

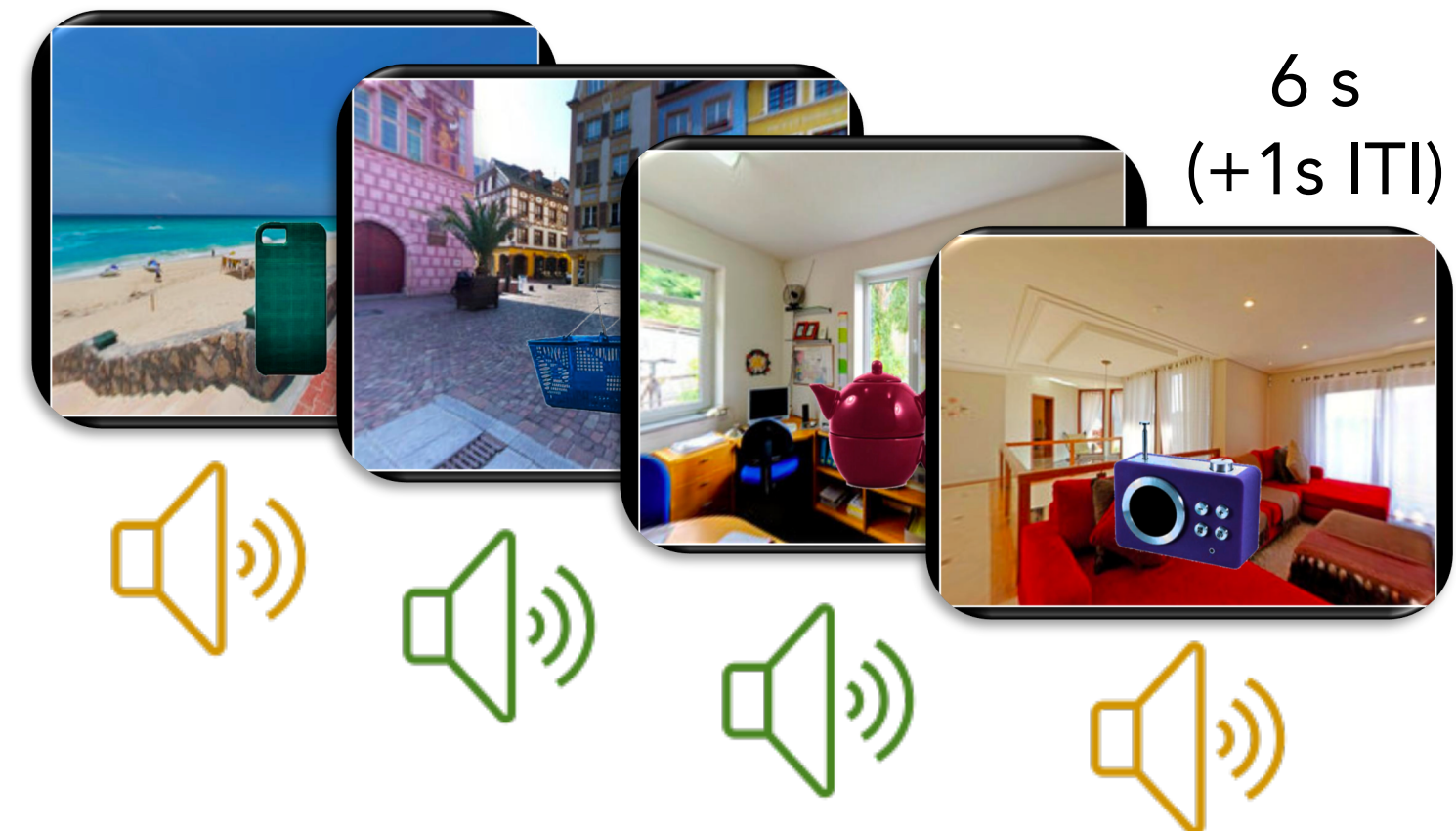
## Background

- Episodic memories contain a wealth of multimodal details – e.g., people, objects, places, sounds – that can be reconstructed with varying degrees of precision. Recent fMRI research has shown that continuous measures of episodic memory quality are correlated with cortico-hippocampal network integration during episodic retrieval<sup>1</sup>.
- However, less is known about the timing of the neural processes supporting the reconstruction of different kinds of memory features. Previous EEG work has shown that memory retrieval is associated with enhancements in theta oscillations and decreases in alpha and beta oscillations<sup>2,3</sup>. Recently, it was shown that alpha desynchronization was related to successful retrieval of memory associations and to activity in the posterior medial cortico-hippocampal network<sup>4</sup>.
- **Here, we ask whether changes in neural oscillations are correlated with the quality of episodic memory, that is, how well multiple memory features are reconstructed.**

