Modeling sequential choices in a risky choice task
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INTRODUCTION
• Sequential behaviors such as gambling and foraging rarely involve the isolated choices that are typically studied in probabilistic choice procedures.
• The previous outcome of a choice can affect the subsequent choice behavior.1
• The weight that a previous outcome has on the subjective value of a choice may decay exponentially or hyperbolically as a function of time.2,3
• Here, simple models for valuation and decision-making mechanisms were simulated to elucidate the psychological processes of sequential risky-choice behavior.

METHOD – EXPT. 1: DATA COLLECTION
• 24 male Sprague-Dawley rats chose between a certain and a risky outcome
• Certain outcome: Food always delivered (1 or 3 pellets)
• Risky outcome: Food probabilistically delivered (3 or 9 pellets)
• P(risky food) was constant across an experimental session (static probability training) or changed across the session (dynamic probability training).
• Static probability of risky food: p(risky food) = .1, .33, .67, and .9
• Dynamic probability of risky food:
  • Session onset: p(risky food) = .33
  • Following an unrewarded risky choice: p(risky food) = .17
  • Following a rewarded risky choice: p(risky food) = .67

METHOD – EXPT. 2: MODEL SIMULATIONS

Valuation Mechanisms

Hyperbolic Rule

\[ V_{N,t} = \sum_{i=1}^{t-1} \left( R_{N,i} / T_{N,i} \right) / \sum_{i=1}^{t-1} \left( 1 / T_{N,i} \right) \]

• \( V_{N,t} \): value of choice \( N \) at trial \( t \)
• \( R_{N,i} \): magnitude of reward \( i \) of choice \( N \) that occurred \( T_{N,i} \) s in the past

Exponential Rule

\[ V_{N,t} = V_{N,t-1} + \alpha (R_{N,t} - V_{N,t-1}) \]

• \( V_{N,t} \): value of choice \( N \) at trial \( t \)
• \( R_{N,t} \): magnitude of most recent reward of choice \( N \)
• \( \alpha \): decay rate parameter (.05 and .20)

Decision Mechanism

Compute relative value of risky choice
\[ \hat{V}_R = \frac{V_R}{V_C + V_R} \]
Sampled threshold
\[ U(0,1) = b \]

Make choice based on \( \hat{V}_R \) and \( b \)

Risky Choice: \( \hat{V}_R > b \)
Indifference: \( \hat{V}_R = b \)
Certain Choice: \( \hat{V}_R < b \)

Static Probability Phase
Fig 1. Overall Choice Behavior

Dynamic Probability Phase
Fig 2. Post-Outcome Choice Behavior

RESULTS

• The overall choice behavior was fit best by the hyperbolic model (Fig. 1).
• The exponential models provided better fits to the post-outcome choice behavior (Fig 2).

DISCUSSION

• The rats and simulated models showed sensitivity to the probability of risky food delivery.
• The hyperbolic model\(^1\) provided a better fit to the choice behavior across a series of choices.
• The exponential models\(^2\) provided better fits to the choice behavior at a more local level.
• Future models of choice behavior should include both time-based (hyperbolic) and trial-based (exponential) components to account for sequential risky-choice behavior.

REFERENCES


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