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

$$V_{N,t} = \sum_{i=t-1}^{t-(n-1)} (R_{N,i}/T_{N,i}) \Big/ \sum_{i=t-1}^{t-(n-1)} (1/T_{N,i})$$

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

Exponential Rule

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

- $\boldsymbol{V_{N,t}}$: value of choice N at trial t
- $\boldsymbol{R_{N,t}}$: magnitude of most recent reward of choice N
- **α**: decay rate parameter (**.05** and **.20**)

Decision Mechanism

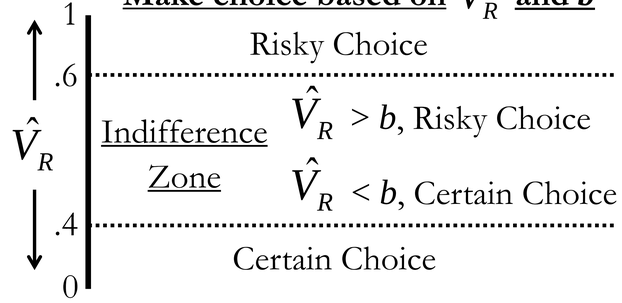
Compute relative value of risky choice

$$\hat{V}_R = \frac{V_R}{V_C + V_R}$$

Sampled threshold

$$U(0,1) = b$$

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



RESULTS

Static Probability Phase

Fig 1. Overall Choice Behavior

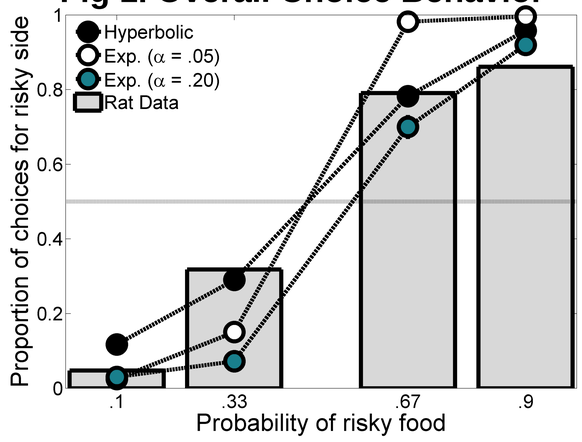
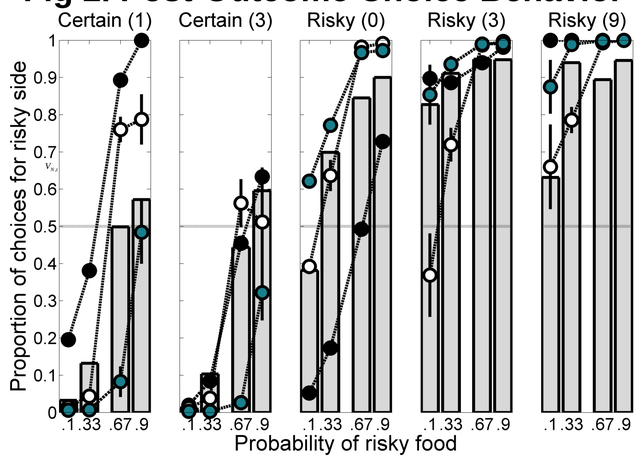


Fig 2. Post-Outcome Choice Behavior



- 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).

Dynamic Probability Phase

Fig 3. Overall Choice Behavior

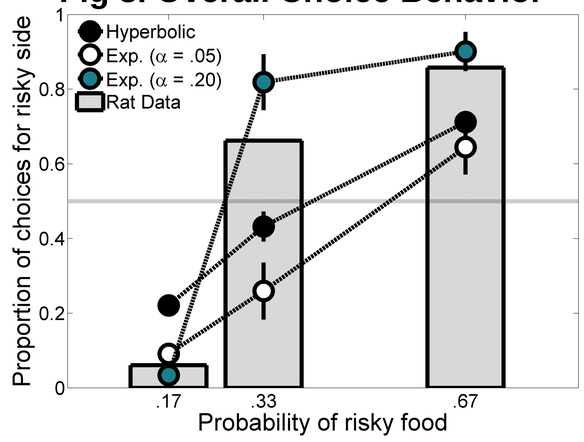
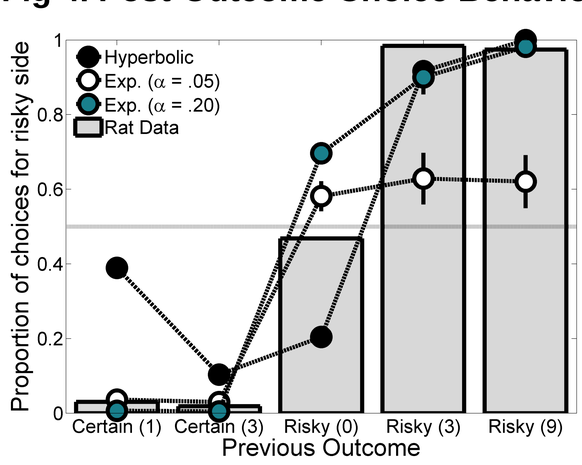


Fig 4. Post-Outcome Choice Behavior



- The overall choice behavior and the post-outcome choice behavior were best fit by the exponential (α = .20) model (Figs. 3-4).

DISCUSSION

- The rats and simulated models showed sensitivity to the probability of risky food delivery.
- The hyperbolic model[3] 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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