The Effects of Reward Anticipation on Cognitive Control and Memory Encoding Processes: A Meta-Analysis

Kyle E. Thurmann and Kimberly S. Chiew, Ph.D.

Department of Psychology, University of Denver

Motivation, Affect, & Cognition Lab

Just as the desire to get an “A”, or to understand the world, can motivate individuals to remember information, the promise of a reward can motivate people to form new memories and exert more control (Rowe et al., 2008)

Abstract

Reward anticipation has been shown to influence cognitive control and memory encoding, but a wide variety of cognitive task designs have been used to investigate both cognitive control and memory performance without being systematically accounted for when examining reward effects on performance. The proposed research is novel and innovative in using a meta-analysis approach, examining reward anticipation effects on cognition across many studies to examine the extent to which aspects of task design modulate this interaction.

Background

Research has linked reward anticipation with enhanced performance on cognitive control and memory encoding tasks

- The prospect of rewards influence cognitive processes that determine our responses to events (Stanek, J., Dickerson, K., Chiew, K., et al., 2018)
- A variety of different task-design elements have been used in studies of reward and cognition

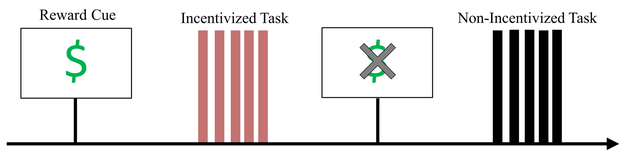
However, the extent to which different task- design elements affect reward anticipations effect of cognitive and memory performance is unknown

- Task-design elements: event-related vs. block designs; intentional vs. incidental reward contingencies; varying retention intervals between memory encoding and retrieval; varying response duration; reward feedback; and reward type

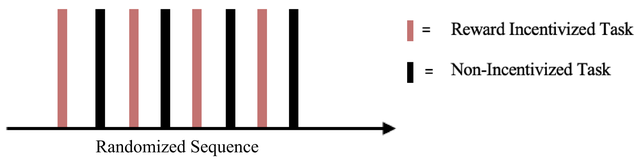
Task-Design Elements

Event-Related Vs. Block Designs

Block designs – Task trials presented in epochs of "reward" periods during which the task is performed under reward prospect, alternating with "off" periods of no-reward[3]



Event-related design – Task trials presented in randomized sequences



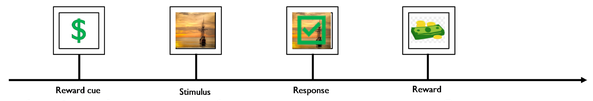
Dopamine activity may differ due to the timescale difference in each design

- It is not well understood whether the relationship between dopamine activity and the timing difference between the designs impact performance.

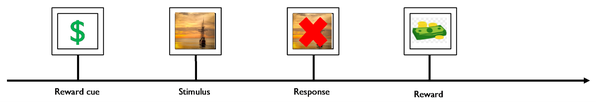
Continued — Task-Design Elements

Intentional Vs. Incidental Reward Contingencies

Intentional reward - Receives reward due to successful memory performance



Incidental reward - Receives reward no matter outcome of memory performance

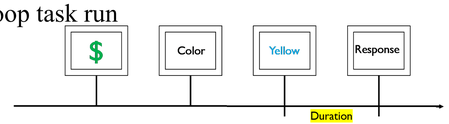


Both intentional and incidental rewards have been linked to enhanced memory performance, but to what extent, is unknown

Varying Response Duration

Duration Between Stimulus presentation and participants response

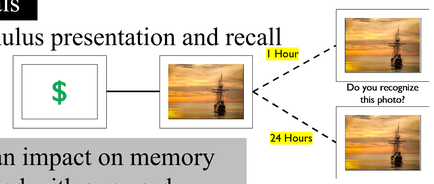
- Example of a Stroop task run



It is possible a certain duration of time may best benefit cognitive performance due to the timescale of the dopamine

Varying Retention Intervals

Time interval between stimulus presentation and recall

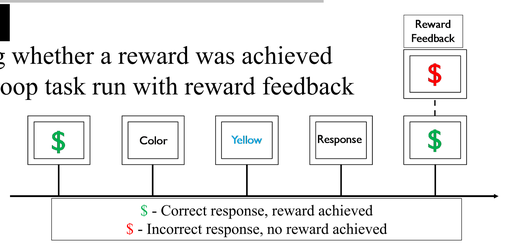


Sleep encoding may have an impact on memory performance when associated with a reward

