A Normative Account of the Influence of Contextual Familiarity and Novelty on Episodic Memory Policy

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Summary

- Empirically, a familiar/novel stimulus trigger lingering retrieval/encoding mode, even if this stimulus is incidental (Duncan et al. 2012/2016/2019). It is unclear why this is the case from a normative standpoint.
- A neural network model learned episodic memory (**EM**) policy in autocorrelated environment can capture human data (Duncan et al. 2016/2019), suggesting these lingering EM modes are optimal adaptation reflecting environment statistics, resonating with theories proposed by Anderson & Schooler (1991) and Honey et al. (2023).

Familiarity/novelty trigger lingering EM modes

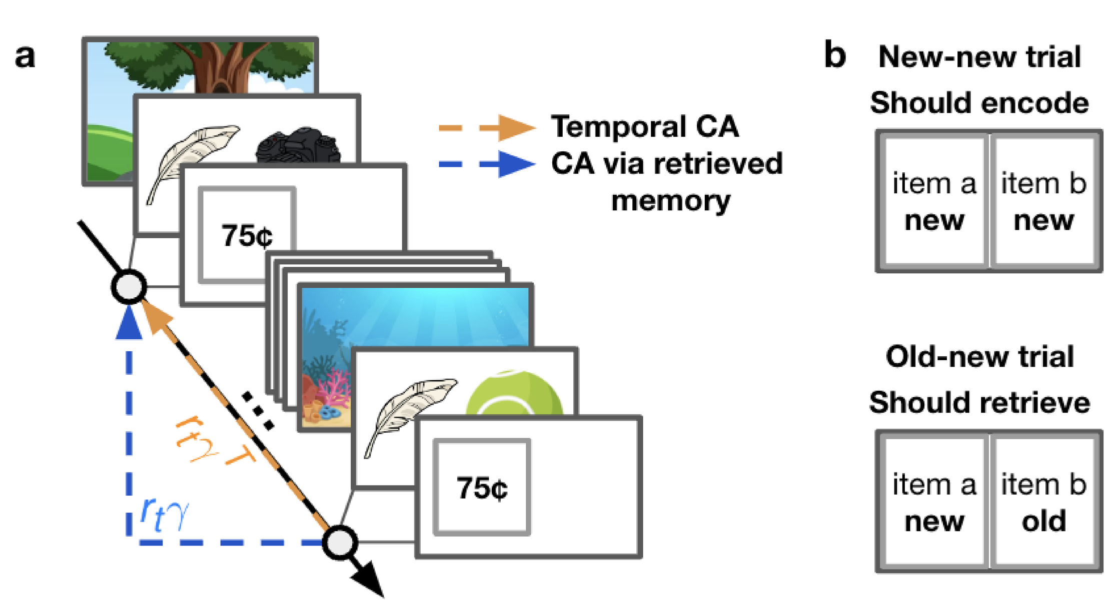

Figure 1: A) The task paradigm of Duncan et al. (2016/2019) and an illustration of credit assignment (CA) via retrieved memory; B) Participants either choose between two new items or a new versus an old item.

- In Duncan et al. (2016; Fig.1a), subjects either chose the higher value item between two new items or an old versus a new item (Fig.1b).
- Subjects should encode in new-new trial and recall in old-new trial.
- Before every choice, subjects either view a familiar context image or a novel context image (Fig.1a).
- The findings show that choices were more influenced by past EMs in a familiar context, and EM encoding was better in a novel context.