## Methods

n = 23 participants with 64-channel BioSemi EEG; 11 additional participants excluded due to data quality (number of “clean” epochs)

### ENCODING PHASE



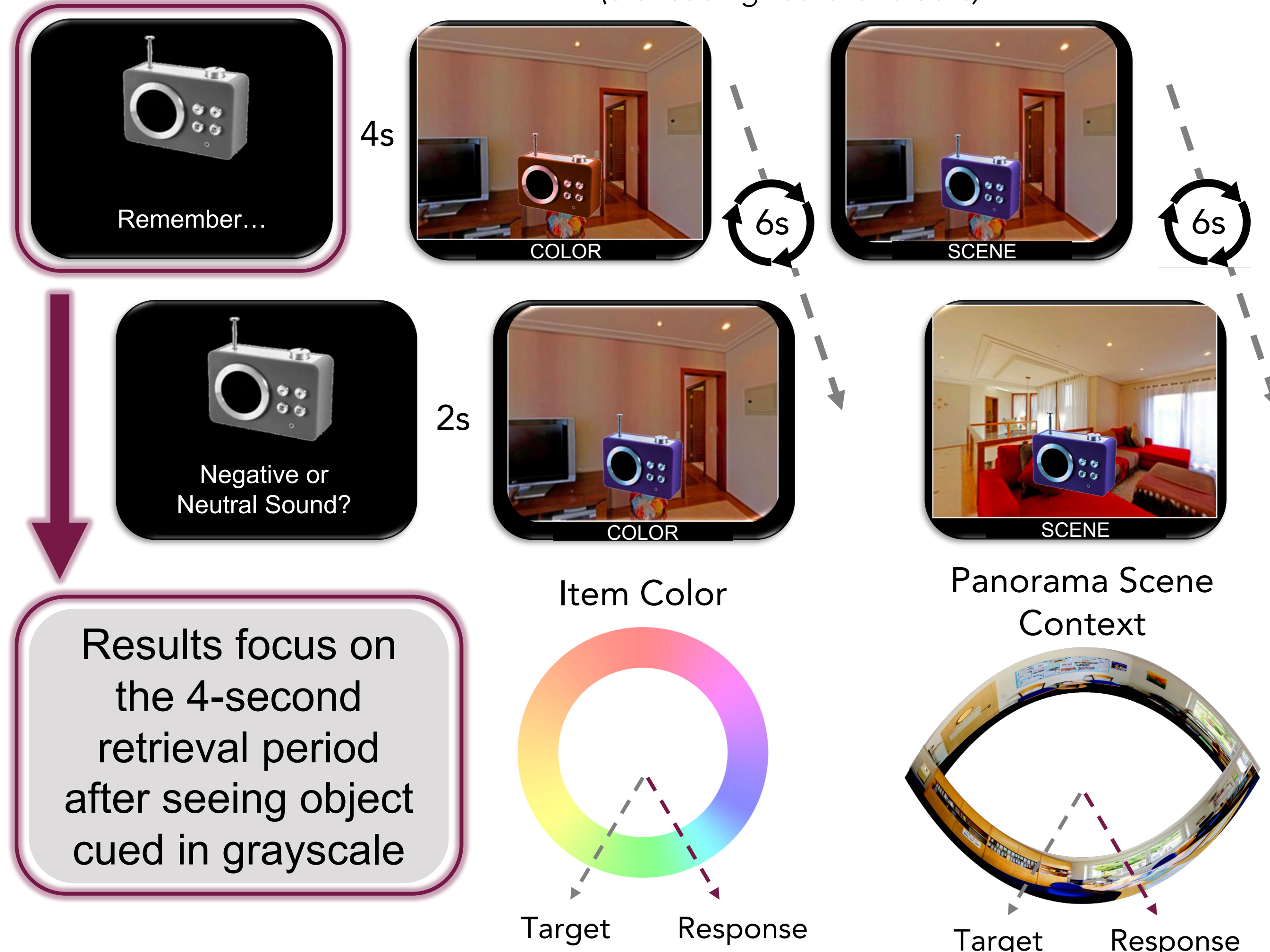
144 objects with:

1. A **negative** or **neutral** sound.
2. A color from a circular color spectrum.
3. A location within a 360° panorama scene (6 total).

