Children and Younger Adolescents Show Greater Reward-Boosted Working Memory Performance than Older Adolescents and Adults

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INTRODUCTION

- Rewards have the potential to act s powerful motivators for cognitive performance, enhancing cognitive performance in tasks that require cognitive control in adult samples.[1]
- However, prior studies investigating how monetary rewards shape cognitive function during adolescence show mixed results.[2]
  - Several studies have shown that reward-related performance boosts in cognitive control do not appear until late adolescence or early adulthood.[3,4]
  - On the other hand, there is also work suggesting that adolescents exhibit larger reward-related boosts in performance as compared to children and adults.[5,6]
- These mixed findings suggest that **the effects of reward on cognitive performance across development may be domain-specific.**
- Here, we investigate how rewards influence performance on a **working memory** task in youth to test how reward-related benefits emerge with age to facilitate this form of executive function.

METHODS

Study Design:

- N=187 (ages 10-20, mean 15.7±3.2 years; 91F) participated in an online study.
  - Part 1: baseline N-back task: 1-back, 2-back, & 3-back; 2 blocks each
  - Part 2: cognitive effort discounting paradigm[7] to index willingness to engage in 1-back, 2-back, or 3-back tasks for differing levels of reward
  - Part 3: rewarded N-back task: 1-back, 2-back, & 3-back blocks were rewarded for each correct response (12 blocks rewarded 3¢ or 15¢ per trial)

Rewarded N-Back Working Memory Paradigm

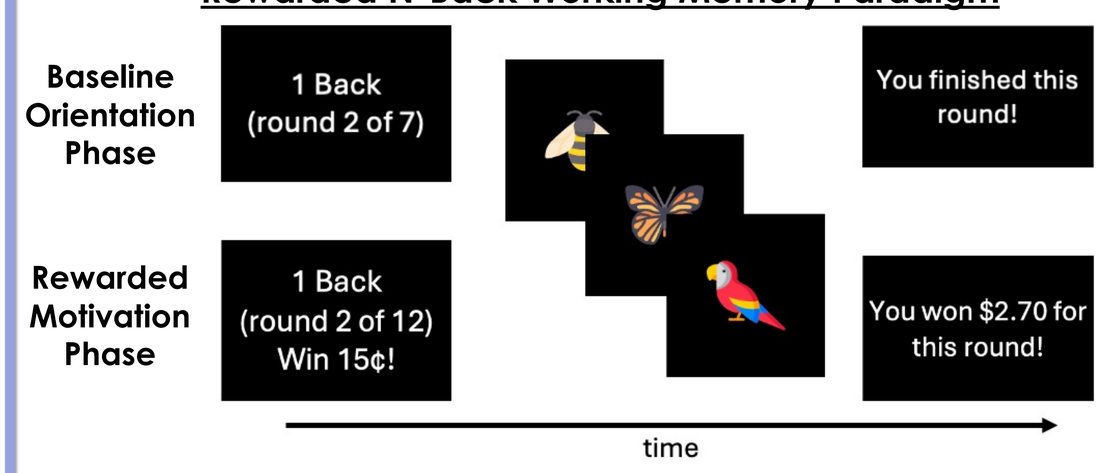


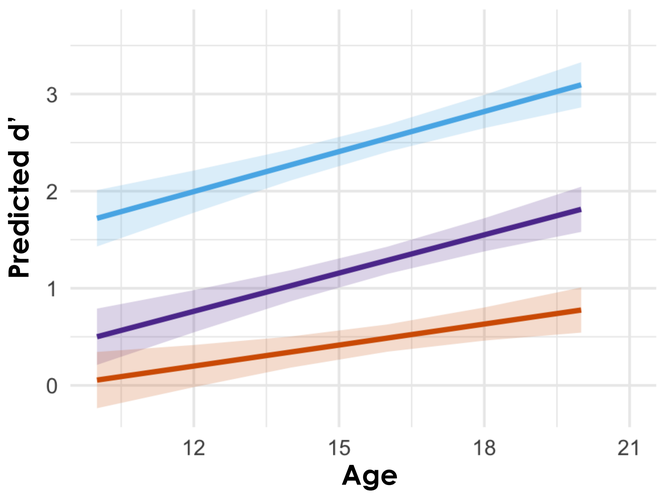
Figure 1. Schema of N-Back Working Memory Task. The figure shows an example of 1-back blocks in the baseline (top panel) and rewarded (bottom panel) phases of the experiment. During the baseline orientation phase, there was no money at stake. During the rewarded motivation phase, there was money at stake given for each correct response (15¢ in this example).

