

Enhanced neural reinstatement and memory for naturalistic episodes following hippocampal-targeted noninvasive stimulation



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Background

- Episodic memory depends on widespread network of regions including hippocampus and posterior parietal lobe
- Transcranial magnetic stimulation (TMS) of lateral parietal regions with high functional connectivity to hippocampus can alter episodic memory and its neural correlates¹
 - Stimulation-induced improvements in paired-associates, word-list, spatial precision tests of episodic memory^{2,3,4}
 - Associated improvements in resting state functional connectivity
- Currently unclear whether effects of hippocampal-targeted stimulation generalize to more naturalistic forms of episodic memory, which involve distinct neural mechanisms⁵
 - Parietal stimulation has been shown to alter autobiographical memory^{6,7}, but findings are inconsistent perhaps due to lack of control
- Effects of stimulation on memory-related neural activity unclear
 - Neural reinstatement thought to underlie episodic memory

Present Study

Current study investigated effects of hippocampal-targeted parietal stimulation on memory for naturalistic video-clip episodes.

- Does hippocampal-targeted stimulation affect memory for naturalistic, complex events?
- What are the effects of hippocampal network-targeted stimulation on large-scale, multivariate memory-related neural activity?

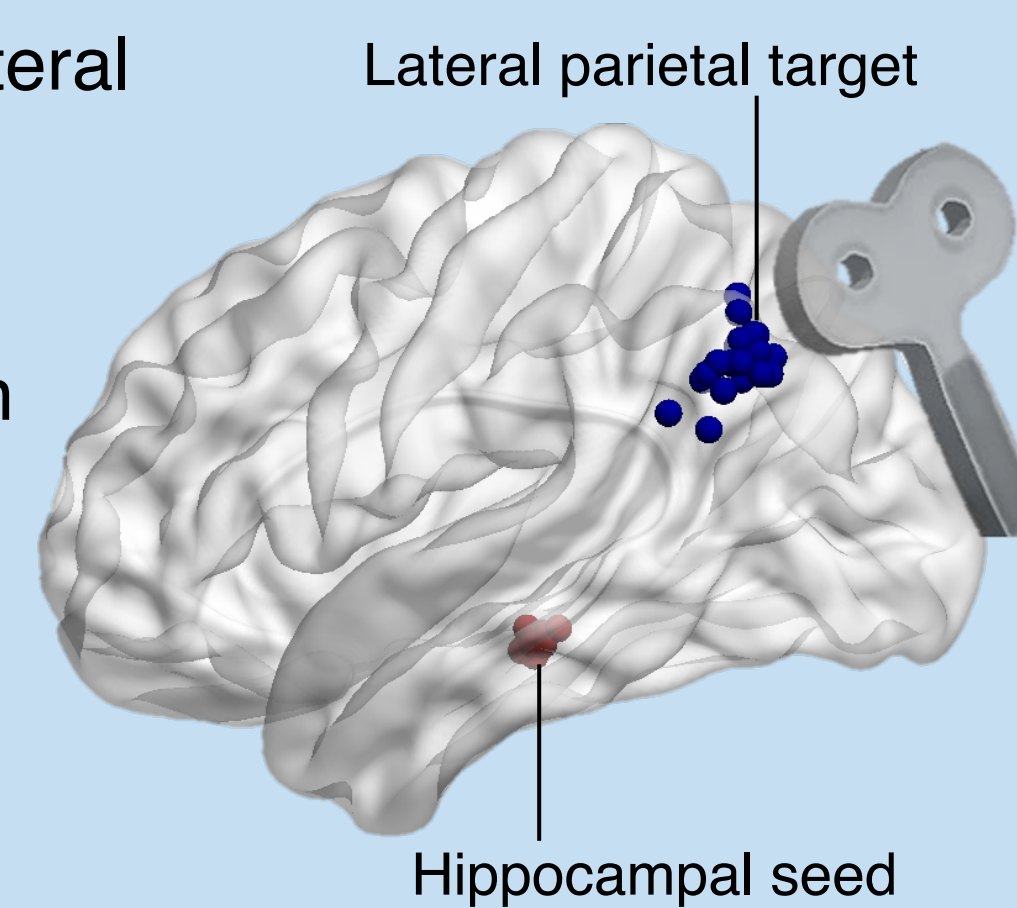
Methods

Study design

- 40s of TMS immediately followed by 45 min episodic memory task with fMRI (n=20)