Reward Feedback

Feedback indicating whether a reward was achieved

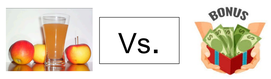
- Example of a Stroop task run with reward feedback



Cognitive studies suggest that reward feedback may influence performance beyond reward anticipation alone (Daniel, R., & Pollmann, S. 2010), but to what extent, is unknown

Reward Type

Primary (food) vs secondary (money) rewards



Apple Juice used as incentive during an adapted arrow flanker task (Chiew, K. S., & Braver, T. S. 2016)

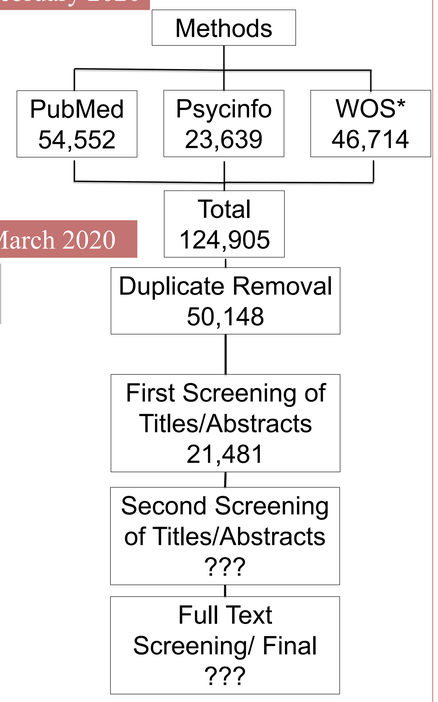
The extent primary vs secondary rewards impact performance is unknown

- Participant's preference may have an impact

Experimental Procedure

Preliminary Search – Completed in February 2020

The search terms included: (“memory encoding” OR “subsequent memory” OR “recognition” OR “cognitive control” OR “executive function” OR “executive control”) + (“reward” OR “reward anticipation” OR “motivation” OR “incentive” OR “motivational incentive”)



*WOS – Web of Science

Duplicate Removal – Completed in March 2020

Duplicates removed by title, within and between each database

Screening of Results - Current

First screening of titles/abstracts completed in August 2020

Inclusion criteria:

- Quantitative study
- Healthy humans, age 18-35 years
- Healthy control groups
- Random assignment
- Use of incidental or intentional rewards, primary or secondary rewards, and comparisons between levels of reward anticipation
- Study domain includes cognitive control and/or recognition memory

Data Extraction, Quality Assessment, and Analysis

The Comprehensive Meta-Analysis (CMA,v3) will be used for the analysis

- The random effects model approach with Cohen’s *d* as the metric for effect size will be used

Overview and Next Directions

Preliminary Search – Completed → Duplicate Removal – Completed → Screening of Results Against Criteria – Current → Data Extraction, Quality Assessment, and Analysis

The plan is to be completed with the *Screening of Results* Stage at the end of July 2021 and begin the *Data Extraction, Quality Assessment, and Analysis* stage by the end of summer 2021.

References

- Rowe, J. B., Eckstein, D., Braver, T., & Owen, A. M. (2008). How Does Reward Expectation Influence Cognition in the Human Brain? Journal of Cognitive Neuroscience, 20(11), 1980–1992. doi: 10.1162/jocn.2008.20140
- Stanek, J. K., Dickerson, K. C., Chiew, K. S., Clement, N. J., & Adcock, R. A. (2018). Expected reward value and reward uncertainty have temporally dissociable effects on memory formation. doi: 10.1101/280164
- Daniel, R., & Pollmann, S. (2010). Comparing the Neural Basis of Monetary Reward and Cognitive Feedback during Information-Integration Category Learning. Journal of Neuroscience, 30(1), 47–55. doi: 10.1523/jneurosci.2205-09.2010
- Chiew, K. S., & Braver, T. S. (2016). Reward favors the prepared: Incentive and task-informative cues interact to enhance attentional control. Journal of Experimental Psychology: Human Perception and Performance, 42(1), 52–66. doi: 10.1037/xhp0000129

Email: Kyle.Thurmann@du.edu