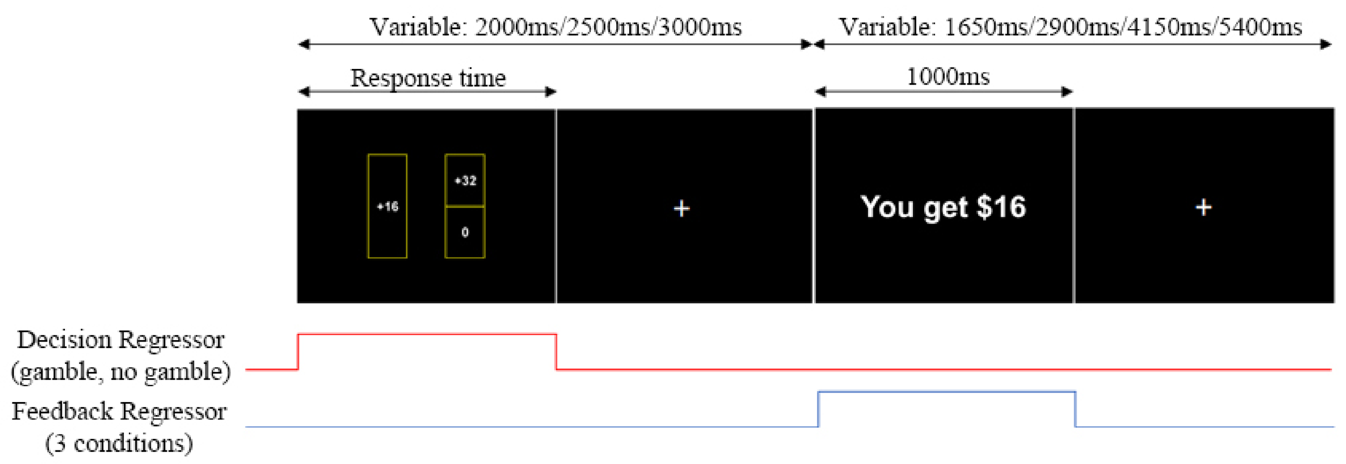
Subjects

- 23 Chinese adolescents from Hong Kong
- 10 males, 13 females
- $M_{age} = 17.8 \pm 0.5$

Design

Loss Aversion Task in fMRI (3 sessions, 84 trials each):

- Participants choose to gamble or not
- NoGamble option gives a guaranteed outcome
- Gamble option has a 50/50 chance of winning or losing



Analyses

Behavioural Data:

- Subjects' responses are fitted into a logistic function modeling probability of gamble.
- Weights of gain and loss are estimated with maximum likelihood.

$$P(Gamble) = \frac{1}{1+e^{-z}}$$

$$z = \beta_0 + \beta_{gain}(gain) + \beta_{loss}(loss)$$

- A loss aversion coefficient (lambda, λ) is calculated for each subjects ($M = 1.54 \pm 0.63$).

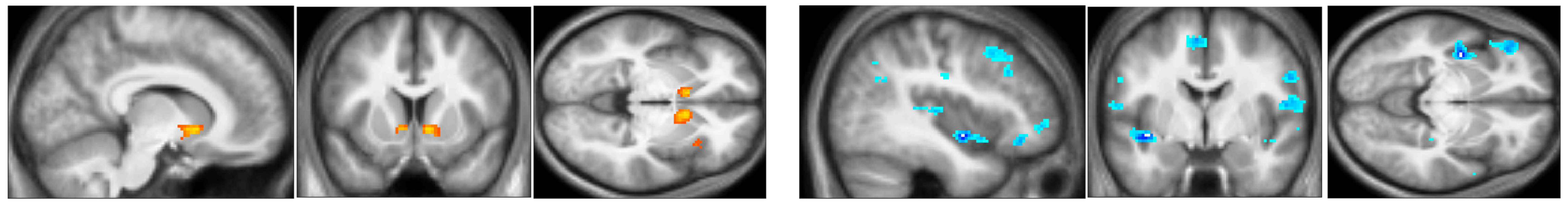
$$\lambda = \frac{-\beta_{loss}}{\beta_{gain}}$$

fMRI Data:

- GLM consists of five condition regressors
- Contrasting the win and loss feedback images with the safe feedback
- Individual lambda is modelled as a covariate at the second level random effect model
- ROI analysis to find correlation between BOLD signal and lambda

