Uncertainty alters the balance between incremental learning and episodic memory

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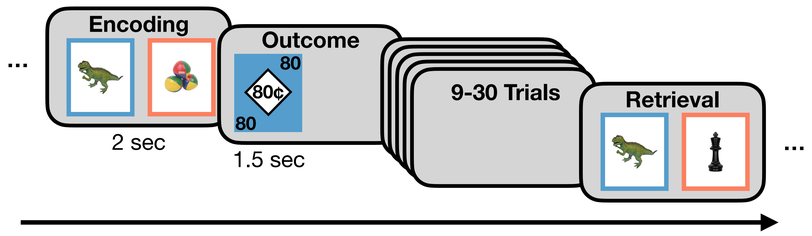
Background

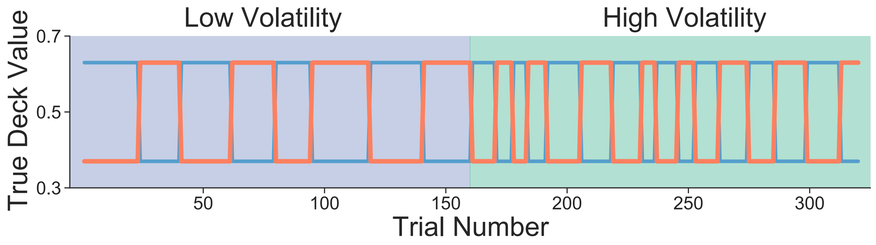
- **Most work on decision making has focused on incremental learning from trial-and-error. Yet, some decisions may require episodic memory.**
- **Episodic memory is useful for choice when there is simply not enough data to construct accurate and reliable incremental estimates.**
- **Prediction: Episodic memory may be recruited for decision making when estimates about value are uncertain.**

Primary Question | **Does uncertainty about rewards modulate the extent to which decisions are guided by incremental learning or episodic memory?**

Experiment



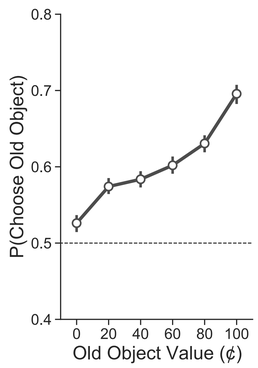
- **254 subjects recruited from mTurk completed a two-armed bandit task.**
- **Choices were between two decks that reversed in expected value periodically. Outcomes were between $0 - $1 in increments of twenty cents.**
- **Decks also featured cards with trial-unique objects that could repeat once after 9-30 trials and were worth the same amount.**



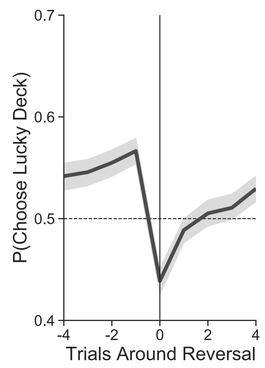
- **Subjects made choices across two environments with high and low volatility.**
- **This allowed us to test for effects of uncertainty both across environments and after reversals in deck value.**

Subjects use both sources of value

Choices are sensitive to old object value

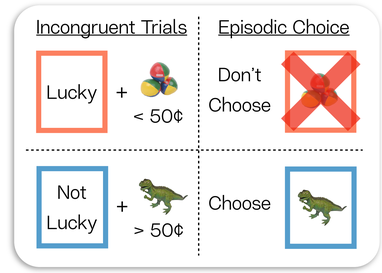


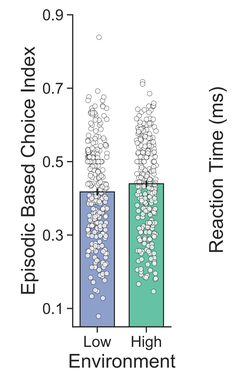
...and to reversals in deck value.

