



Value-based decisions are supported by episodic memory but not incremental learning in patients with cerebellar ataxia



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Background

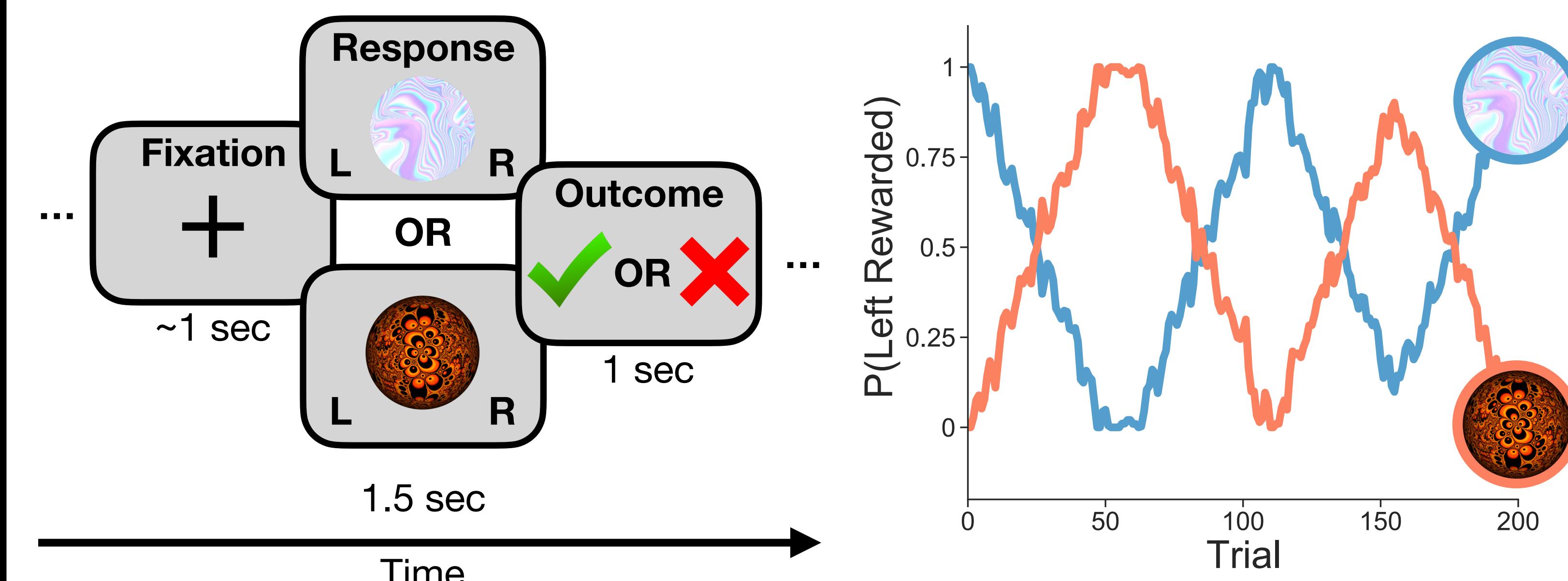
- Recent animal work suggests that the cerebellum may play an unappreciated role in incremental reward learning^{1,2}.
- Cerebellar ataxia provides an opportunity to test whether lesions of the cerebellum impair incremental reward learning in humans.
- Episodic memory is also used for reward learning^{3,4,5}, and is likely independent of the cerebellum.

Primary Question Is the cerebellum necessary for incremental reward learning but not reward learning from episodes?

