

Introduction

- Pattern separation (PS) is a computational process by which patterns of neuronal activation underlying similar memories are made distinct¹.
- Pattern completion (PC) allows us to recall events from degraded/incomplete cues.
- Mnemonic similarity tasks (MST) where participants discriminate similar stimuli can serve as an index of PS and PC².
- fMRI studies of mean activation during a passive retrieval MST in adults reveal evidence of PS in the DG/CA3, with differential activation for repeated Target stimuli relative to similar Lures and novel Foils and evidence of PC in CA1, with comparable activation for Targets and Lures^{3,4}
- However, mean activation does not provide information on the neural representations underlying PS and PC processes and cannot quantify changes associated with learning.
- The current analyses will go beyond traditional univariate analysis, using local heterogeneity regression⁵, to quantify local differentiation of the neural representations underlying Targets, Lures, and Foils
- We predict greater heterogeneity in DG/CA3 for Targets relative to Lures and Foils and greater heterogeneity for Targets and Lures relative to Foils in CA1. We also predict that individual variability in behaviorally discriminating between Targets and Lures will be related to the Target>Lure heterogeneity measure

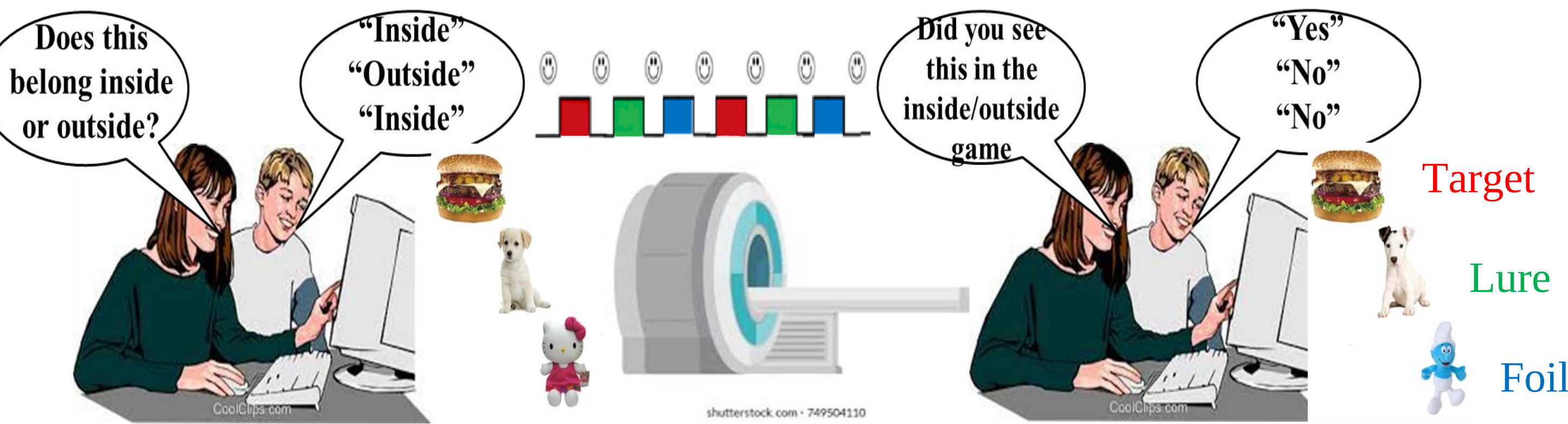
Methods

Participants

- 37 adults (18 – 28 years; M = 23.41 ± 2.98 years) recruited from a metropolitan area

Design

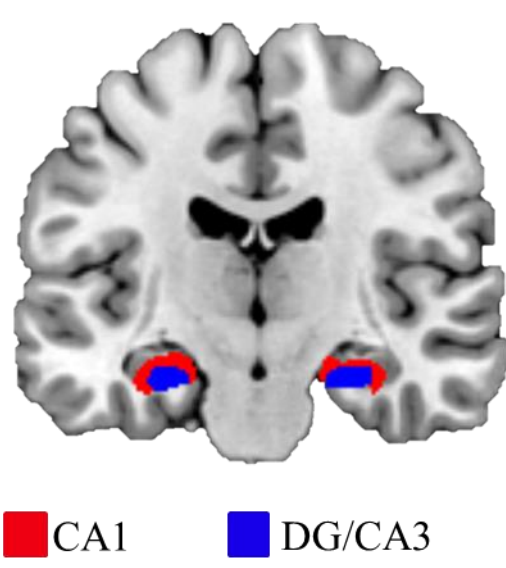
Figure 1. Task Design:



- **Target** = picture seen at encoding
- **Lure** = picture similar to Target, but not seen at encoding
- **Foil** = new picture not seen at encoding

MRI Data Preprocessing

- Image preprocessing in SPM12⁶
- Local-Hreg performed on un-smoothed, pre-processed, MNI normalized data.
- Contrasts built to compare heterogeneity measure for the different task conditions (Targets > Lures, Targets > Foils, Lures > Foils).
- Heterogeneity estimates extracted from CA3/DG and CA1 hippocampal subfield masks
- Greater heterogeneity associated with better learned neural representation



Behavioral Measures

Behavioral: Lure Discrimination Index (LDI) = Target Hits – Lure False Alarms (“Yes” Response to Targets – “Yes” Response to Lure)

Results

Are there representation quality differences between Targets, Lures, and Foils?

