Reward-related memory benefits cannot be explained by post-encoding rehearsal

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Introduction

Memory consolidation refers to the active processes which stabilize memory representations after encoding, allowing them to persist over time[1].

Mechanisms underlying memory consolidation, such as replay and reactivation[2,3], can occur immediately after encoding during periods of wakeful rest[4,5,6].

In the context of human research, post-encoding wakeful rest periods could benefit memory consolidation by providing an opportunity for stimulus-related mentation, however, it is not clear if this is driven by spontaneous or intentional rehearsal processes.

In parallel, the benefits of reward incentives on memory have been shown to be strengthened after periods of consolidation[7]; however these benefits may also be driven by post-encoding rehearsal.

To dissociate memory-related effects of rehearsal strategies during post-encoding periods we used monetary rewards to incentivize post-encoding rehearsal.

This study aims to characterize the relationship between reward-memory benefits and post-encoding rehearsal.

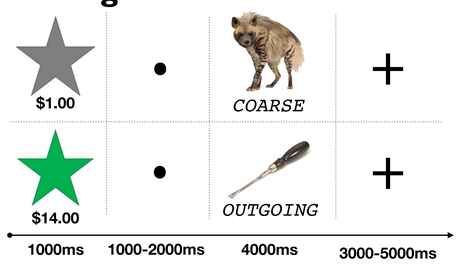
Task design

Session 1: Encoding

Across rest and rehearsal groups, participants performed 120 trials creating associations for trial-unique image and word pairs.

Successful subsequent memory for high reward trials worked towards a $14 bonus, whereas low reward trials worked towards a $1 bonus.

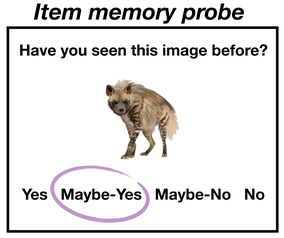
Reward conditions (60 high & 60 low) were distinctly associated with a category of images (animal or tool), and were counterbalanced across groups (rehearsal & rest).



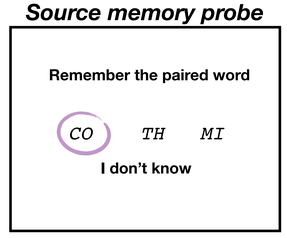
Session 2: *Non-Incentivized* Retrieval

Participants performed 240 trials subdivided as 120 images from encoding plus 120 foils for high and low categories.

Item memory probe



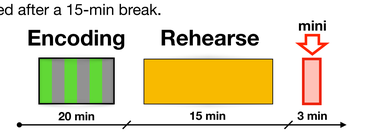
Source memory probe



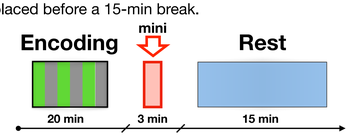
Study design

Session 1: To manipulate rehearsal we introduced a ***mini-incentivized retrieval*** which "determined the amount of money the participant would earn".

Rehearse group: Participants were incentivized to rehearse if the test was placed after a 15-min break.



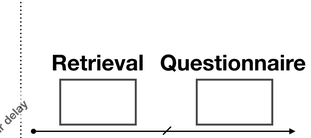
Rest group: Participants were not incentivized to rehearse when the test was placed before a 15-min break.



24-hour delay

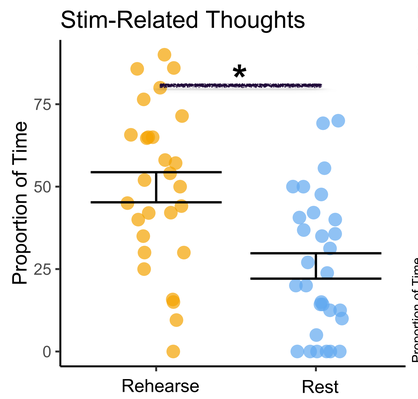
Session 2:

Participants performed a surprise non-incentivized retrieval test.



After the experiment participants completed a questionnaire characterizing thought content.

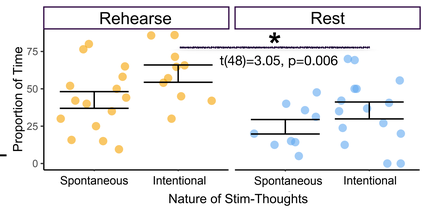
Validation of rehearsal manipulation



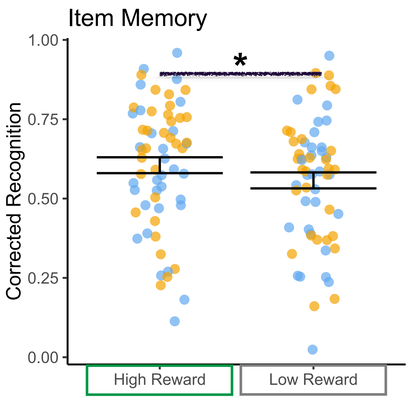
Participants completed a self-report questionnaire[8] that queried the amount of time during the post-encoding period in which their thoughts were related to items used in the task, personal experiences, etc…