Methods

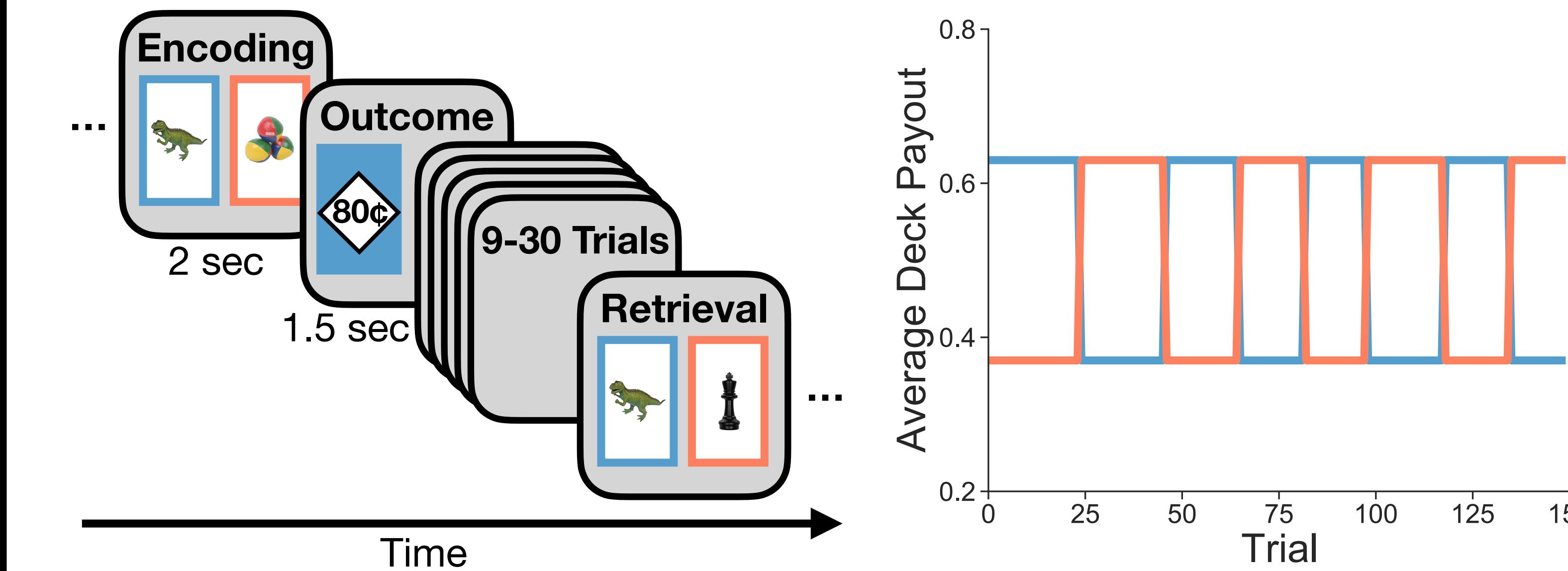
- 19 patients with cerebellar ataxia and 57 age- and sex-matched controls (3/patient) participated in two experiments.

Experiment 1: Assessing Incremental Learning



- Participants saw one of two cues and pressed with either their left or right hand to receive probabilistic binary feedback that drifted over time.