A neural net model of EM policy

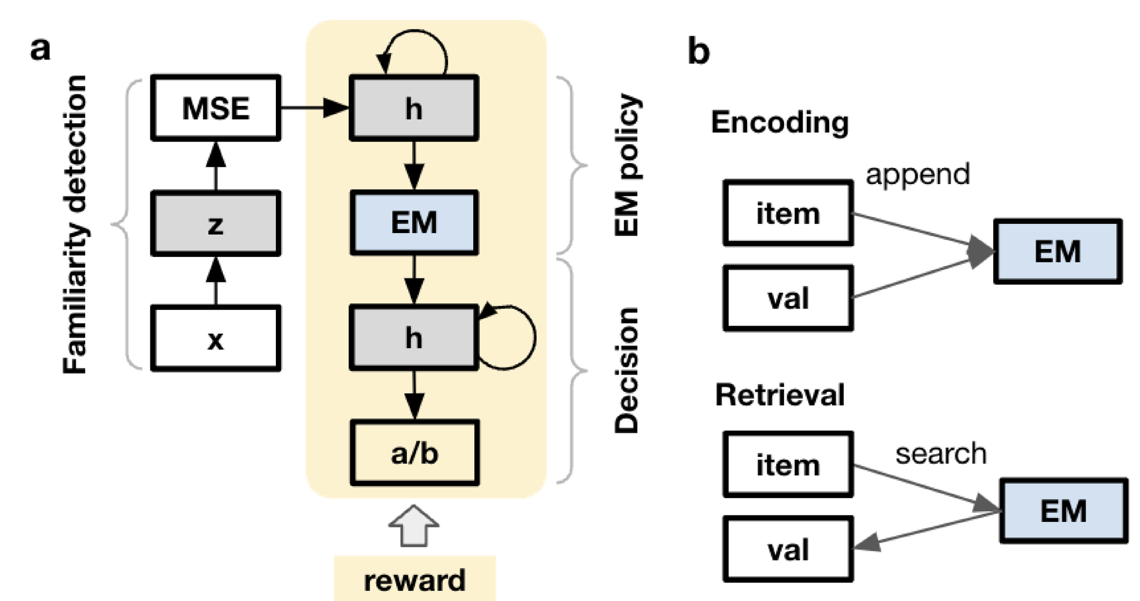

Figure 2: a) A neural net model of EM policy trained with RL; b) Episodic encoding and retrieval.

- Familiarity detector: an autoencoder that minimizes reconstruction mean squared error (MSE), with lower MSE for experienced stimuli indicating familiarity.
- EM Policy layer: an RNN takes familiarity signal as input, outputs binary action – retrieve or encode (Fig. 2b). It learned to recall/encode when the stimulus is familiar/novel (Fig.3a).
- Decision layer: an RNN that take the retrieved value to produce choices, which learned to chose higher valued items (Fig. 3b).
- Learning: The EM Policy and the decision layer were trained with RL. CA via retrieved memory reinforces encoding actions retrospectively when retrieval leads to rewards (Fig.1a), critical for learning optimal encoding policy.

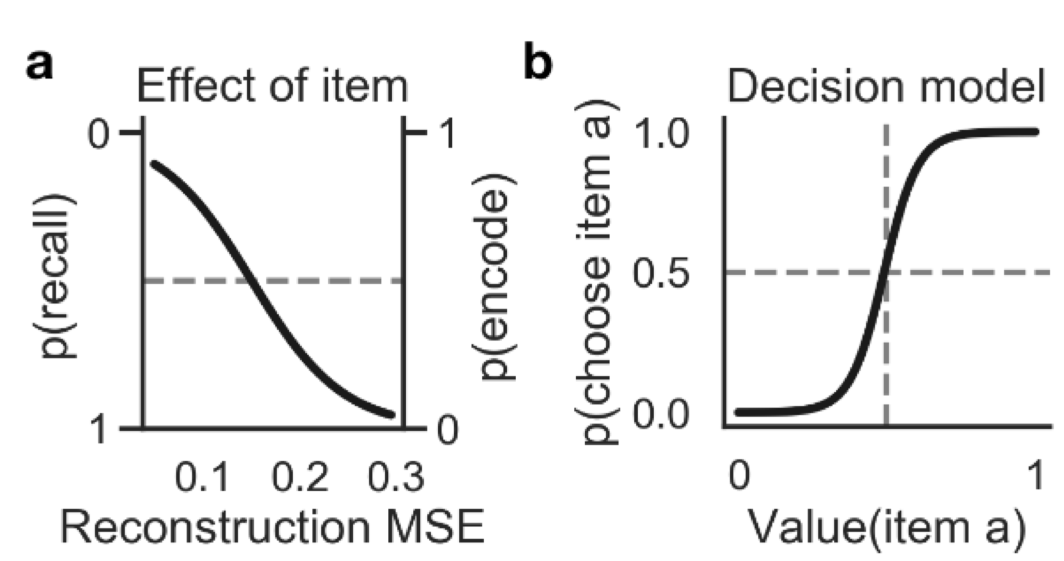

Figure 3: a) probability of recall/encode as a function of stimulus familiarity. b) probability of choosing item a as a function of its value.

Simulate Duncan et al. 2016

- Hypothesis: Context familiarity/novelty biases are adaptations to environmental autocorrelation.
- Method: To test the hypothesis, models were either trained in i) autocorrelated environment, where familiar/novel stimulus precede familiar/novel stimulus or ii) non-autocorrelated environment.

