Decision ambiguity modulates activation of the posterior inferior frontal sulcus

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1 INTRODUCTION

Many decisions are made under limited information about potential outcomes. What two or more outcomes are possible, with bivariate probabilities, decision makers select one (Charness 2003). Decisions might be made with limited knowledge of the probabilities of potential outcomes. Ambiguity has been thought to be the decision problem in the absence of subjective knowledge. However, ambiguity can be long debated within the economic literature (see Knight, 1921). The current study, in contrast, aimed at testing neural responses using functional magnetic resonance imaging (fMRI) whether risk and ambiguity evoke distinct patterns of neural activity during decision making.

Subjects participated in two sessions (time-limited and one fMRI) of choices between pairs of monetary gambles. Each gamble showed either probabilistic outcomes displayed as a pie chart or “spread.” Three gambles were used: Ambiguous, Certain, and Risky. Those gambles could be changed in the following three combinations: Risky (RC), Ambiguous (AC), Risky/Risky (RR), or Ambiguous/Risky (AR).

Experimental Hypotheses

1. That performance of this decision task would evoke activation in anterior (and/or) posterior (rIFJ) and in posterior parietal cortex (pPAR). For each, we expected to examine neural activation in two phases.

2. That activation in rIFJ would be influenced by the risk or ambiguity associated with those decisions.

3. That ambiguity effects within pPAR would be found in posterior regions associated with contextual analysis, not in anterior regions associated with behavioral selection.

2 METHODS

Subjects

• Participants were 13 young adults (mean: 22y).

Experimental Task

• Subjects made choices between pairs of monetary gambles (~300/session).

• Each gamble was depicted as a roulette wheel (e.g., pie chart).

• There were three types of gambles:

• Certain: 100% chance of winning a shown reward

• Risky: 25%, 50%, or 75% chance of winning large / small rewards

• Ambiguous: Chance of winning small rewards (small rewards)

• After subjects selected one gamble, any ambiguity was revealed and both gambles were displayed.

• At the end of the experiment, subjects were paid off on a proportion of their gambles, randomly selected from all choices.

Behavioral Measures

• For all subjects, we estimated risk and ambiguity preference parameters using power- and exponential utility functions, respectively.

• We estimated impulsiveness for 10/13 subjects using the Barratt Impulsiveness Scale (BIS).

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Data Acquisition using fMRI at 1.5T

• Images were acquired sensitive to BOLD contrast (i.e., T2*-weighted).

• We used a spiral-in pulse sequence (TR: 1500ms; TE: 35ms).

• We acquired 34 axial slices (3.75*3.75*3.8mm voxels).

• We preprocessed steps (SPM99) included motion correction, slice timing correction, normalization, and spatial smoothing (fsl).

Data Analysis

• We conducted multiple regression analyses using SPM2.

• Regressors were created for each of the three phases of the trials, and were analyzed by trial type, t-runs, and all included.

• Head motion parameters were included as regressors of no interest.

• The general linear model was designed to test the effects of risk and ambiguity types.

• Significance was assessed using uncorrected random effects analyses.

• Significance was calculated by selecting voxels (300) and (16000).

• The contrasts were calculated from the functional regions of interest (ROIs) derived from the functional-effects analyses.

• Brain activation was correlated with measures of behavioral measures: Risk preference, Ambiguity Preference, and BIS scores.

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3 EXPERIMENTAL PARADIGM

4 TRIAL PHASES

5 AMBIGUITY EFFECTS

6 BEHAVIOR/brain CORRELATIONS

7 CONCLUSIONS

1. Decisions between monetary gambles evoke activation in prefrontal and parietal cortices, along with motor and visual regions.

2. Ambiguity increased activation in the posterior inferior frontal sulcus (pIFS), anterior insula (aINS), and posterior parietal cortex (pPAR).

3. The ambiguity effect in pIFS tracked both ambiguity preference (positively) and behavioral impulsiveness (negatively).

4. The ambiguity effect in pPAR tracked risk preference (negatively).

5. The results suggest that the pIFS implements contextual analysis while inhibiting impulsive responses.