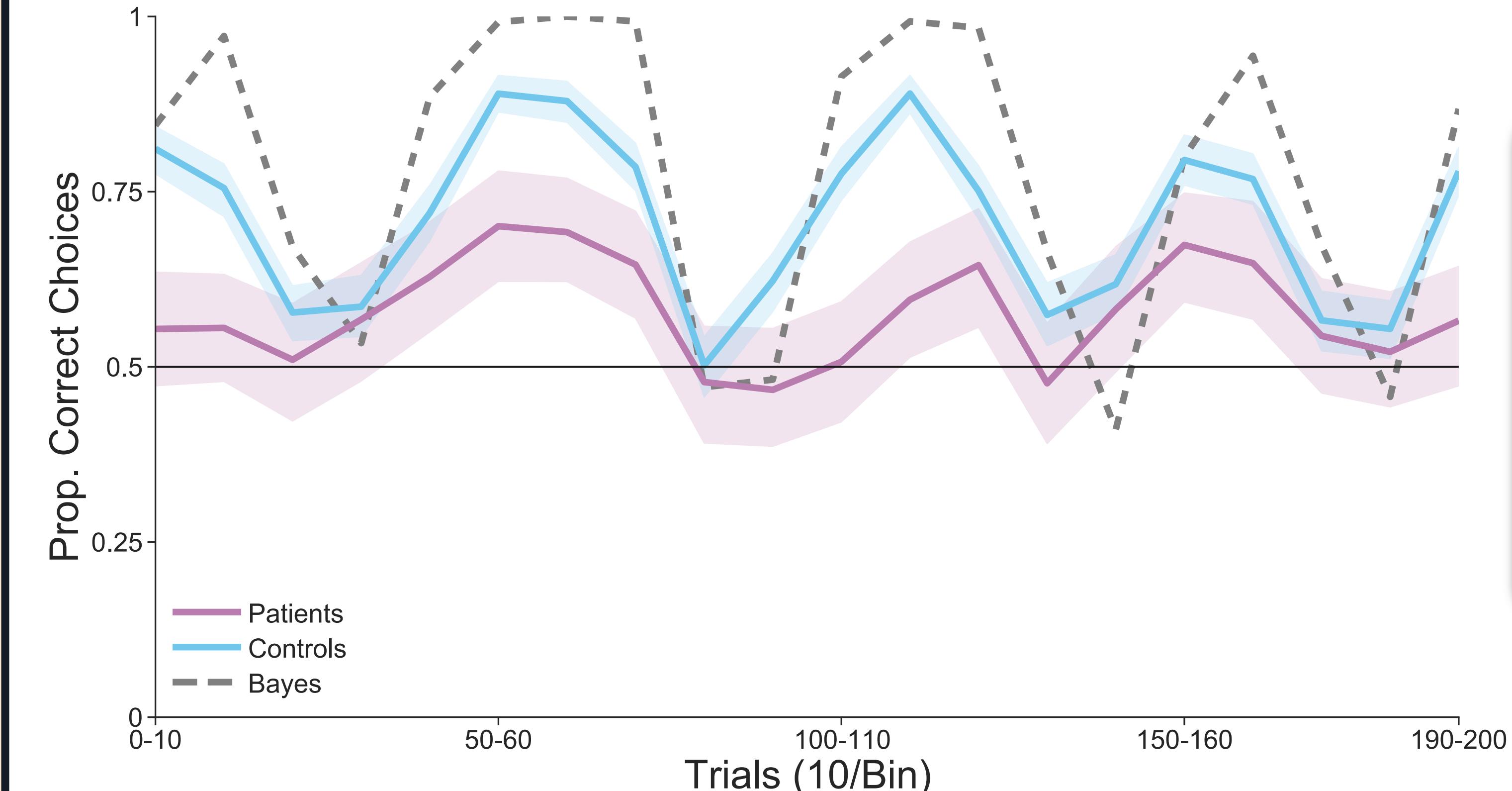
Experiment 2: Adding Episodic Memory



- Participants chose between two decks of cards that featured trial-unique objects and received reward. Decks reversed in expected value periodically.
- Objects could repeat once after 9-30 trials and were worth the same amount.
- Participants later completed a standard subsequent memory test for objects.