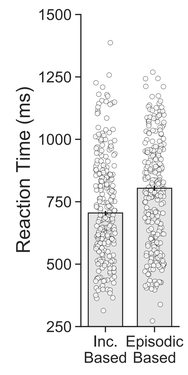


High volatility increases episodic choice

On incongruent trials...







...choices are more episodic when volatility is high

...and episodic choices take longer.

Behavior is best described by a Bayesian learner with hybrid choice

Bayesian learner + hybrid choice model

- Incremental value is updated by reward prediction error
- Learning rate is updated by uncertainty
- Uncertainty consists of *relative uncertainty* and change point probability

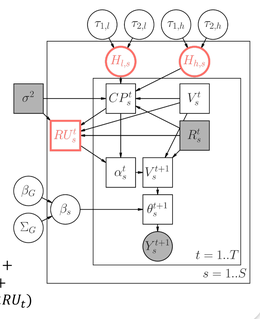
$$V_{t+1} = V_t + \alpha_t(R_t - V_t)$$

$$\alpha_t = CP_t + (1 - CP_t)RU_t$$

$$RU_{t+1} = \frac{Unc.about\ V_t}{Unc.about\ V_t + \sigma^2}$$

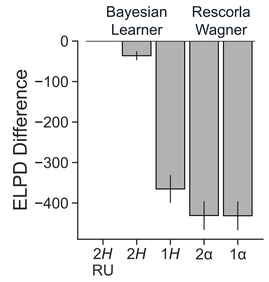
- Hybrid choice consists of:
  1. Inc. bias
  2. Inc. value sensitivity
  3. Ep. bias
  4. Ep. value sensitivity
  5. *Ep. value X RU sensitivity*

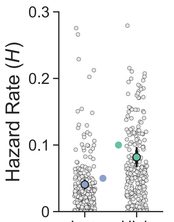
$$p(Choice_t) = logit^{-1}(\beta_0 + b_{0,s} + (\beta_1 + b_{1,s})V_t + (\beta_2 + b_{2,s})Old_t + (\beta_3 + b_{3,s})OV_t + (\beta_4 + b_{4,s})OV_t \times RU_t)$$



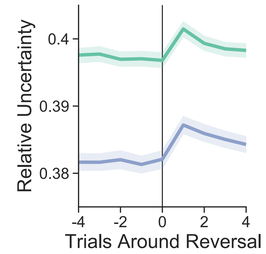
Built upon Nassar et al., 2010. All priors excluded for concision.

Participants are impacted by the volatility manipulation



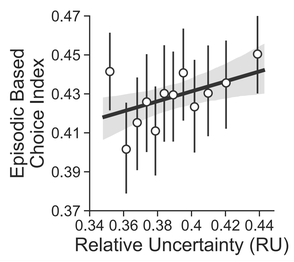


...and relative uncertainty increases after reversals.

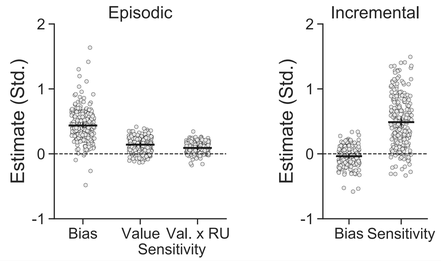


Episodic choices increase with uncertainty

Choices are more episodic under greater uncertainty

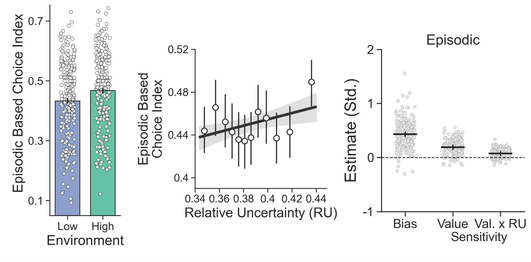


...and are more sensitive to episodic value under uncertainty.



All results replicate

Choices were more episodic under uncertainty in a separate sample (n=223)



Take Home

Given the option, people recruit episodic memory for decisions made under more uncertain conditions.