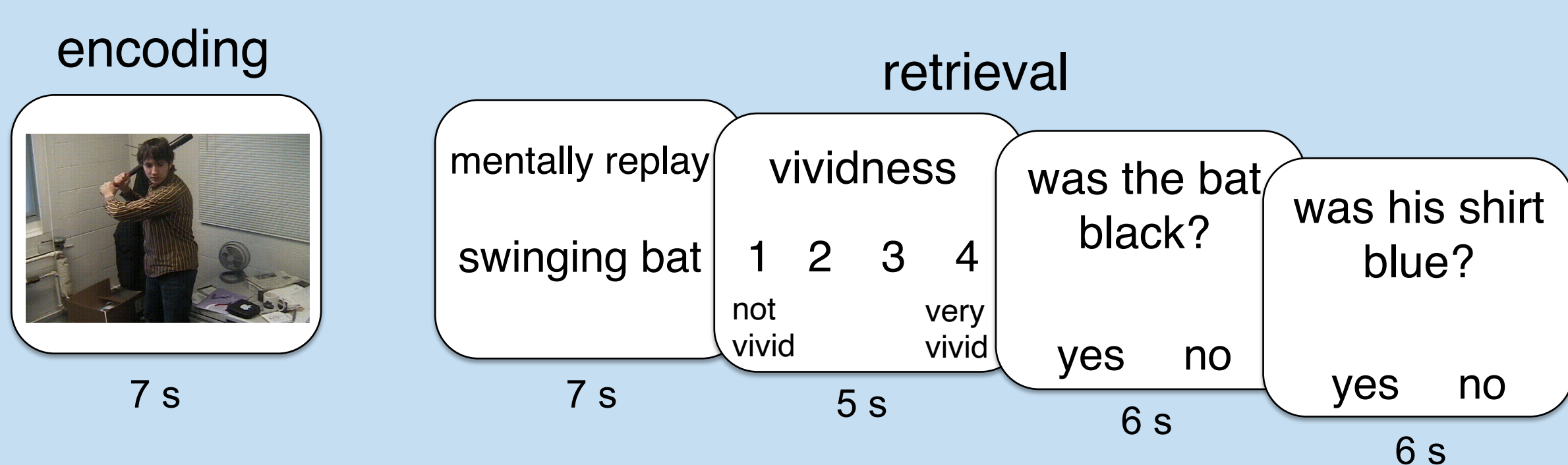
TMS methods

- Active stimulation:** subject-specific lateral parietal target with high functional connectivity to hippocampus
- Control stimulation:** vertex stimulation (low connectivity to hippocampus)
- Continuous theta burst stimulation (cTBS) – bursts of 3 50 Hz pulses delivered at 5 Hz