Patients are impaired at incremental reward learning relative to controls

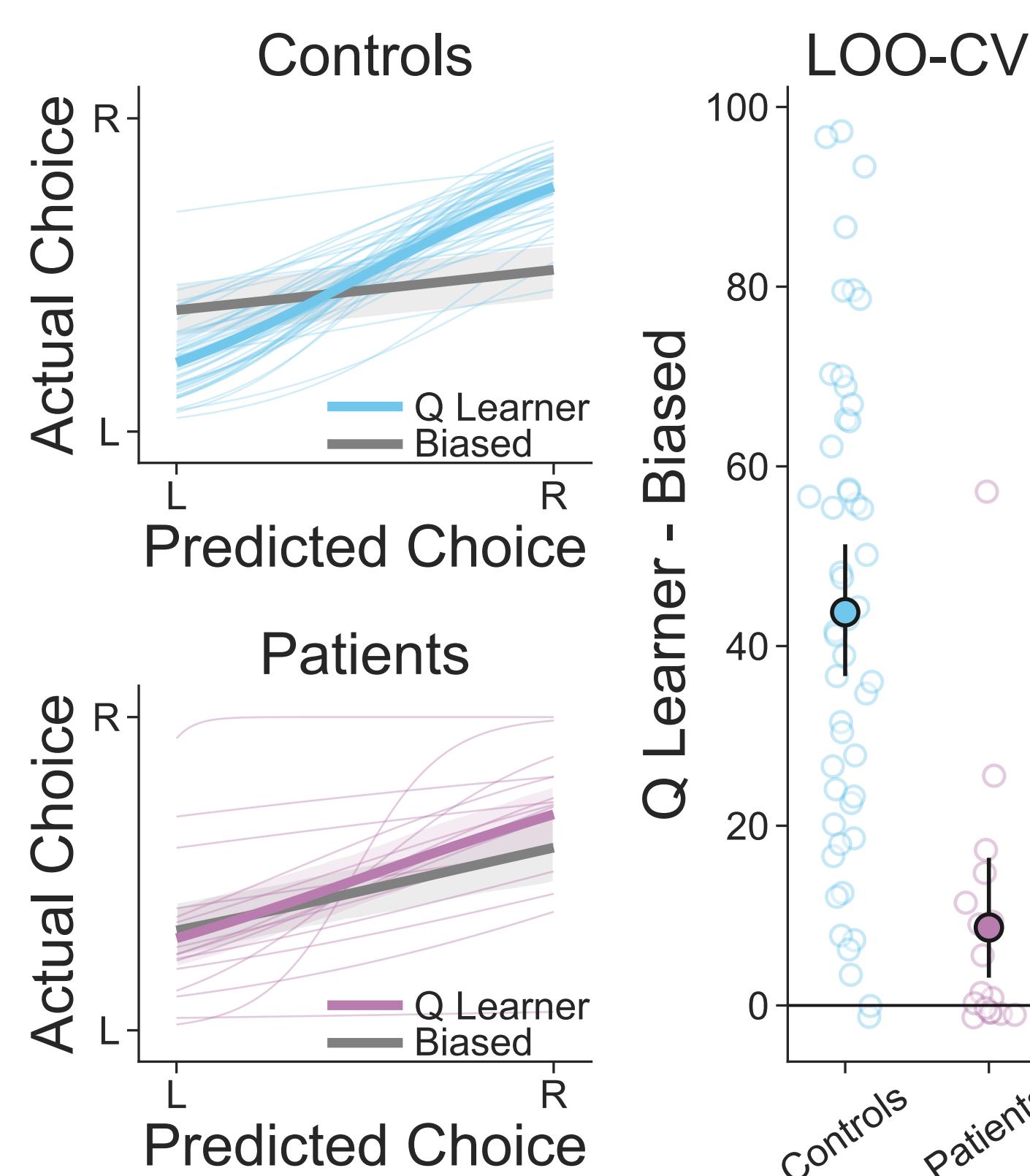
Patients hardly learn button mappings



...and their behavior is not well fit by a model of incremental reward learning.