In a later **memory test**, participants reconstructed the features of each object, cued in grayscale<sup>1</sup>.

### RETRIEVAL PHASE

(6 encoding-retrieval blocks)



Results focus on the 4-second retrieval period after seeing object cued in grayscale

#### Sound (0-1)

0 = incorrect  
0.5 = low confidence, correct  
1 = high confidence, correct

#### Color (0-1)

0 = incorrect, >50% chance error due to guessing (> +/- 48 degrees from correct location in color wheel)  
> 0 to 1 = <50% chance error due to guessing, weighted by precision

#### Scene (0-1)

0 = incorrect, >50% error due to guessing (> +/- 30 degrees from correct location in panorama scene)  
> 0 to 1 = <50% chance error due to guessing, weighted by precision

**Memory quality =**  
sound + color + scene  
(0 – 3)

Using single trial time frequency data, we can look at how temporally dynamic changes in brain activity correlate with continuous **overall memory quality** and with **feature-specific memory quality**.

## Results

### Single Trial Analysis of Time-Frequency Data

We correlated behavioral measures of memory quality from the retrieval task with aggregated single trial time-frequency data in our 0 – 4s window of memory reconstruction.

Results are collapsed over ROIs as there were no significant differences by location.

### Frequency Bands

Theta (5 – 8 Hz)  
Alpha (9 – 12 Hz)  
Low Beta (13 – 17 Hz)  
High Beta (18 – 30 Hz)