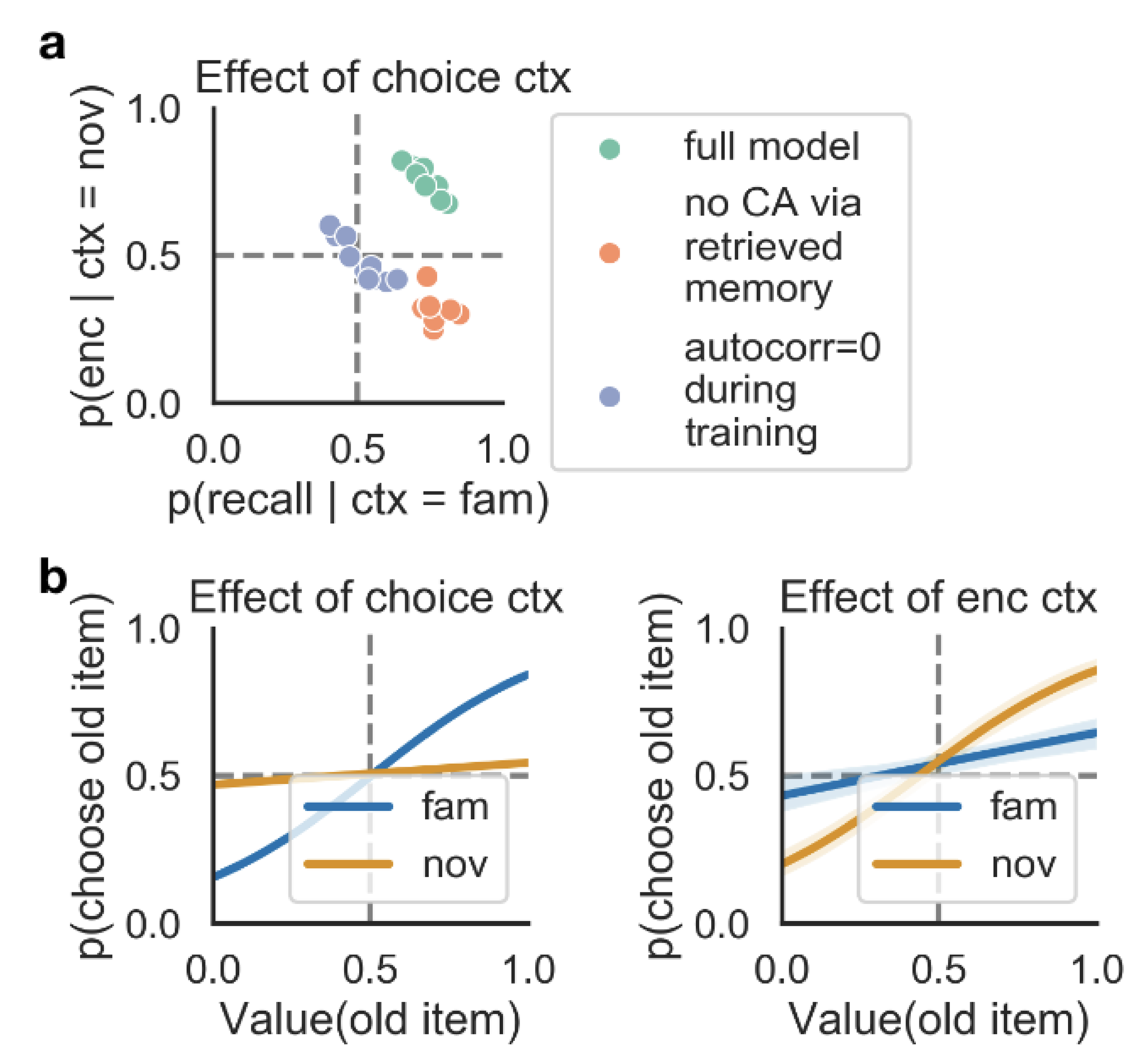

Figure 4: The influence of context familiarity/novelty on a) EM policy and b) decisions.

Models trained in autocorrelated environments ...

- were more likely to recall/encode when the preceding context was familiar/novel (Fig.4a), this is not the case for models trained in non-autocorrelated environment or models without CA via retrieved memory.
- captured the human data (Duncan et al. 2016; (Fig.4b) – the level of influence of retrieved value was steeper i) when the preceding context was familiar and ii) when a novel context was presented at encoding, right before the value of the item was initially observed.

Simulate Duncan & Shohamy 2019

- Duncan & Shohamy (2019) further studied cases where subjects need to coordinate between episodic and incremental values to make optimal decisions (Fig. 5a).
- Again, models trained in the autocorrelated environment qualitatively captured the human data (Fig. 5b), showing that choices in a familiar/novel context were more/less episodic-dependent.