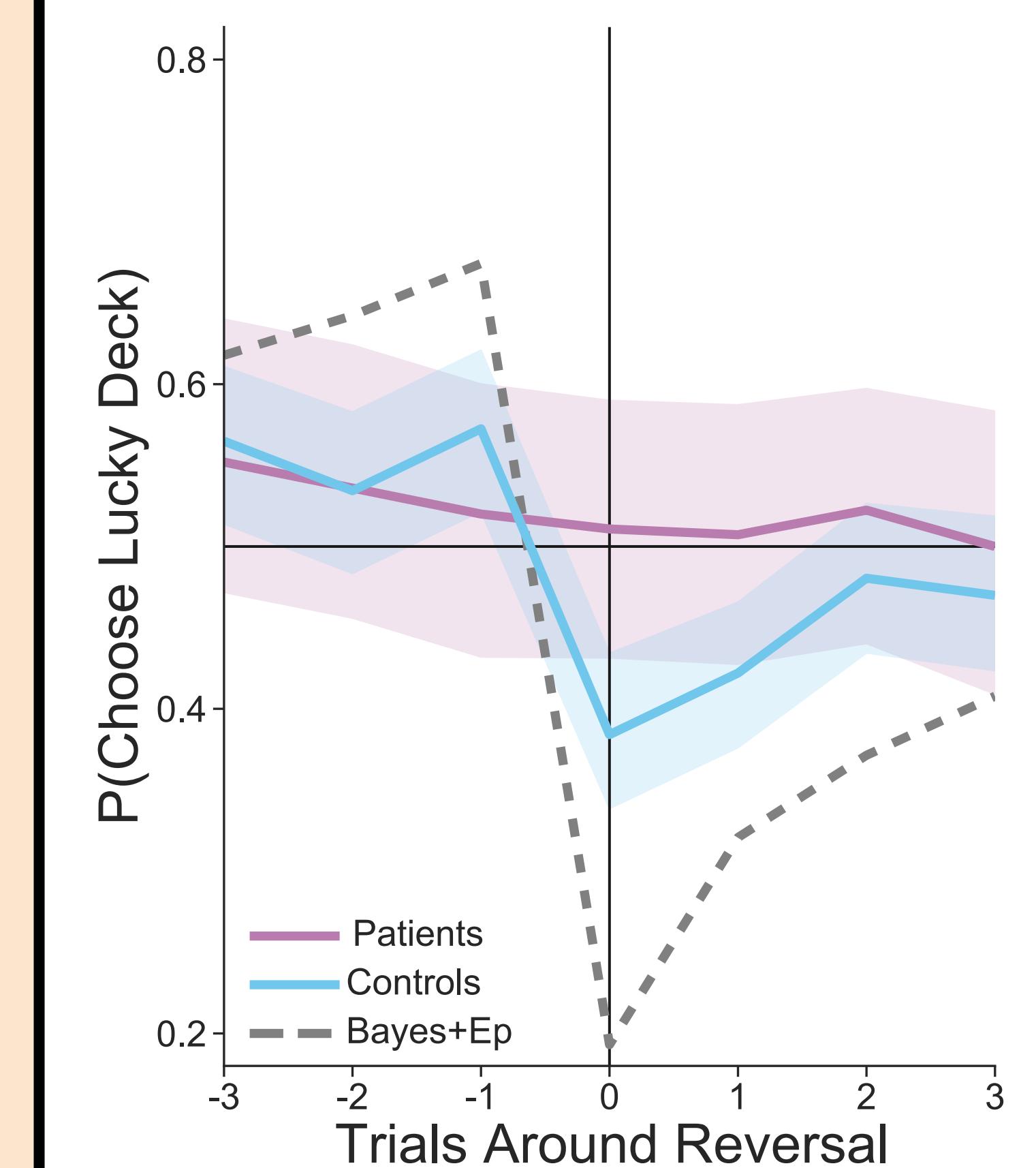
Q Learner
 $Q_{h,t+1} = Q_{h,t} + \alpha(Q_{h,t} - r_t)$
 $p(L_t) = \phi(\beta(Q_{L,t} - Q_{R,t}))$
 $\phi(x) = \frac{1}{1 + e^{-x}}$