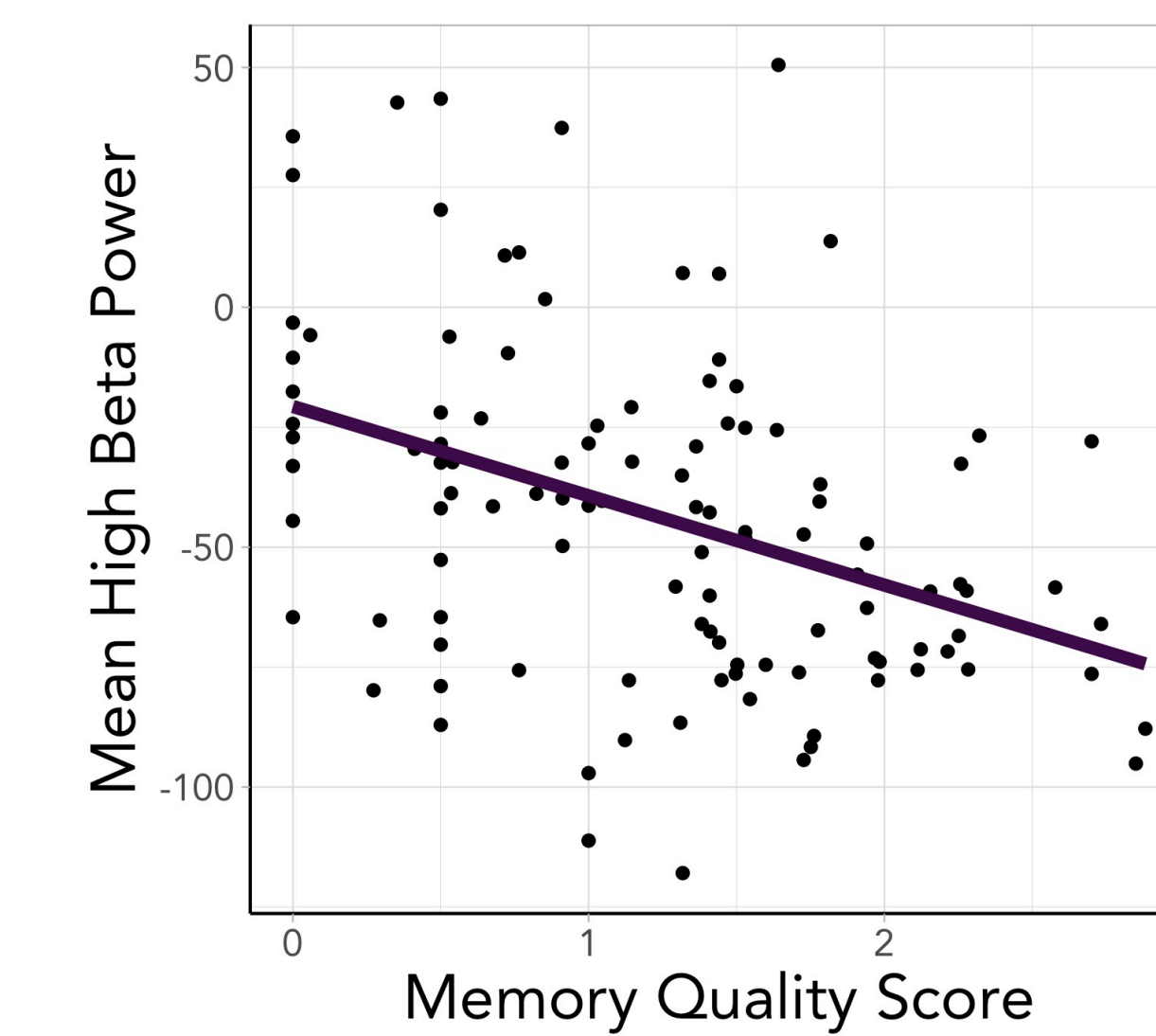
### Time Bins

Bin times into 1s windows:  
- .440 – 0s: baseline  
0 – 1s: “construction”  
1 – 2s: “early elaboration”  
2 – 3s: “late elaboration”  
3 – 4s: “response preparation”