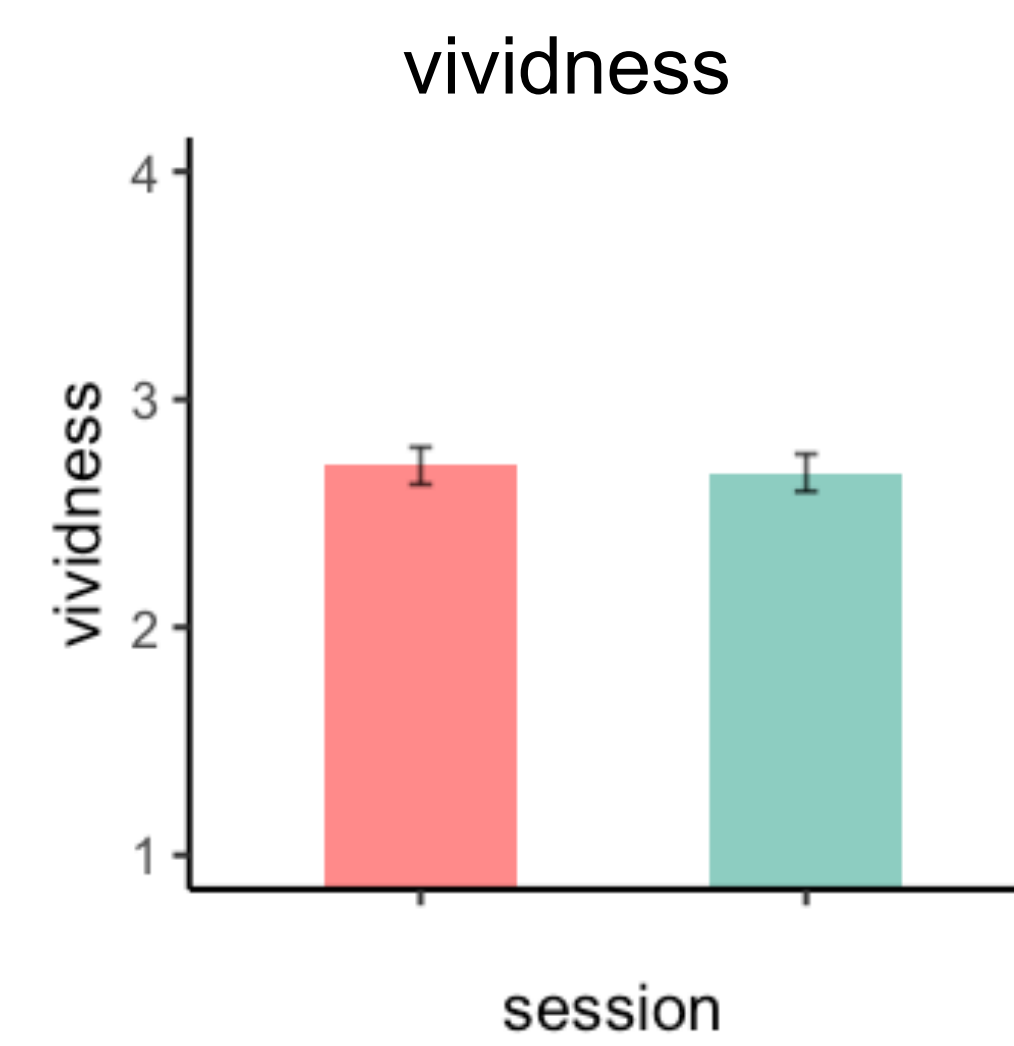
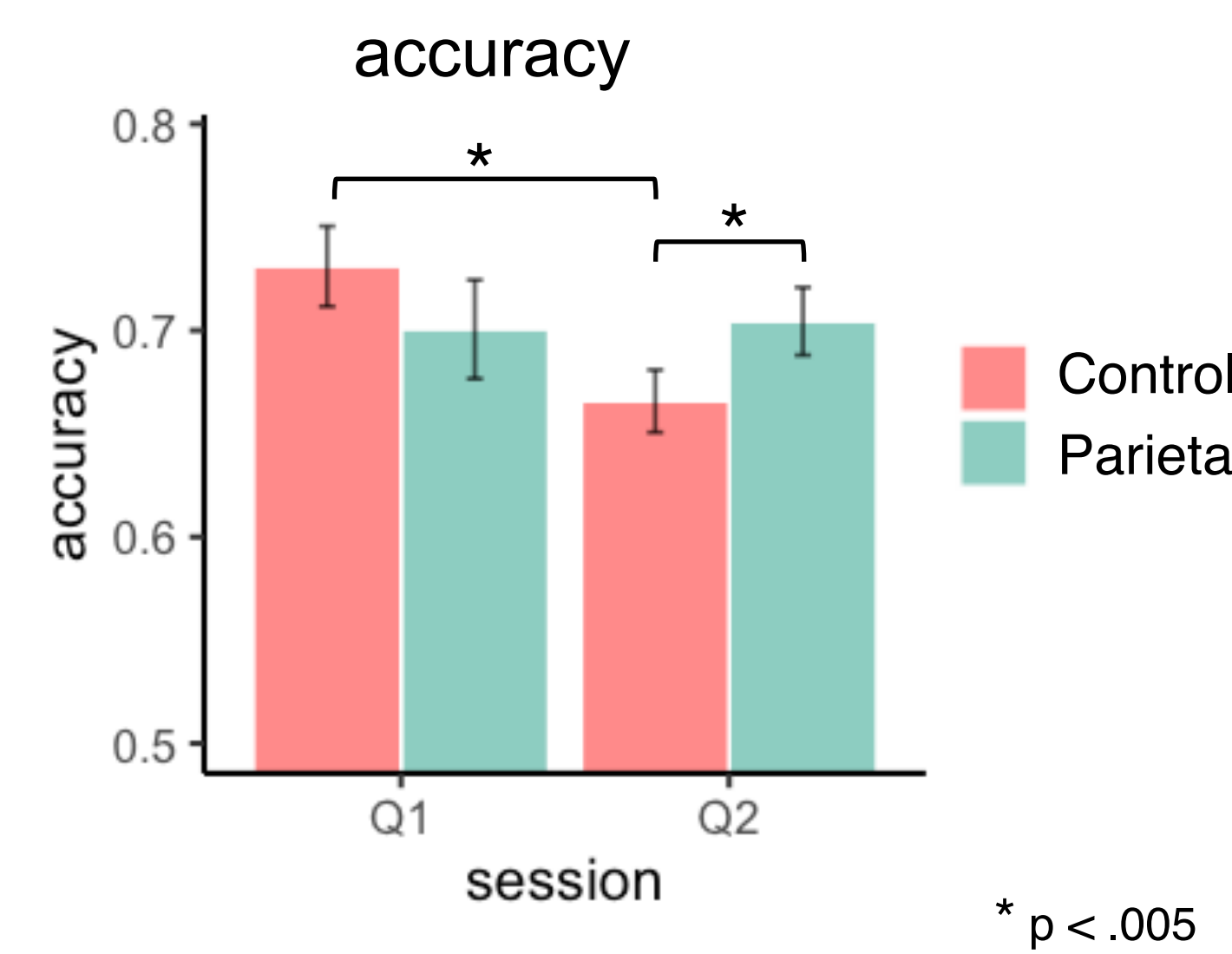


Episodic memory task

- Encoding: 50 short videos depicting everyday events per session
- Retrieval: subjective and objective memory measures