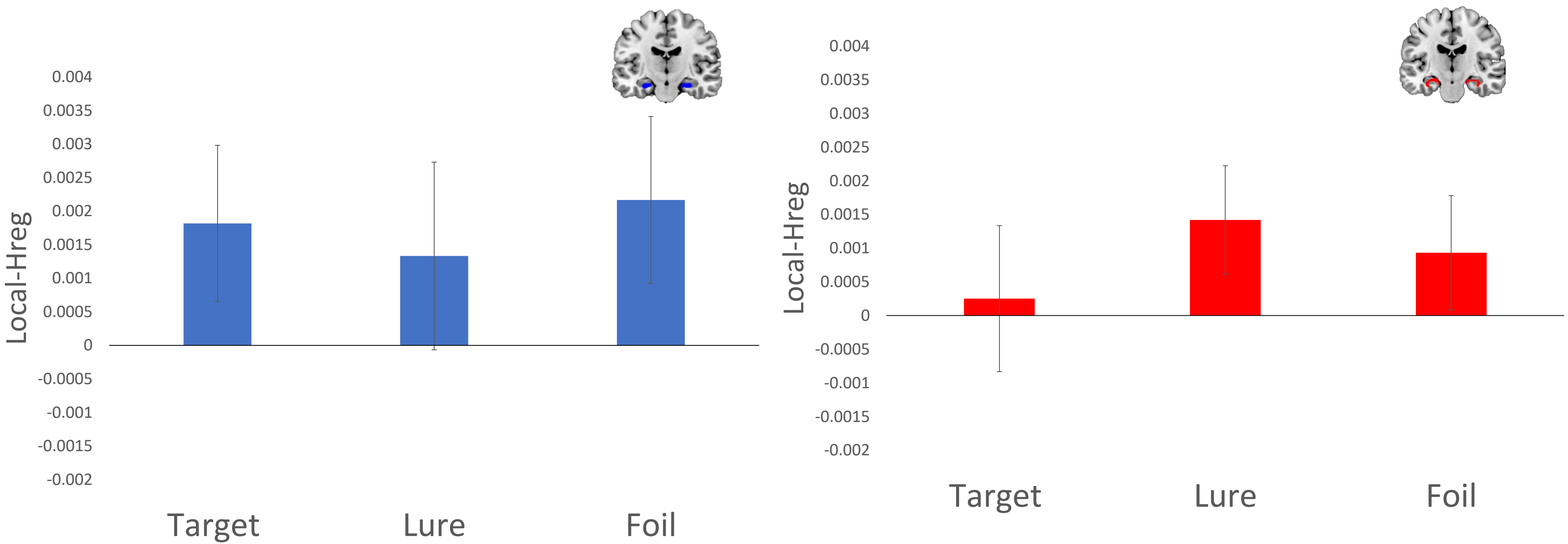
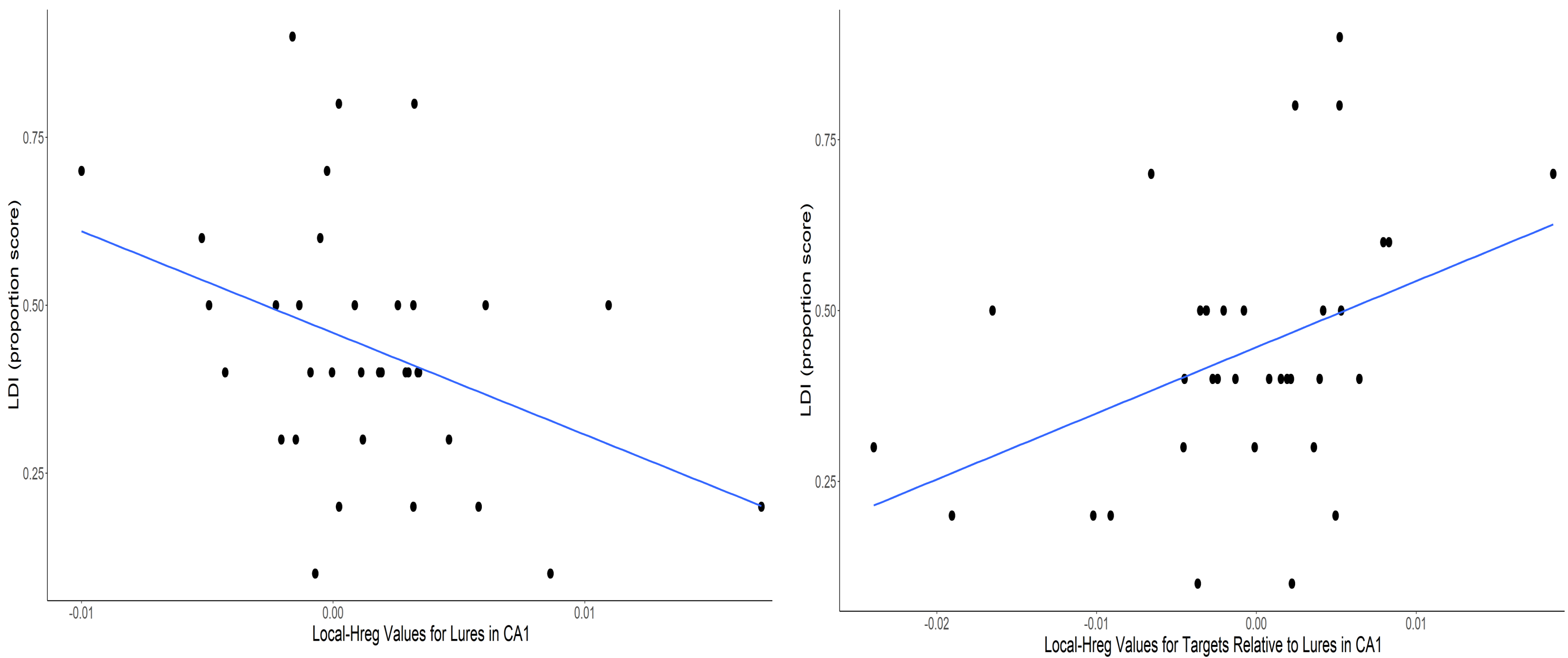