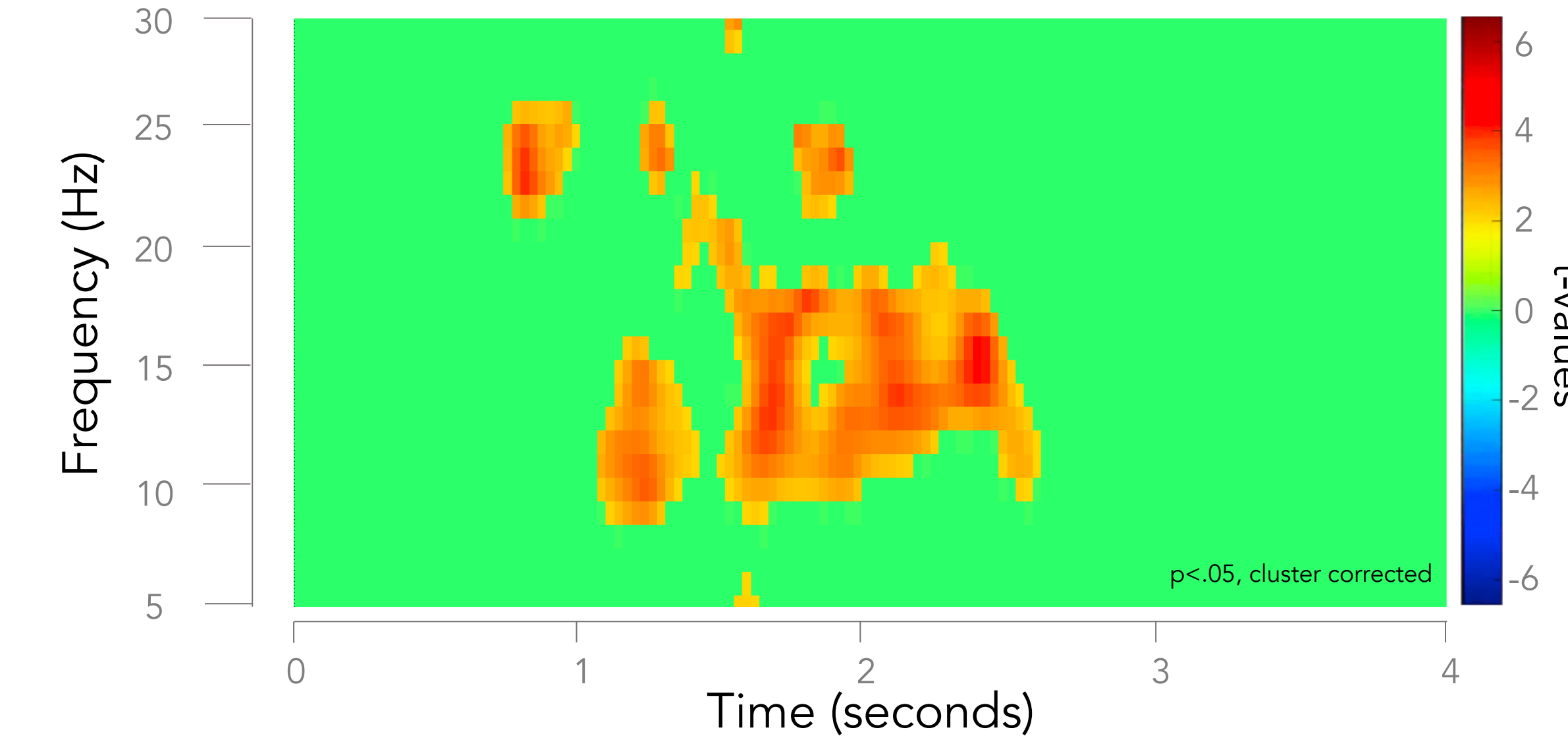
### Regions of Interest

9 ROIs, defined laterally (left, right, and center) and from anterior to posterior (frontal, central, and posterior)

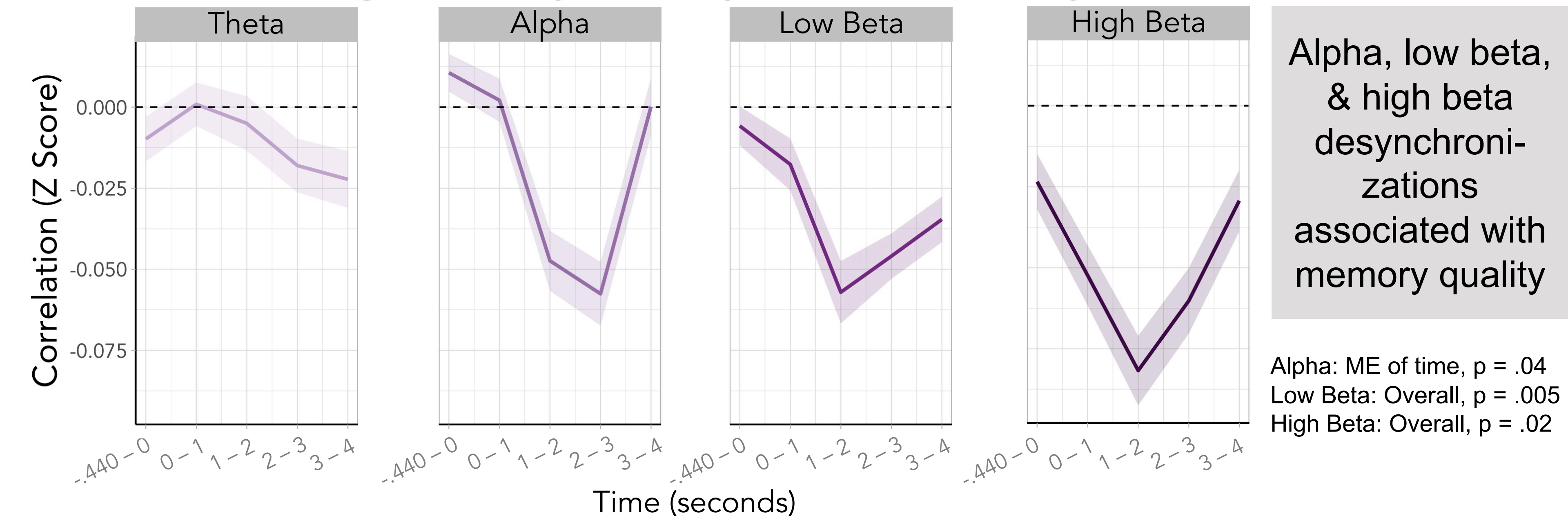
Example subject’s trial-by-trial relationship between Overall Memory Quality and Mean High Beta Power



