Differential Effects of Reward Magnitude and Uncertainty in the Explore-Exploit Dilemma
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Introduction

Background
1) Strategies for balancing exploration/exploitation are based on an interplay between reward magnitude and uncertainty
2) But most studies are not designed to study their effects separately.

Questions
How does uncertainty affect exploration? How does magnitude affect exploration? How do they interact?

Task
The Two-armed bandit task
- Uncertain
- Certain

Explore

Exploit

Certain reward: reduced each play by 1 point. $\mu_{\text{cert}} \in [20;80]$

Uncertain reward: $\mu_{\text{unc}} = \mu_{\text{cert}} + U(-8,8)$

60 games per session
15 trials per game

Results

Magnitude and Uncertainty Effects

Sensitive to magnitude
With equal information
Higher certain rewards
Decreased exploration

Sensitive to uncertainty
Indifference point is shifted
Bias to explore Uncertainty bonus

Model

Tracking reward values
$\hat{\mu}_{\text{unc}}(t+1) = \hat{\mu}_{\text{unc}}(t) + \alpha(R - \hat{\mu}_{\text{unc}}(t))$

Softmax choice function
$y_i = \frac{1}{1 + \exp(-\beta^*(\theta + \Delta\mu))}$

Description of Behavior

Explore early
Explore regardless of $\Delta\mu$
Switch depending on $\mu_c$

Strategy: Explore – Estimate – Compare -- Choose

Discussion

Exploration patterns reflect differential influence of reward magnitude and uncertainty
High uncertainty encourages information-seeking exploratory behavior (uncertainty bonus)
Relative ($\Delta\mu$ ) and absolute ($\mu_{\text{cert}}$ ) reward affect exploration differently

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