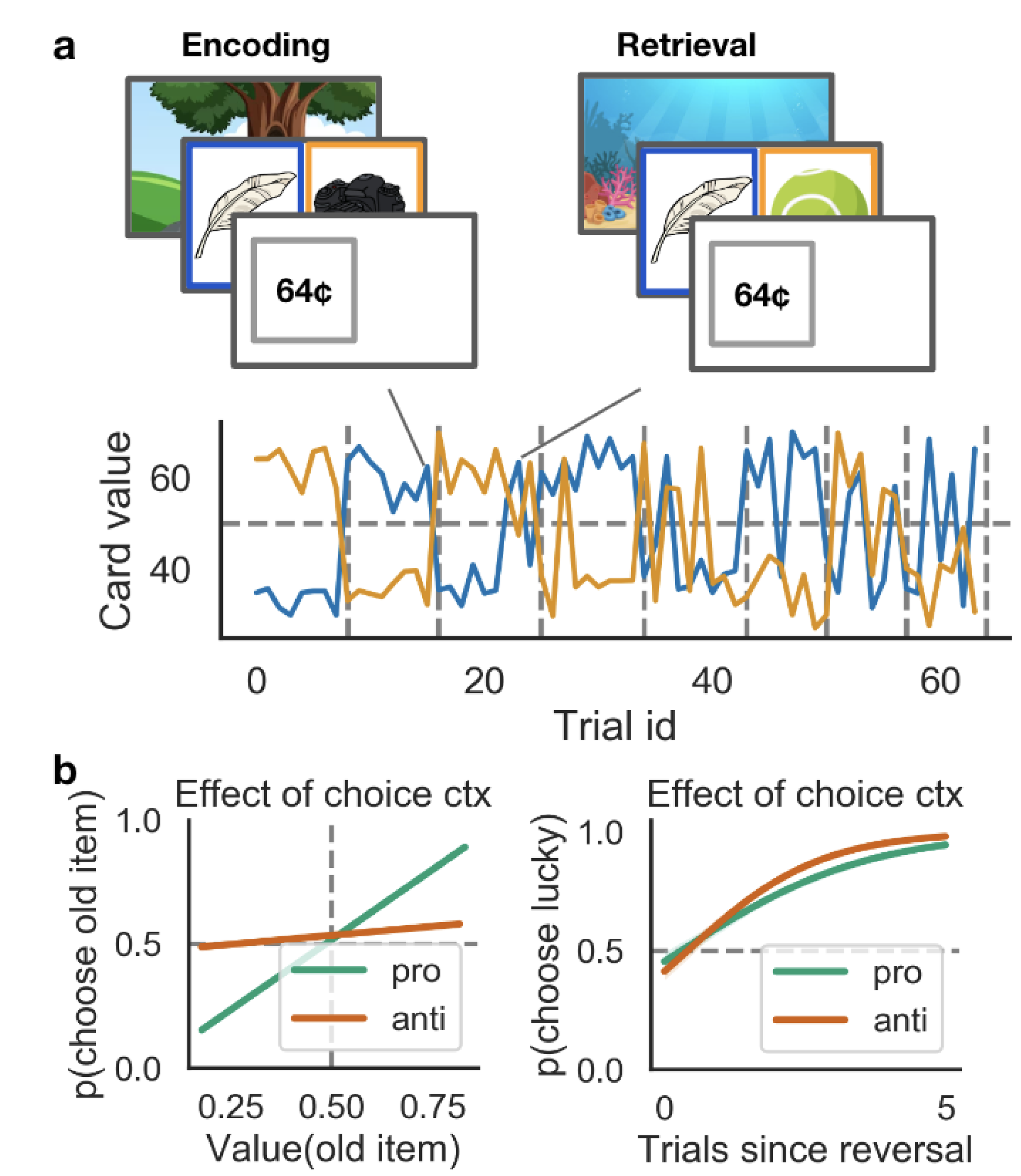

Figure 5: a) In the Duncan & Shohamy (2019) task, card has color (blue or orange). At any moment, cards from one of the colors have a higher mean value. b) The modeling results.

References & Acknowledgement

References: [1] Duncan et al. (2012). Science; [2] Duncan et al. (2016). J Cog Neuro; [3] Duncan & Shohamy (2019). JEP.G; [4] Anderson & Schooler (1991). Psych Science; [5] Honey et al. (2023). Current Direction in Psych Science; [6] Lu et al. (2022). eLife;

Acknowledgement: NIMH/NIH grant (1R01MH130068); Multi-University Research Initiative grant (ONR/DoD N00014-17-1-2961); Zuckerman Institute Alan Kanzer Postdoctoral Fellowship; Gatsby Foundation (GAT3708); Kavli Institute for Brain Science at Columbia.