Biased Responder
 $p(L_t) = \phi(\beta)$



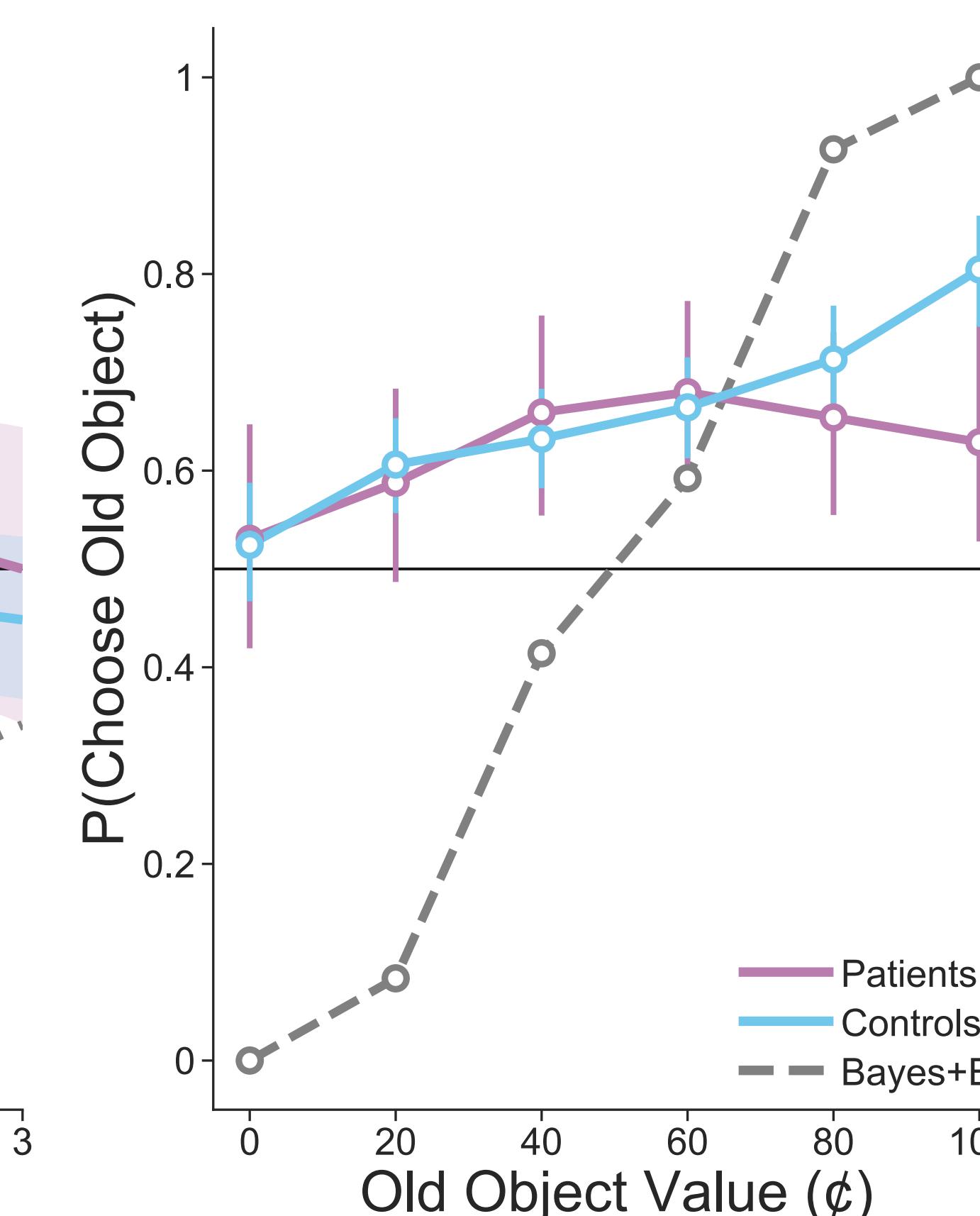
Patients base decisions on episodic memory but not incremental reward

Patients are not sensitive to reversals in deck value



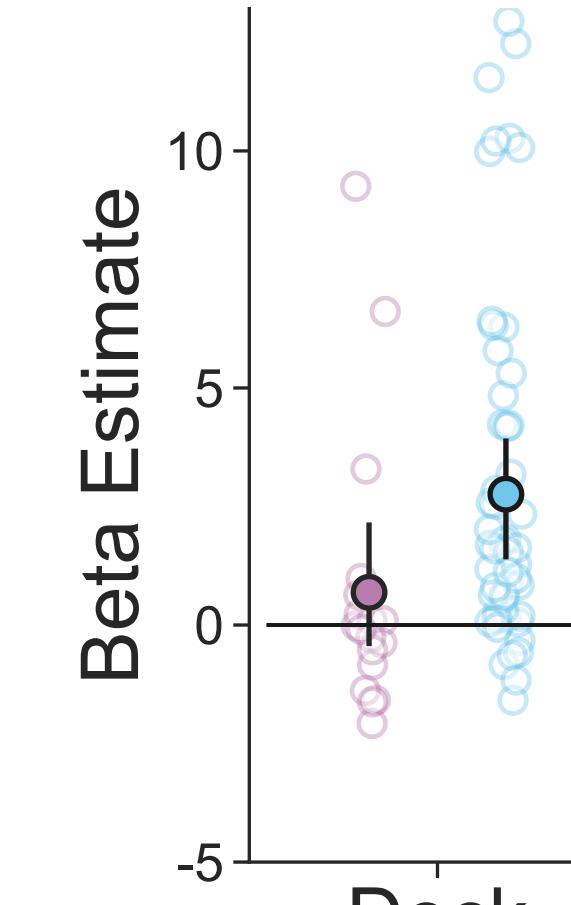
...but are sensitive to single experiences.