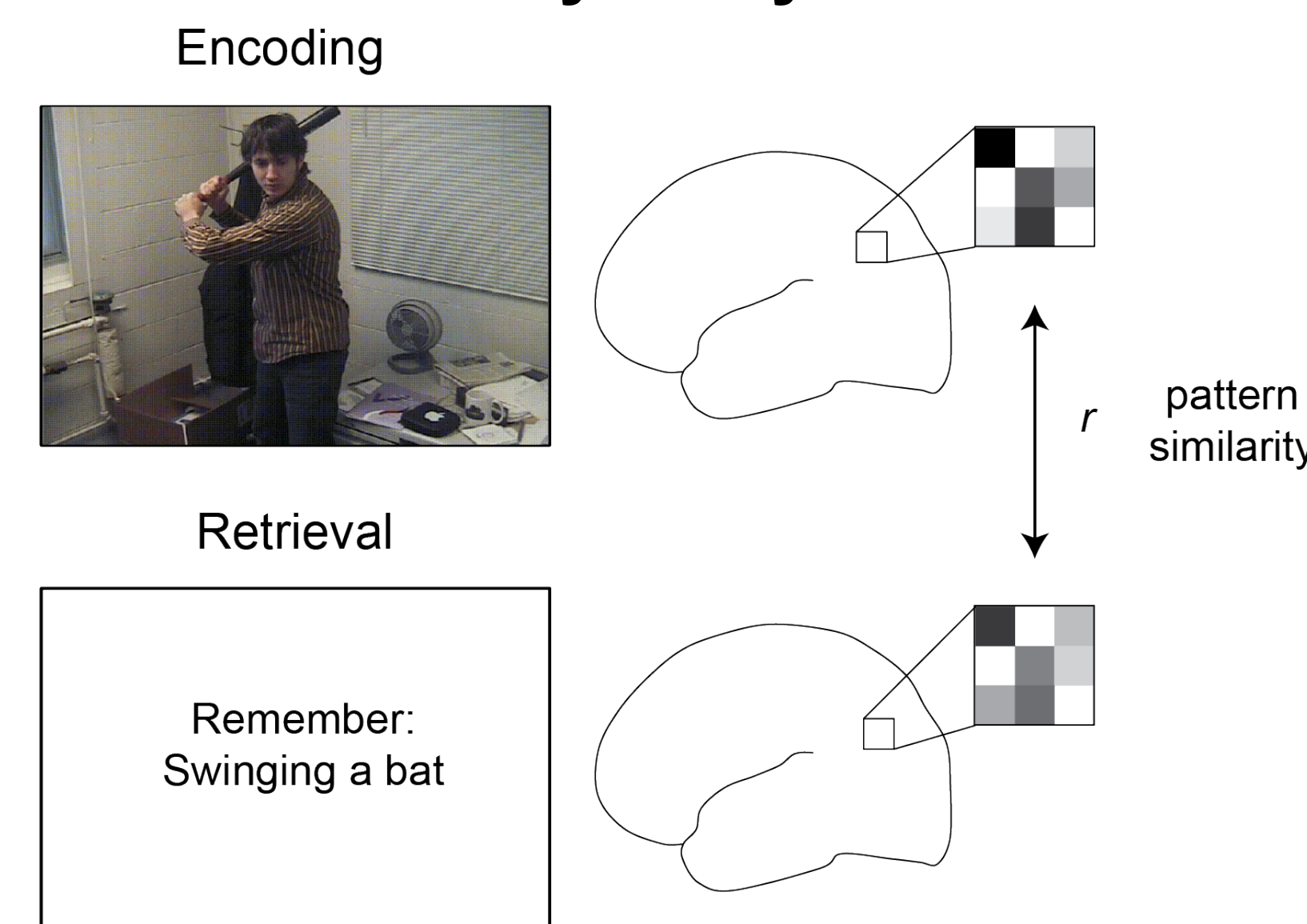
Behavioral Results



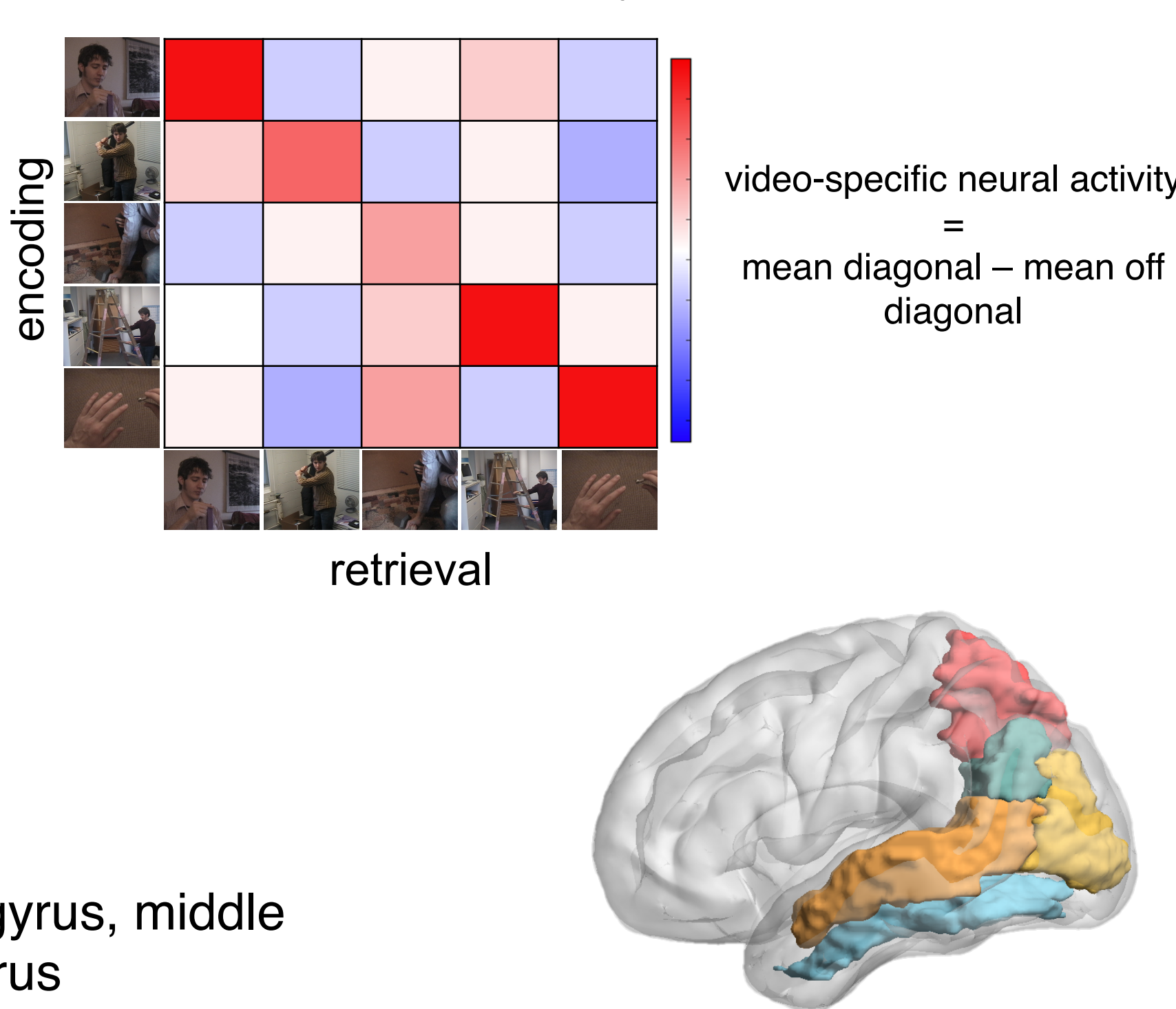
- Parietal stimulation improves objective memory accuracy on the second question ($p < .005$) but not the first ($p > .05$)
- Accuracy on the second question is worse than on the first for control stim, but not for parietal stim
 - May reflect interference, rescued by parietal stimulation
- No effect of stimulation on subjective vividness ($p > .05$)

