The Influence of Reward-Motivated Memories on Learning Across Development

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Cues associated with past rewarding experiences can harness attention and influence choices in new situations; increased attention to previously reinforced stimuli might confer benefits for other goal-directed behaviors.

Heightened reward sensitivity may lead to a particularly robust influence of value-related memories on future behaviors during adolescence, relative to childhood and adulthood.

**Aim:** characterize age-related changes in how prior reward associations impact later learning.

**methods**

**Participants:** 90 subjects ages 8-25 (M̄age = 16.12 yrs, 45 F)

- 70% previously high reward
- 30% previously low reward
- 70% novel
- 30% previously low reward

**Computational Models:** variants of Q-learning algorithms, using softmax choice policy

\[ Q_{t+1}(s, a) = Q_t(s, a) + \alpha \delta_t \]

\[ p(\alpha|s) = \frac{\exp(\beta Q(s, a))}{\sum_i(\exp(\beta Q_i(s, a)))} \]

- \( t \) decision time point
- \( s \) stimulus
- \( a \) selected action
- \( \alpha \) learning rate
- \( \delta_t = r_t - Q_t(s, a) \) prediction error
- \( r_t \) reward outcome

- **Value transfer to initial value estimates**
  - Reward history may influence value estimates of choice options at outset of new learning. Transfer mechanism supported by best-fitting computational model.
- **Value transfer effects on learning rate**
  - Reward history may influence how feedback is incorporated into choice option valuations.

**background**

**results**

**Learning: Accuracy**

Main effects of instance, stimulus type, and age on response accuracy; significant interaction between instance and age (p < .001)

**Learning: Reaction Time**

Main effects of instance and stimulus type on reaction time; significant interaction between instance, stimulus type, and age-squared (p < .05)

**Parameter Estimates**

- Inverse Temperature
- Initial Value Estimates
- Learning Rate

Choice behavior becomes more deterministic with increasing age, suggesting that older individuals can better discriminate between reinforced stimuli in a probabilistic learning task. Initial value estimates of choice options decrease with age, suggesting that prior reward associations affect future goal-directed behavior less in older individuals.

Adults are more efficient learners in this task and may be better at adjusting their learning to the statistics of their environments. Thus, they may rely less on value-transfer mechanisms as an aid for new learning, while children may leverage reward history as a strategy in their future, goal-directed behavior.

**Future directions:** investigate potential age-related differences in best-fitting computational model to explore how previously rewarded experiences influence early learning trajectories across development.

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¹Insel et al. (2019). Neurodevelopmental shifts in learned value transfer on cognitive control during adolescence. Develop Cogn Neurosci.
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