Human hippocampus forms abstract, pattern separated representations of motivational context during encoding

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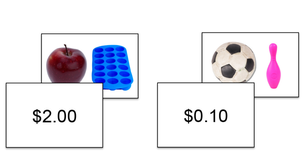
Motivation influences memory

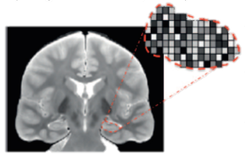
- **Monetary incentive task**: Reward-based motivation enhances memory for stimuli associated with potential future rewards (Adcock et al., 2006; Wolosin et al., 2012)

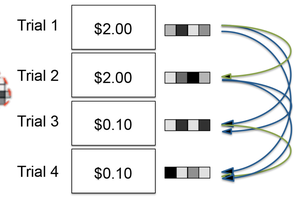


- Reward cues increase activation in dopaminergic midbrain and modulate **hippocampal** and medial temporal lobe (MTL) function (Adcock et al., 2006; Kuhl et al., 2010; Wittman et al., 2005)

- Distributed hippocampal and MTL codes differentiate reward cues (Wolosin, Zeithamova, Preston, 2013), suggesting that **motivational context** is incorporated into memories (Shohamy & Adcock, 2010; Wolosin, Zeithamova, Preston, 2012)

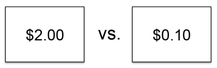
Pattern similarity analysis
(Kriegeskorte et al., 2008)





reward representation =
same reward trials similarity > different reward trials similarity

- **Reward representation?**
  Reward value always confounded with visual appearance of the cue

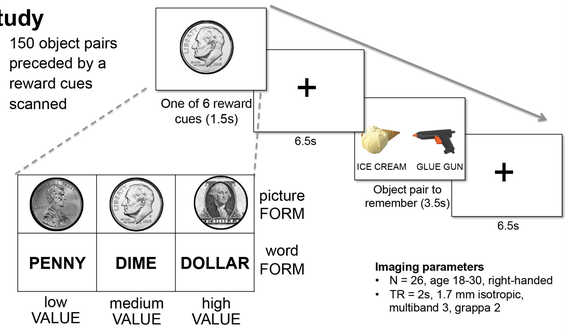


Does reward representation in hippocampus reflect abstract reward value or the specific reward cue?

Modified monetary incentive task

Study

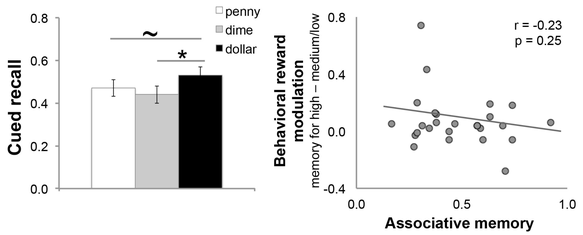
- 150 object pairs preceded by a reward cues
- scanned



Imaging parameters
- N = 26, age 18-30, right-handed
- TR = 2s, 1.7 mm isotropic, multiband 3, grappa 2

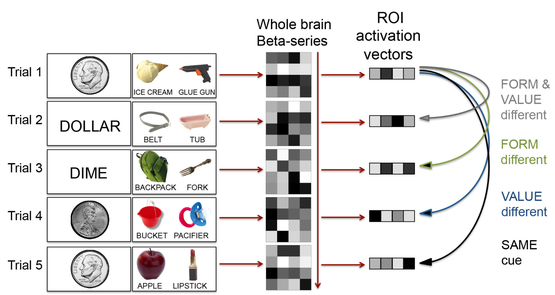
Cued recall test

- not scanned

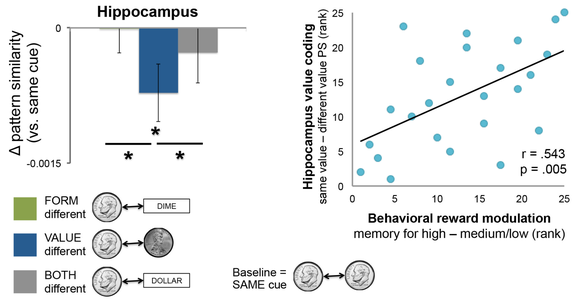


- High value pairs remembered better than other pairs
- Individual differences in the degree of behavioral reward modulation, not related to overall performance

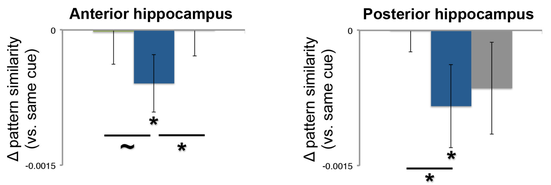
fMRI pattern similarity analysis



Pattern separation in Hippocampus

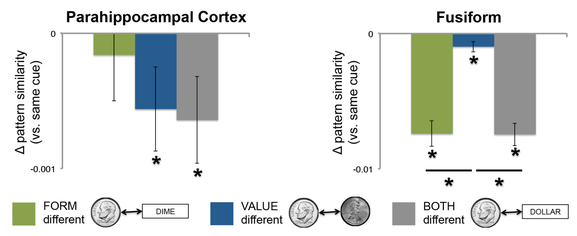


- Same value cue represented similarly, irrespective of visual form
- Different value cues are less similar, especially for same visual form
- Value representation tracks individual differences in behavioral reward modulation



- Two forms of pattern separation in the hippocampus:
  - Posterior: Separation based on value
  - Anterior: Only visually similar cues of different value are pattern separated (non-monotonic relationship between input and output similarity)

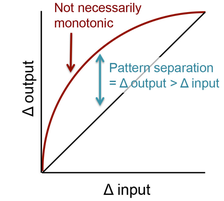
Pattern similarity in control regions



- Parahippocampal cortex (and middle temporal gyrus and inferior frontal cortex) showed sensitivity to value but not non-monotonic pattern
- Fusiform cortex (and lateral occipital cortex) showed greater sensitivity to visual form than value

Conclusions

- Reward-based motivation modulates memory for events, but behavioral sensitivity to reward varies across individuals
- Distributed hippocampal codes reflect **abstract representation** of reward **value**: same value events represented similarly, different values dissimilarly, irrespective of how value is cued
- Hippocampal value representation tracks individual differences in the behavioral sensitivity to reward
- Anterior hippocampus **pattern separates** different value cues only when cues are visually similar - challenges standard view of pattern separation



- Hippocampal context representations go beyond time and space to represent **motivational salience** of events

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Acknowledgments

This work was supported by a National Science Foundation CAREER Award (ARP), NIH-NIMH R01 MH100121-01 (ARP), and NIH-NIMH National Research Service Award F32MH094085 (DZ).