Neural Reinstatement

Pattern similarity analysis



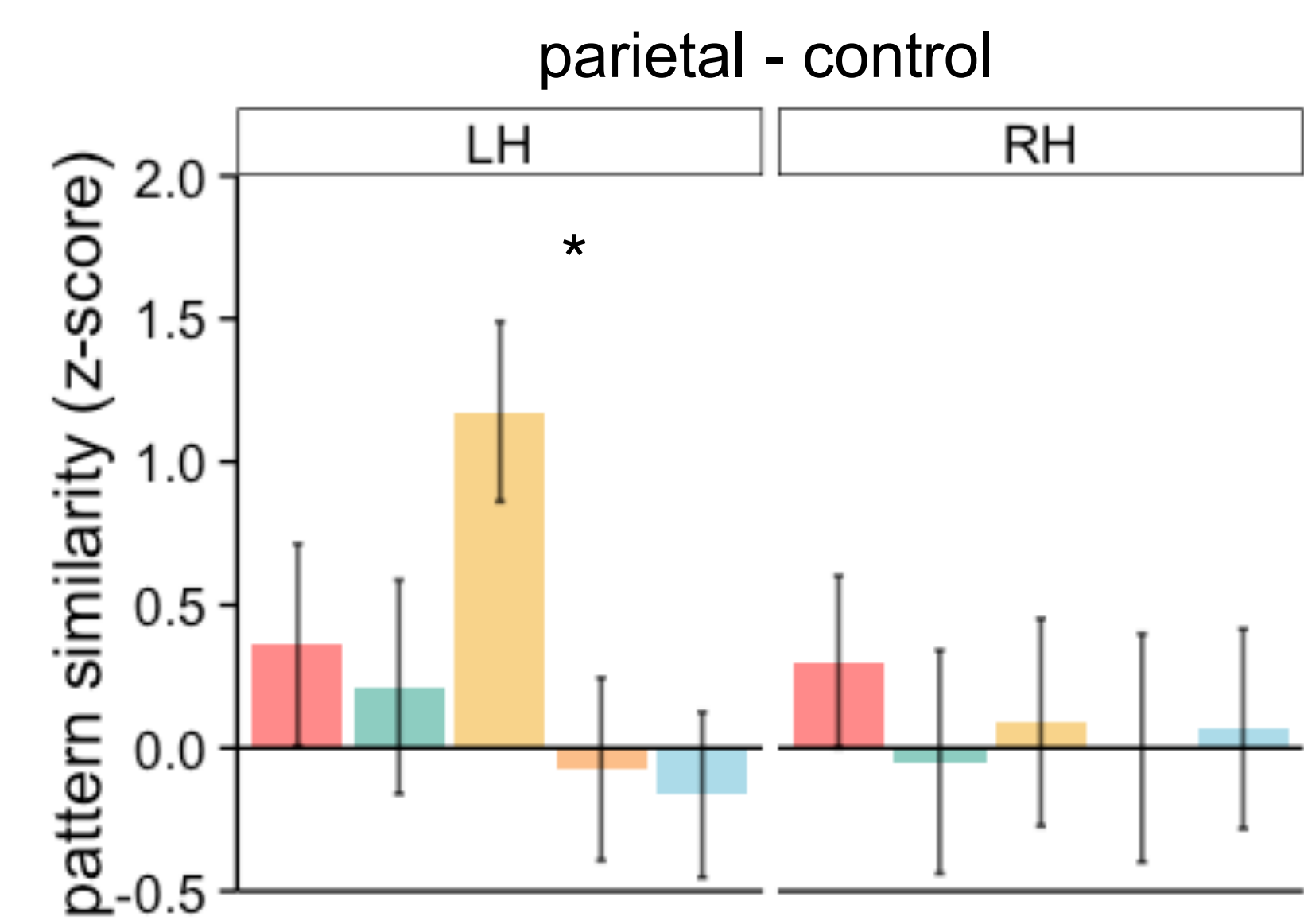