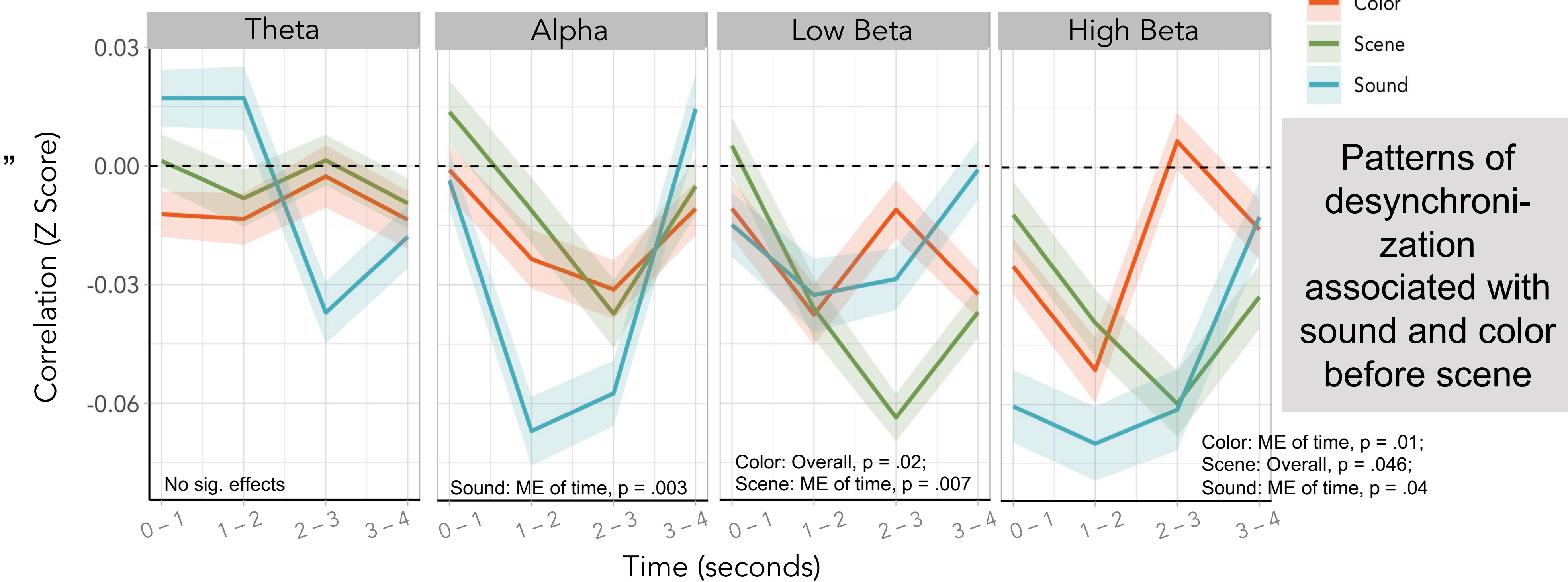
Low – High Overall Memory Quality (median split)  
Channel CP4



### Correlating Memory Quality with Frequency Power



### Correlating Feature-Specific Quality with Frequency Power



## Summary

- Desynchronization in the alpha and beta frequency bands was associated with the multidimensional quality of episodic retrieval, scaling with the number of features retrieved and how well they were reconstructed. Surprisingly, there were no changes in theta power associated with memory quality.
- There is some evidence for differences in the timing and neural processes involved in recovering different kinds of memory features.
- These results are consistent with accounts linking alpha and beta desynchronization to the cumulative recovery of episodic information<sup>3</sup> and activity in the posterior medial cortico-hippocampal network<sup>4</sup>.

## References

- 1 Cooper & Ritchey (2019) Cortico-hippocampal network connections support the multi-dimensional quality of episodic memory. *eLife*, 8:e45591.
- 2 Klimesch, Schimke, & Schwaiger (1994) Episodic and semantic memory: an analysis in the EEG theta and alpha band. *Electroencephalography and Clinical Neurophysiology*, 91(6), 428-441.
- 3 Hanslmayr, Staresina, & Bowman (2016) Oscillations and episodic memory: addressing the synchronization/desynchronization conundrum. *Trends in Neuroscience*, 39(1), 16-25.
- 4 Martín-Buro et al. (2020) Alpha rhythms reveal when and where item and associative memories are retrieved. *Journal of Neuroscience*, 40(12), 2510-2518.