Cognitive Effort Discounting Paradigm

Figure 2. Schema of Cognitive Effort Discounting Paradigm. The figure shows one example of a choice with which the subjects were presented during the cognitive effort discounting paradigm. Subjects completed 54 choices in total, with money and difficulty options updating dynamically based on previous choices.

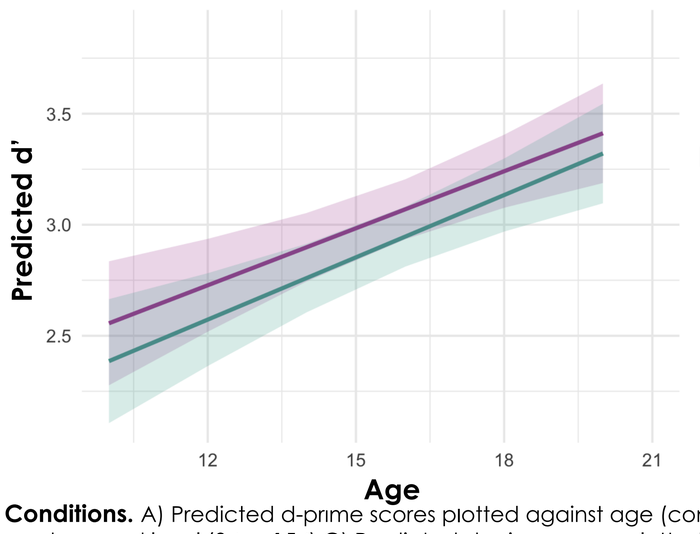
RESULTS

A. N-Back Performance Increases with Age and Decreases with Difficulty



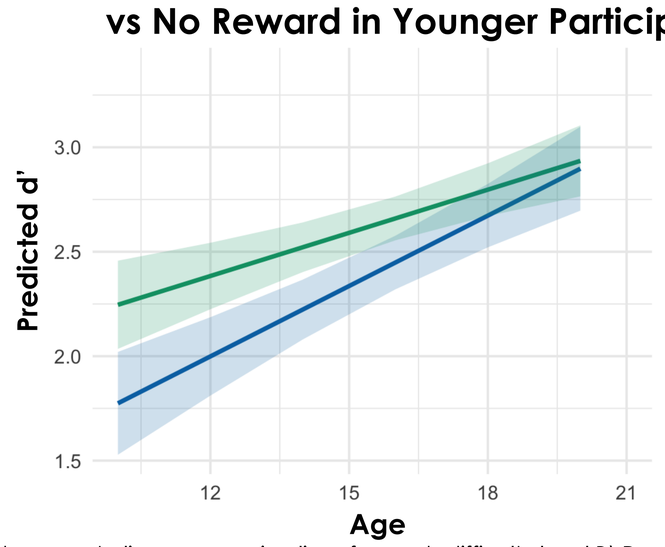
- N-back performance decreased as task difficulty increased (main effect of difficulty, p<0.0001).
- N-back performance increased with age (main effect of age, p<0.001).

B. N-Back Performance Increases with High Reward vs Low Reward Across Age



- N-back performance improved when increased rewards are at stake (main effect of reward, p<0.05).
- Reward-related improvements in performance did not change with age (age by reward interaction, p=0.77).

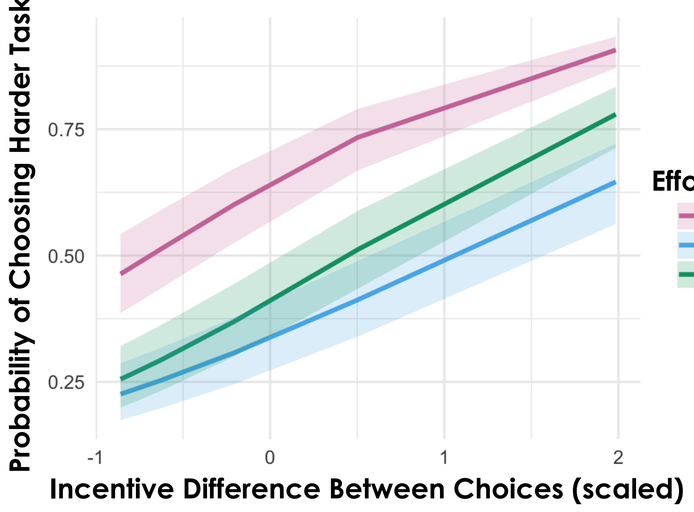
C. N-Back Performance Increases with Reward vs No Reward in Younger Participants