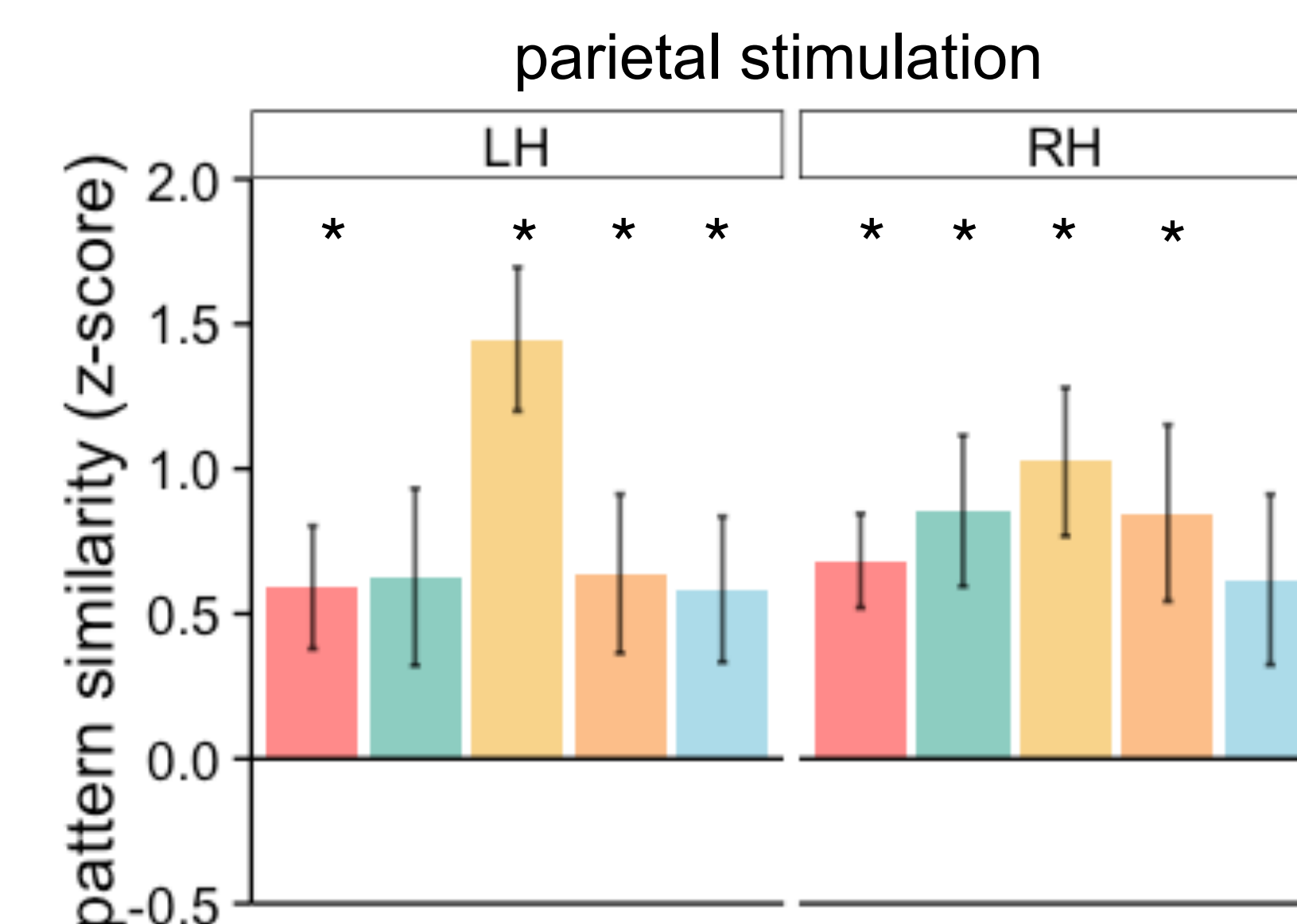
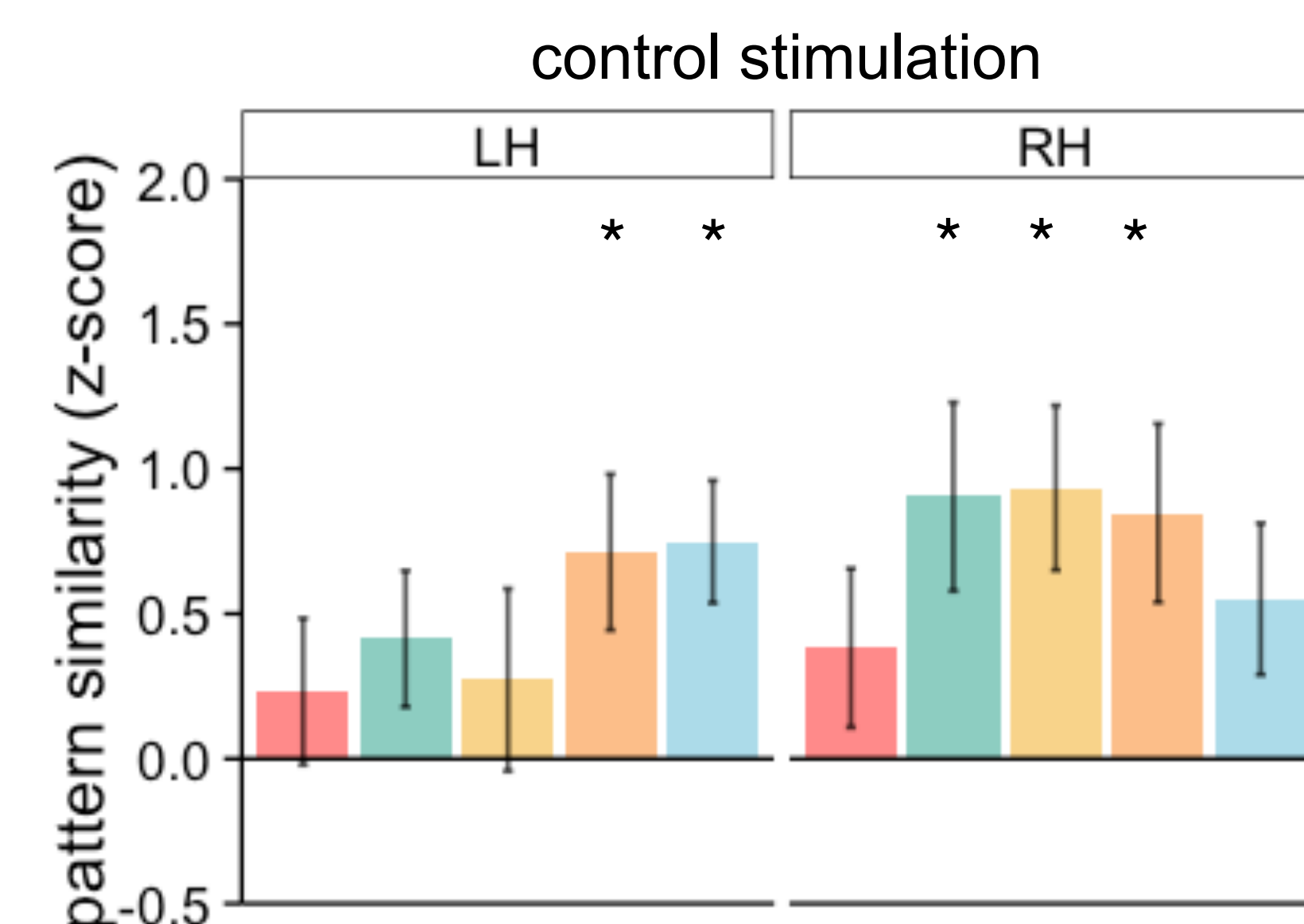
Example pattern similarity matrix