Figure 1. Local-Hreg values in DG/CA3 and CA1 ROIs for conditions of interest against baseline – Targets, Lures, and Foils

- ROI analyses revealed no significant differential activation for Targets, Lures, and Foils

Do measures of local differentiation relate to out-of-scanner behavioral performance?



- Local-Hreg values for Lures in CA1 were negatively associated with LDI performance ($\beta = -15.14$, $t = -2.36$, $p = .0244$) and differential Local-Hreg values for Targets relative to Lures in CA1 was positively associated with LDI performance ($\beta = 9.67$, $t = 2.57$, $p = .015$)
- Differential Local-Hreg values for Targets relative to Foils in CA1 was marginally positively associated with LDI performance ($p = .05$)

Discussion

- There was no evidence of representation quality differences between Targets, Lures, and Foils in CA1 or DG/CA3
- This could be because heterogeneity values were extracted from the whole ROIs, which includes voxels that were not active for the task
- This makes interpretation of brain-behavior relations difficult

Future Directions

- Extract heterogeneity values from only task-active voxels within the hippocampal subfield ROIs
- Quantify representation quality differences between Targets, Lures, and Foils in a child sample
- Investigate whether Local-Hreg values predict outside-of-scanner behavioral performance in a child sample
- Extend analyses to parahippocampal gyrus and cortical regions, such as dorsal medial PFC, which are also implicated in pattern separation processes

References

1. Norman, K. A., & O'Reilly, R. C. (2003). Modeling hippocampal and neocortical contributions to recognition memory: a complementary-learning-systems approach. *Psychological review*, 110(4), 611.
2. Yassa, M. A., & Stark, C. E. (2011). Pattern separation in the hippocampus. *Trends in neurosciences*, 34(10), 515-525.
3. Lacy, J. W., Yassa, M. A., Stark, S. M., Muftuler, L. T., & Stark, C. E. (2011). Distinct pattern separation related transfer functions in human CA3/dentate and CA1 revealed using high-resolution fMRI and variable mnemonic similarity. *Learning & memory*, 18(1), 15-18.
4. Bakker, A., Kirwan, C. B., Miller, M., & Stark, C. E. (2008). Pattern separation in the human hippocampal CA3 and dentate gyrus. *science*, 319(5870), 1640-1642.
5. Purcell, J. J., & Rapp, B. (2018). Local response heterogeneity indexes experience-based neural differentiation in reading. *Neuroimage*, 183, 200-211.
6. Ashburner, J., Barnes, G., Chen, C. C., Daunizeau, J., Flandin, G., Friston, K., ... & Penny, W. (2014). SPM12 manual. Wellcome Trust Centre for Neuroimaging, London, UK, 2464(4).

Acknowledgments

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