This is confirmed by a hybrid learning model



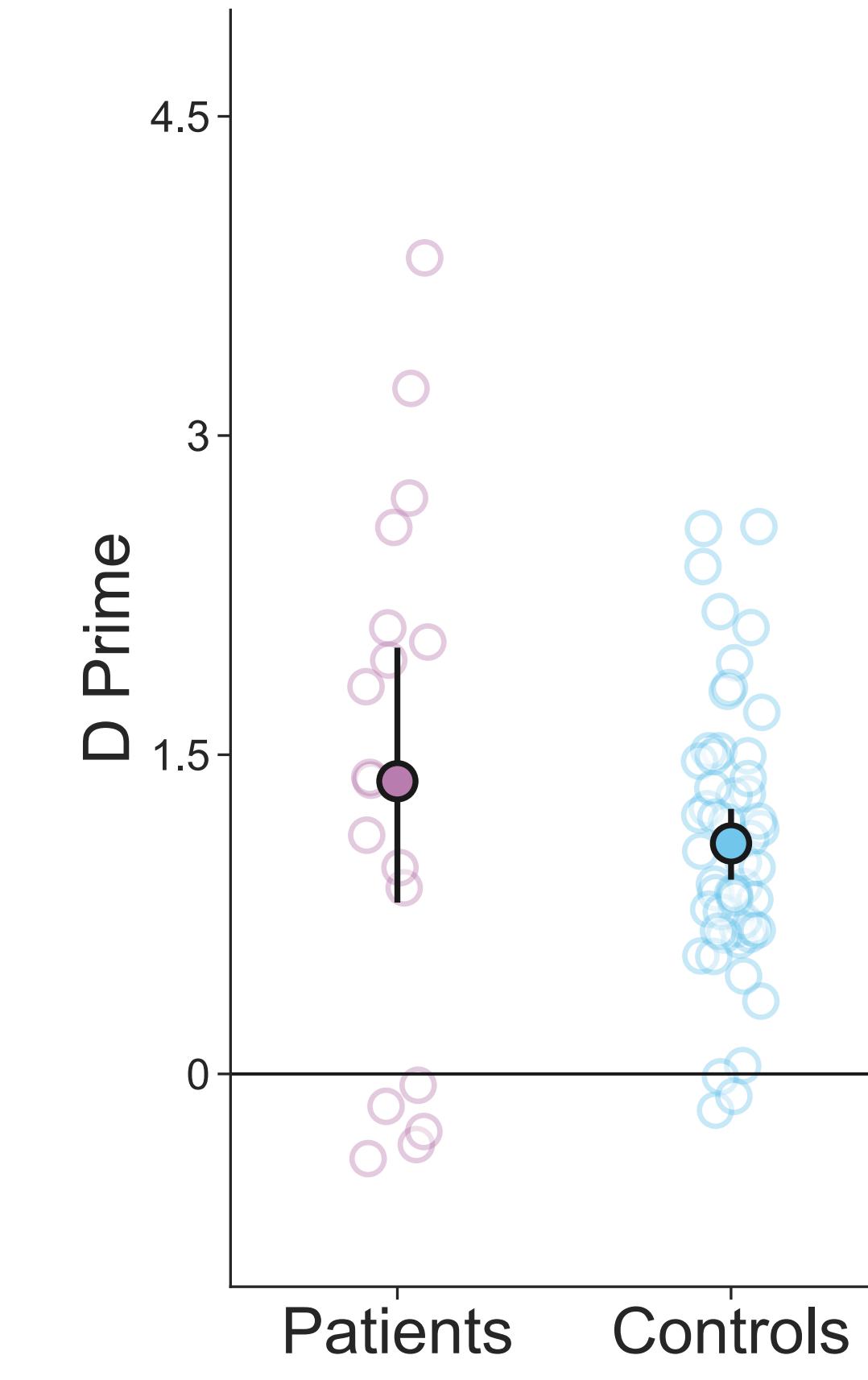
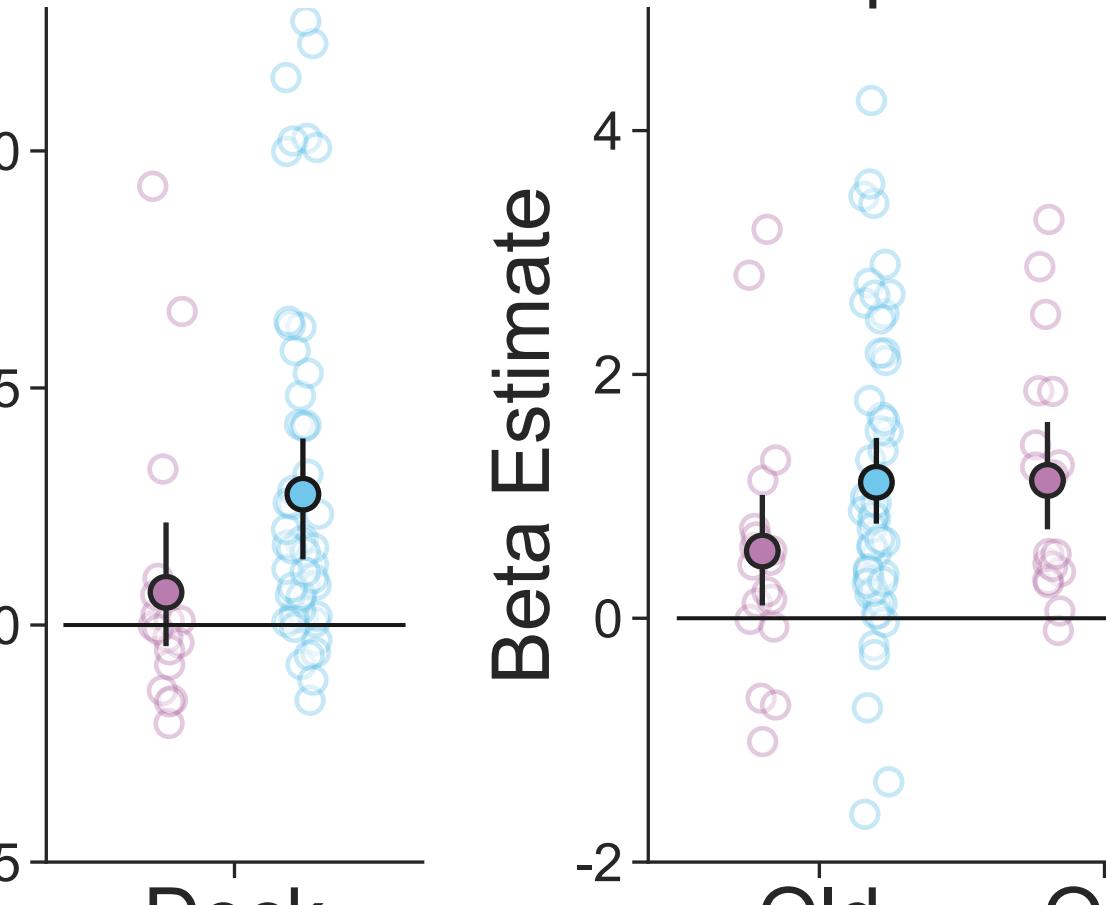
...and similar subsequent memory to controls.

Incremental



Q Learner + Hybrid Choice
 $Q_{d,t+1} = Q_{d,t} + \alpha(Q_{d,t} - r_t)$
 $p(Red_t) = \phi(\beta_1(Q_{red,t} - Q_{blue,t}) + \beta_2(OldValue) + \beta_3(OldDeck))$

Episodic



Take Home

The cerebellum is necessary for learning about reward incrementally but not from episodes.

References and Acknowledgements

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