Regions of interest (ROIs)

- 5 bilateral regions of interest: precuneus, angular gyrus, middle occipital gyrus, middle temporal gyrus, fusiform gyrus

Pattern similarity results



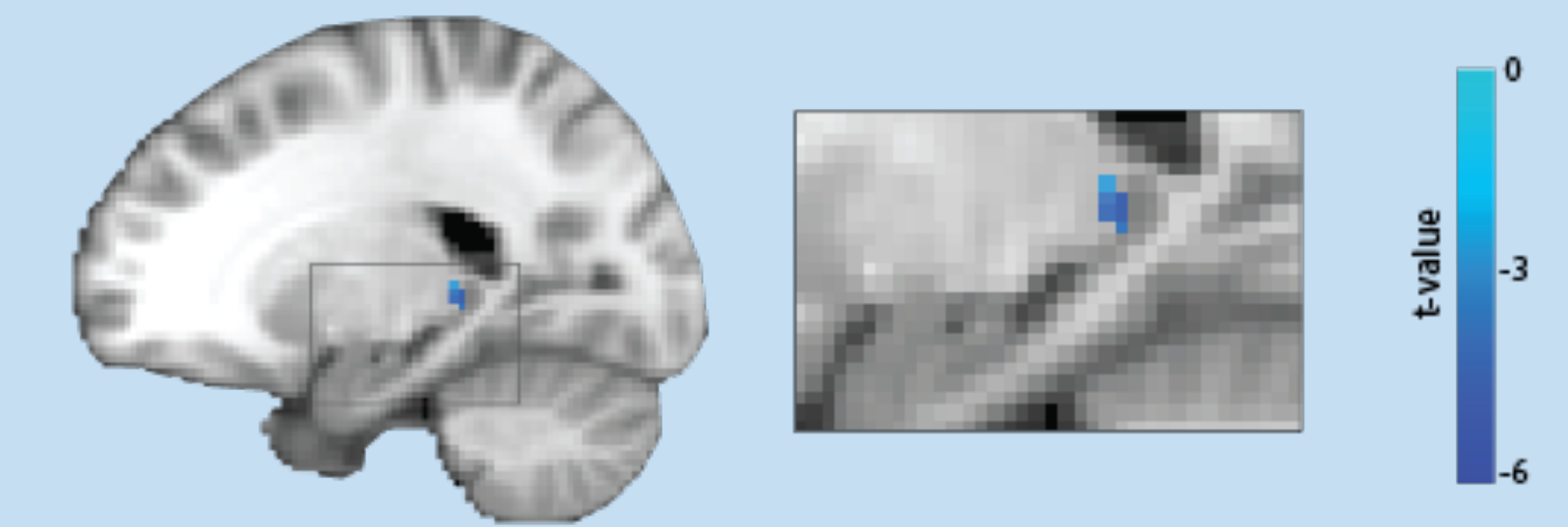
- Precuneus
- Angular gyrus
- Mid. Occipital gyrus
- Mid. Temporal gyrus
- Fusiform gyrus