Proportion of stimulus-related thoughts was significantly greater for *rehearsal* (M=49.82, SD=24.15) versus *rest* (M=25.95, SD=21.07) group.

t(52)=3.99, p<0.001



Reward-memory benefits are equivalent across groups

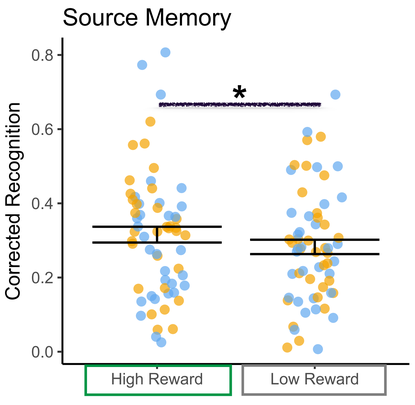


*Item and source memory are calculated as corrected recognition (hits – false alarms)

High-reward items were better remembered than low-reward items.
df=1, *F*-value=5.3 p=0.025*

There were no significant differences in overall memory across groups.
p=0.32, BF=0.4

There were no differences in reward memory benefits across groups.
p=0.72, BF=0.2



High-reward items were better remembered than low-reward items.
df=1 *F*-value=5.5 p=0.02*

There were no significant differences in overall memory across groups.
p=0.93, BF=0.19

There were no differences in reward memory benefits across groups.
p=0.51, *BF=0.07*

Together, these findings suggest that reward significantly enhances both item and source memory.

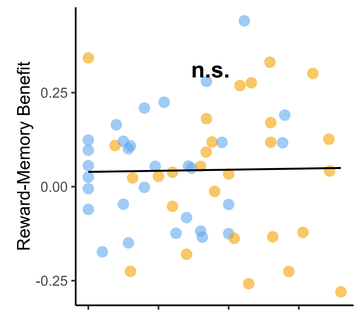
However, there were no differences in these enhancements across groups, suggesting that rehearsal is insufficient to explain 24-hour reward memory benefits.

Self-reported stimulus-mentation is not related to reward-memory benefits

Some participants in the rest condition self-reported "thinking about the stimuli" during the 15-min break, therefore we conducted an individual difference analysis to confirm there are no significant group differences for rest vs rehearsal.

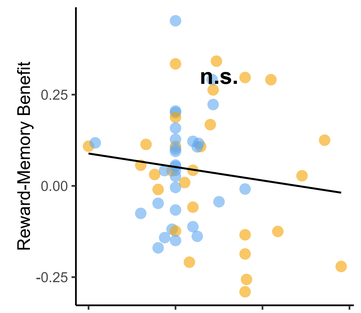
Across groups, the proportion of time thinking about stimuli during the post-encoding period is not related to reward-memory benefits.

t(1,47)=1.02, p=0.32



Across groups, the proportion of time thinking about **high-reward items** during the post-encoding period is not related to reward-memory benefits.

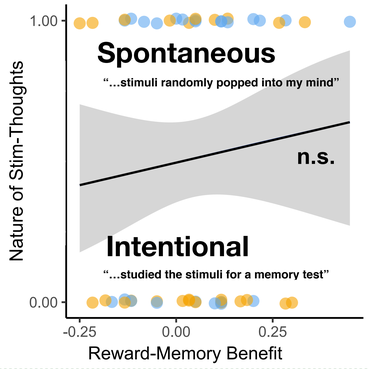
t(1,47)= -0.51, p=0.61



*Reward-memory benefit is calculated as (high-low item memory) for each participant

*we also see this non-significant pattern with source memory

Nature of stimulus-related thoughts do not influence reward memory benefits



Participants who self-reported stimulus-related thoughts during the post-encoding rest were further asked if such thoughts were spontaneous or intentional.

A binary logistic regression shows that the relationship between the nature of stimulus-related thought and experimental group was non-significant.

z(47) = 0.71, p=0.48

*we also see this non-significant pattern with source memory

Discussion

Congruent with prior work showing that the benefits of rest on memory do not appear to be driven by rehearsal[8,9,10], reward memory benefits are not influenced by post-encoding rehearsal.

Endogenous processes that occur during post-encoding rest periods are sufficient for reward-related memory consolidation effects.

Future work using neuroimaging can investigate how rehearsal influences neural markers of reactivation.

References 1.McClelland et al. 1995, Psychol Rev. 2.Sutherland & McNaughton, 2000, Current Opinion in Neurobio. 3.Rasch & Born 2007, Science. 4.Karlsson & Frank 2009, Nat Neurosci. 5.Diba & Buzsaki, 2007, Nat Neurosci. 6.Peigneux et al. 2006, PLoS Biology. 7.Murty, Adcock et al. 2017, JNeuro. 8.Brokaw et al. 2016, Neurobio of Learning and Mem. 9.Dewar et al. 2014, PLoS One. 10.Craig et al. 2015, 2016, 2018, 2019.