



Are Reward Expectancies in Choice Tasks Processed as Ratios or Differences?: Implications for Theories of Reward Processing in the Orbitofrontal Cortex (OFC)

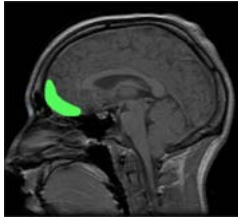
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Introduction

– Much evidence implicates the OFC in reward processing.
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– Are reward ratios and differences processed by the same mechanism?³

– If not, possibly separate neural systems for ratio and difference comparisons.

Aims of Study

– Examine effects of ratio- and difference-preserving reward manipulations on:
– total reward
– proportion of optimal choices (exploration vs. exploitation)

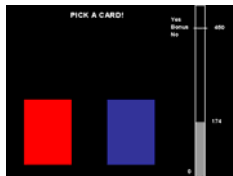
– To inform future work examining the neural correlates of reward processing

General Methods

– **Participants:** Healthy young adults.

– **Task:** Two choice n-armed bandit task^{4,5}

– 80 choice trials
– Could earn monetary bonus



Theoretical Motivation

– Several reinforcement learning models propose that **Expected Values (EVs)** of each option are compared to determine choice.⁵

– Subtle difference between decision rules

Ratio Rule⁶

$$P_{a,j} = \frac{EV_i(a)^j}{\sum_{b=1}^n EV_i(b)^j}$$

Distance Rule⁶

$$P_{a,j} = \frac{e^{jEV_i(a)}}{\sum_{b=1}^n e^{jEV_i(b)}}$$

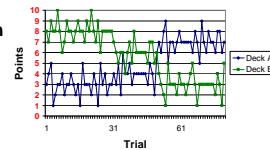
– Rules make different theoretical assumptions
– Distances or ratios compared?

Experiment 1

– Altered distance or ratio between EVs

Control Condition

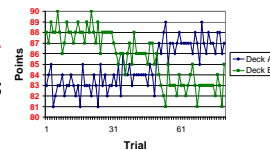
Gained between **1 and 10 points** on each trial



– Optimal strategy was to *exploit* Deck B for trials 1-50, Deck A for trials 51-80

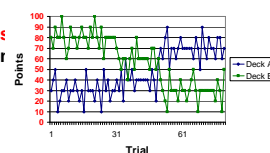
Distance Preserving Condition

Gained between **81 and 90 points**. Ratio between EVs was **smaller**; distance was the same.



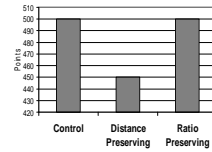
Ratio Preserving Condition

Gained between **10 and 100 points**. Distance between EVs was **larger**; ratio was the same.

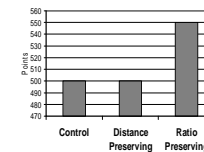


Predictions

Ratio Hypothesis



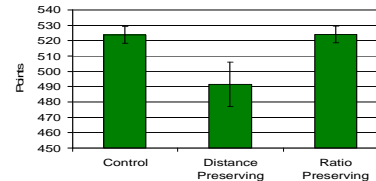
Distance Hypothesis



– Rules generate alternate predictions about behavior

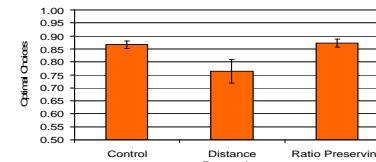
Results

Total Adjusted Points Earned



– Distance preserving worst
– Control and ratio preserving equivalent
– Supports **Ratio Hypothesis**

Proportion of Optimal Choices



– Distance preserving fewer optimal choices
– Control and ratio preserving equivalent

Summary

– **Ratio hypothesis supported**
– Performance worse when ratio decreased
– **Difference hypothesis rejected**
– Performance unaffected by difference change

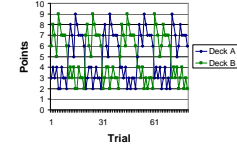
Experiment 2

– Increased task difficulty by decreasing the stationarity of the environment.

Control Condition

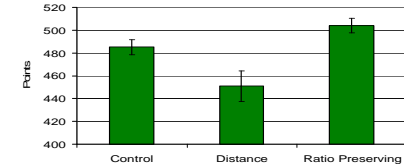
Optimal deck switch every ten trials

Distance and Ratio preserving conditions adjusted as in Experiment 1



Results

Total Adjusted Points Earned



– Distance Preserving condition earned fewer points than Control
– Ratio Preserving earned significantly *more* points than Control
– Supports **Ratio and Distance Hypotheses**

Conclusions

– The **ratio** between EVs effects exploitation of the best option.
– Experiment 2 suggests that the **differences** between EVs can also influence exploitation of the best option.

– Implications for Neuroscience

– Possibly separate neural systems used for ratio and difference comparisons.
– Or predispositions for certain reward contexts
– OFC and DLPFC may respond differently to different contexts.
– OFC – implicated in estimation of reward magnitude
– DLPFC – implicated in comparison of alternate rewards
– Regional activation may differ by reward scales.
– OFC may compute EV; DLPFC may compute relative value

– Implications for models of choice

– Predictions based on models may be an alternate form of model validity to goodness of fit.
– Choice rules used may make unwanted assumptions.