- Posterior parietal and occipital regions show reinstatement of video-specific multivariate patterns of neural activity
- Parietal stimulation enhances reinstatement in left middle occipital gyrus

* p < .05, corrected for multiple comparisons

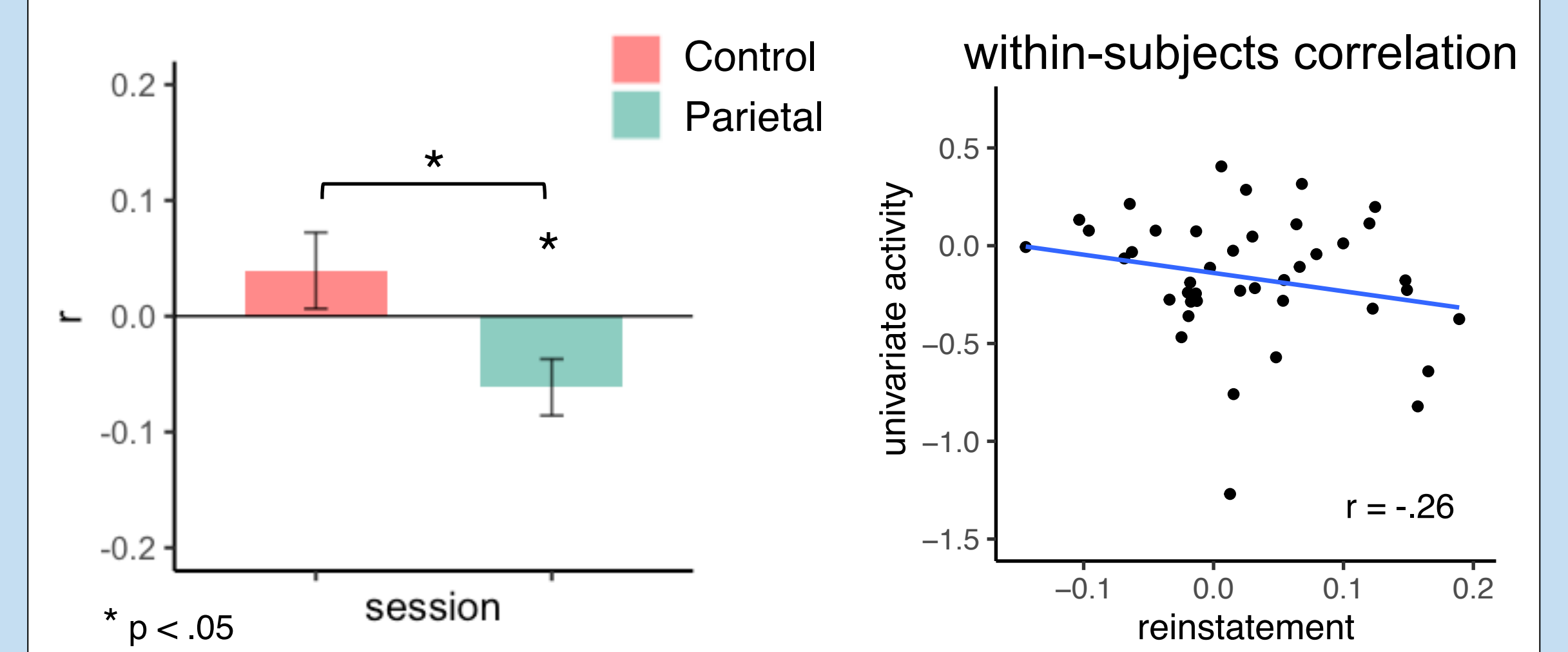
Univariate Results

parietal > control stimulation



- Parietal stimulation leads to decreased left posterior hippocampal activity during memory encoding (cluster corrected threshold $p < .005$)

Correlation between hippocampal activity and reinstatement



- Stimulation leads to a negative within-subject correlation between univariate left posterior hippocampal activity at encoding and reinstatement in left medial occipital gyrus

Conclusions

- Lateral parietal stimulation alters objective but not subjective memory for naturalistic episodes
 - Accuracy improved on the second question only, suggesting reduced interference
- Memory for lifelike events supported by reinstatement of event-specific patterns of neural activity in posterior midline regions
- Lateral parietal stimulation alters reinstatement of event-specific multivariate activity
- Stimulation decreases posterior hippocampal univariate activity during memory encoding
- Stimulation alters within-subject association between univariate hippocampal activity and medial occipital reinstatement
- Hippocampal-targeted stimulation alters large-scale, event-specific multivariate patterns of neural activity and objective memory for naturalistic episodes

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