Enhancing object-location associative memory through reward

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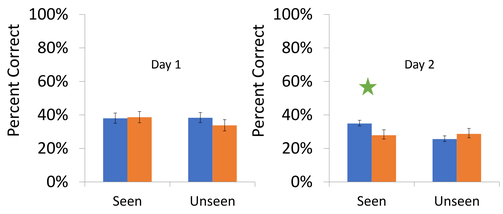
Introduction

- The influence of dopamine on memory in the medial temporal lobe has been linked to enhanced memory consolidation for stimuli associated with reward.[1]
- Reward can not only strengthen memory consolidation for a conditioned stimulus but also for unconditioned-associated stimuli.[2]
- This effect of reward on memory association has been observed only after a delay in testing, [3] which seems to further support the involvement of a slower, longer lasting mechanism affecting consolidation.
- Furthermore, reward can retroactively enhance memory for stimuli-background associations.[4] Therefore, we hypothesize that reward can strengthen memory not only for object-spatial position associations, but also for unconditioned semantically-related location-stimuli pairings.

Results

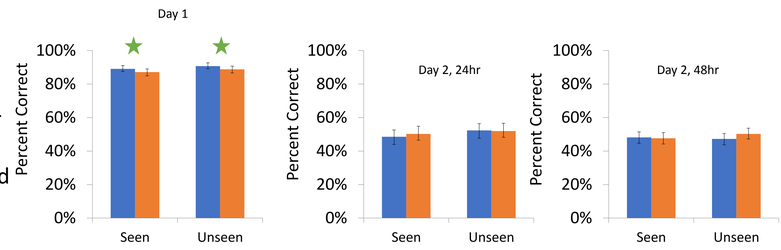
Experiment 1
- N = 31
- No reward effect on Day 1
- 97.5% high reward success
- 97.6% low reward success

Experiment 2
- N = 20
- Reward led to better memory on Day 2
- Poor memory overall
  - Tests at end of session
- 99.2% high reward success
- 99.2% low reward success

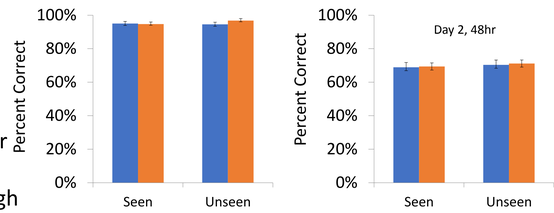


Significant Reward Effects Summary
- Experiment 2, Delayed memory improved
- Experiment 3, Immediate memory improved
- Many null results

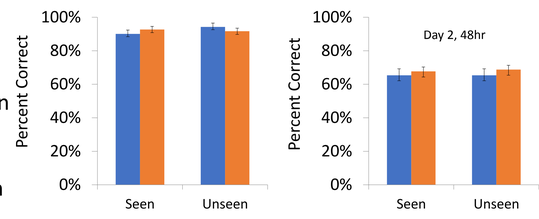
Experiment 3
- N = 51
  - 24 hr, n=20
  - 48 hr, n=29
- Reward led to better memory on Day 1
  - 83.5% high reward success
- No effects on Day 2
  - Either delay



Experiment 4
- N = 26
- No reward effects on yes/no recognition test for location
  - 88% average high reward success



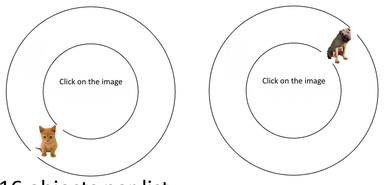
Experiment 5
- N = 16
- No reward effects on yes/no recognition test for location
  - 91% average high reward success



Methods

Study

Remember the location of each object



- 16 objects per list
  - Experiments 1 & 2
- 8 objects per list
  - Experiments 3-5
- Objects split between two categories
- Each in a unique location
- Each image shown for 3s
- Studied twice
  - Experiments 3-5

Session Structure

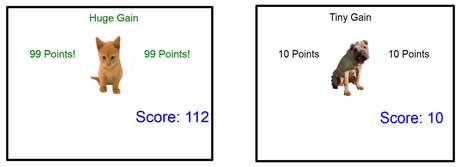
- 12 lists (All experiments)
- Retest at 24 (Experiment 3) or 48 (Experiments 2-5) hours later, ±6 hours

Reward

Earn points!

High Reward: Wait exactly 3s Then click

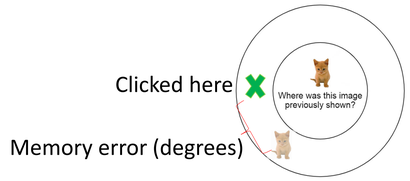
Low Reward: Watch for 3s



- Rapid response with surprise points: Exp 1 and 2
  - Click image quickly within 4x4 grid
  - High/low point values by category
- Delay Estimation Task (shown): Exp 3, 4, 5
  - Correct response (within ±250ms) = [80-100] points
  - For Experiment 5, images were presented in their studied location (not central)
  - Control task = [5-15] points
  - High/low reward task were by category
- Half the studied stimuli were rewarded
  - Half unseen
  - Experiments 1-2 included an additional half of non-studied, semantically related stimuli

Memory Location Test

Where was this object studied?



- If error was < 45 degrees, trial scored correct (Experiments 1, 2, 3)
- For Experiments 1, all stimuli tested at end of session
- For Experiment 2, half of the stimuli tested end of Session 1, half on Session 2
- For Experiments 4-5, participants made Yes/No response about original study location

Example protocol for one list
- Participants saw 8 cats and 8 dogs at unique locations
- During reward, 4 cats shown with high-reward task
  - 4 dogs with low-reward
  - The rest unseen
- All 16 images tested for location recall
  - Done with this list for the day
- 48hr later all 16 images tested again

Conclusion

- We found slightly greater immediate memory for object-location pairs associated with high reward (Exp 3). This modest effect also carried over to memory for pairings of semantically-associated object-locations.
- We also found an enhanced memory effect that persisted to the delayed testing session for object-location memory associated with high reward (Exp 2)
  - But did not occur for stimuli semantically-associated with the rewarded category[2]
  - Better reward salience may be important for this effect
- Recognition tests for object-location associations did not appear to be affected by reward (Exp 4, 5) even though recognition tests have been effective in prior research. [1 3 4]

References

(1) Murayama K. & Kitagami, S. (2014). Consolidation power of extrinsic rewards: Reward cues enhance long-term memory for irrelevant past events. *Journal of Experimental Psychology: General, 143 (1),* 15-20.
(2) Miendlarzewska, E., Bavelier, D. Schwartz, S. (2016). Influence of reward motivation on human declarative memory. *Neuroscience and Biobehavioral Reviews, 61*, 156-176.
(3) Patil, A., Murty, V. P., Dunsmoor, J. E., Phelps, E. A. (2017). Reward retroactively enhances memory consolidation for related items. *Learning & Memory, 24,* 65-69
(4) Gruber M., et al. (2016) Post-learning hippocampal dynamics promote preferential retention of rewarding events. *Neuron, 89,* 1110-1120.