Results

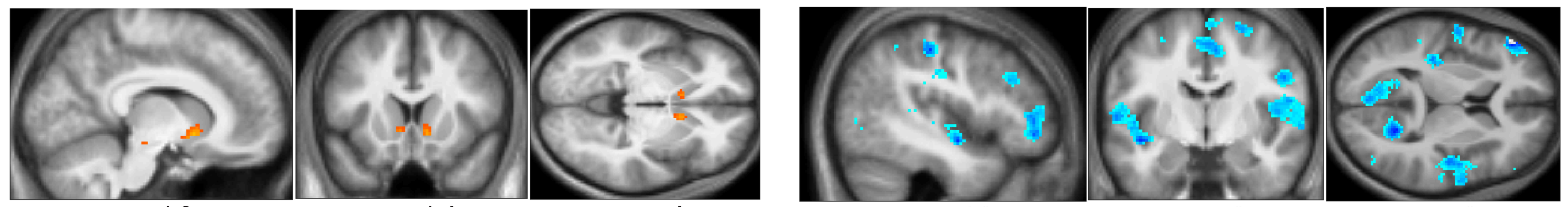
Win feedback



Highlight:

- Activation at right nucleus accumbens (NAcc, $p_{uncorrected} < .001$, $p_{FWE} = .06$, $k_E = 140$) and left NAcc ($p_{uncorrected} < .001$, $p_{FWE} = .70$, $k_E = 36$)
- Deactivation at left posterior insula ($p_{uncorrected} < .001$, $p_{FWE} < .001$, $k_E = 442$)

Loss feedback

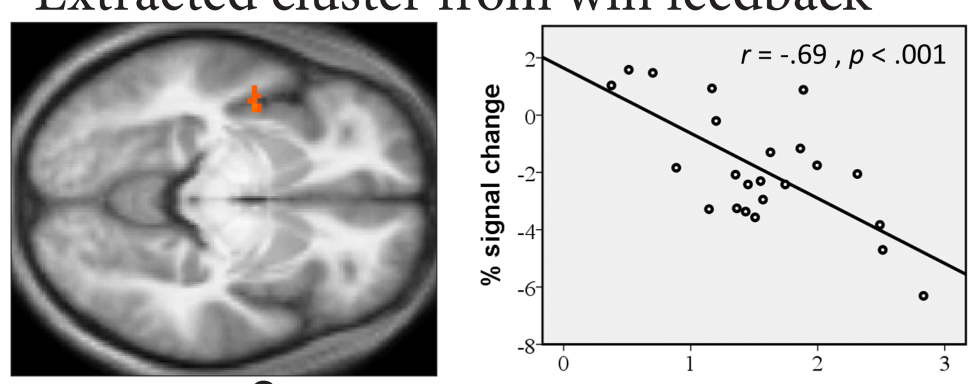


Highlight:

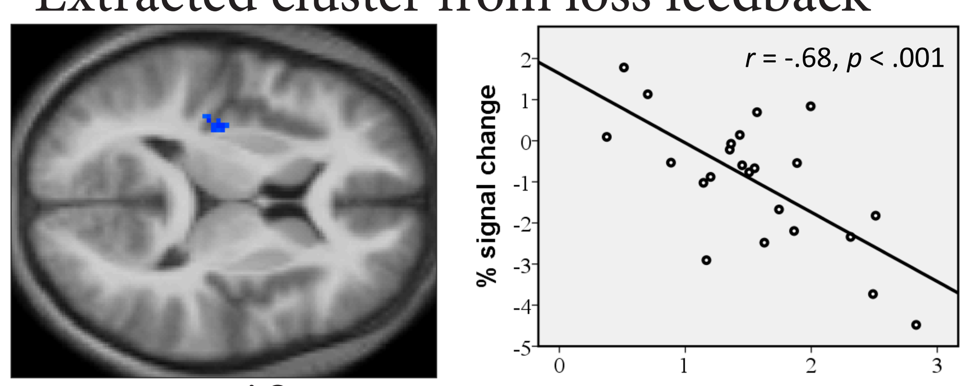
- Activation at right NAcc ($p_{uncorrected} < .001$, $p_{FWE} = .29$, $k_E = 56$) and left NAcc ($p_{uncorrected} < .001$, $p_{FWE} = .77$, $k_E = 18$)
- Deactivation at left posterior insula ($p_{uncorrected} < .001$, $p_{FWE} < .001$, $k_E = 426$), right posterior insula ($p_{uncorrected} < .001$, $p_{FWE} = .04$, $k_E = 169$)

ROI analysis: correlation with lambda

Extracted cluster from win feedback



Extracted cluster from loss feedback



Discussion

- Lambda was found to be negatively correlated with the posterior insular activity.
- Gambling outcome elicit stronger insular response in subjects with lower lambda, while the difference between gambling outcome and guaranteed outcome is not as distinct in those with higher lambda.
- Given posterior insula project to anterior insula, it seems to modulate the salience of the outcome [4-5].
- The different response to gamble and guaranteed outcome may have effect on the RL process and thus people decision in a long run.

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