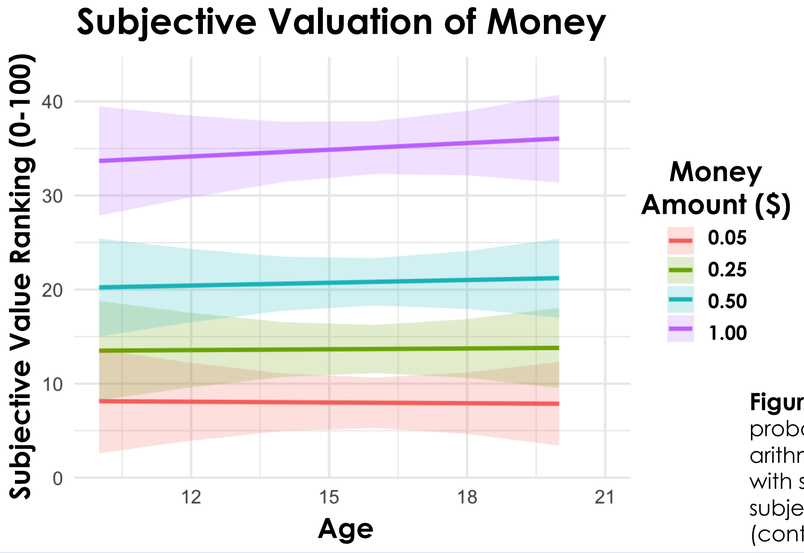
- N-back performance increased during the rewarded phase compared to the baseline phase (main effect of phase, p<0.0001).
- This effect was moderated by age such that **younger participants showed the greatest reward-related improvements in performance** (age by phase interaction, p<0.05).

Figure 3. Working Memory Performance Across Age, Difficulty, & Reward Conditions. A) Predicted d-prime scores plotted against age (continuous) with separate linear regression lines for each difficulty level B) Predicted d-prime scores plotted against age (continuous) with separate linear regression lines for each reward level (3¢ or 15¢) C) Predicted d-prime scores plotted against age (continuous) with separate linear regression lines for each experiment phase

A. No Age-Related Differences in Subjective Valuation of Effort Costs



B. No Age-Related Differences in Subjective Valuation of Money



- Participants were more likely to choose the more difficult task when it was associated with higher reward (p<0.001), aligning with prior work[7,8].
- We found **no effect of age on cognitive effort discounting** (age by incentive difference by effort level interaction, p=0.6).
- In addition, **participants of all ages ranked the monetary amounts similarly** (main effect of age, p=0.8).

Figure 4. Subjective Value of Money and Effort Costs Across Age. A) Predicted probability of choosing the harder N-back option (log-odds) plotted against the scaled arithmetic difference between the reward levels associated with each N-back option with separate regression lines for each decision that participants faced B) Predicted subjective value ranking of monetary amounts plotted on the y-axis against age (continuous) with separate regression lines for each value level included in the scale

CONCLUSIONS

- Rewards enhance performance on a working memory task for **younger participants**, providing evidence that the effect of reward on cognitive performance across development is **domain-specific**.
- This result is **not** driven by age-related differences in subjective valuation of money or effort costs.
- In addition, this work leaves open questions about how results may change based on how reward levels are operationalized during experimental design.

REFERENCES

(1) Botvinick & Braver 2015, *Ann Rev of Psych* (2) Davidow, Insel, & Somerville 2018, *TiCS* (3) Insel et al. 2017, *Nat Comm* (4) Phaneuf-Hadd et al. 2025, *JEPG* (5) Geier et al. 2010, *Cerebral Cortex* (6) Padmanabhan et al. 2011, *DCN* (7) Westbrook et al. 2013, *PLoS One* (8) Ganesan & Steinbeis 2021, *Dev Psych*

We thank the participants and their families for participating in this research, Isabelle Jacques, the Harvard University Foundations for Human Behavior Fund, and the Department of Defense Science and Engineering Graduate Fellowship (NDSEG).