Distributed representations of remembered vs. imagined events

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Background

- Episodic memory supports retrieval of the past and simulation of future/novel events[1,2]
- Retrieval and simulation engage similar brain regions, including parietal, and temporal cortices[2]
- Prior work has shown that episodic simulation may be supported by retrieval of autobiographical memories[3], but it is unclear to what extent recently learned events influence simulation

Can newly formed memories be used to support episodic simulation?

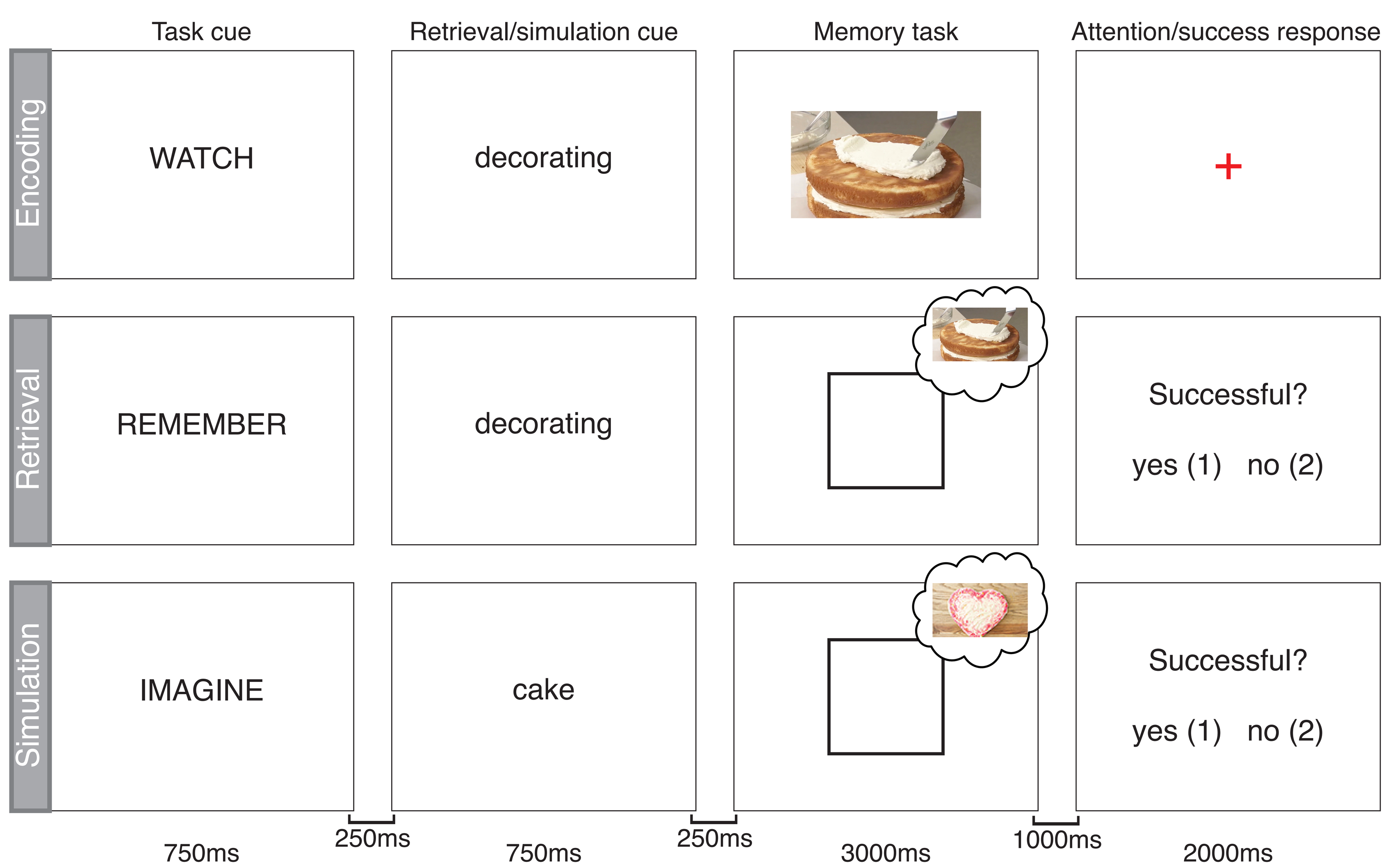
Where is memory content represented during simulation processing?

fMRI methods

- Participants: 28 right-handed healthy adults scanned with Siemens Skyra 3T
- Functional scans: 2mm isotropic voxels, TR = 2s
- Anatomical and functional preprocessing using fMRIprep[4]
- Freesurfer[5] parcellation of regions of interest

Experimental procedures

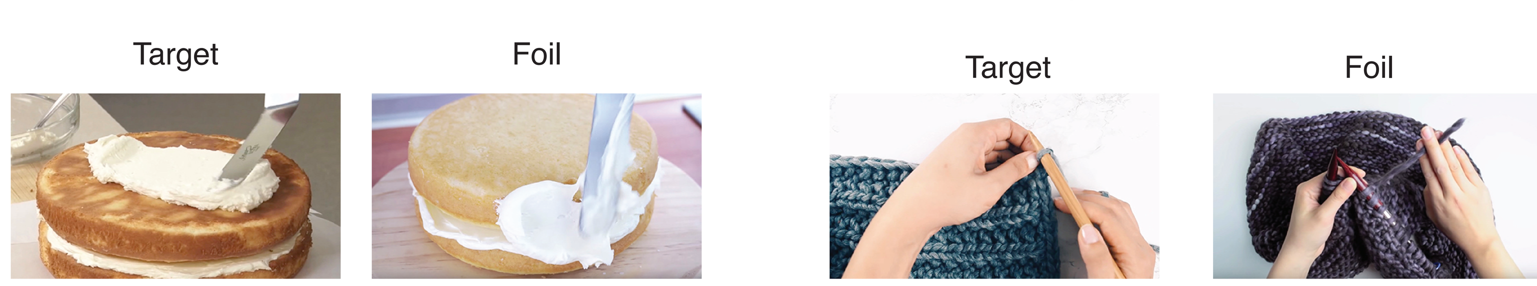
Participants completed separate encoding, retrieval, and simulation tasks during fMRI scanning. The order of tasks was manipulated to examine the influence of prior encoding on simulation.



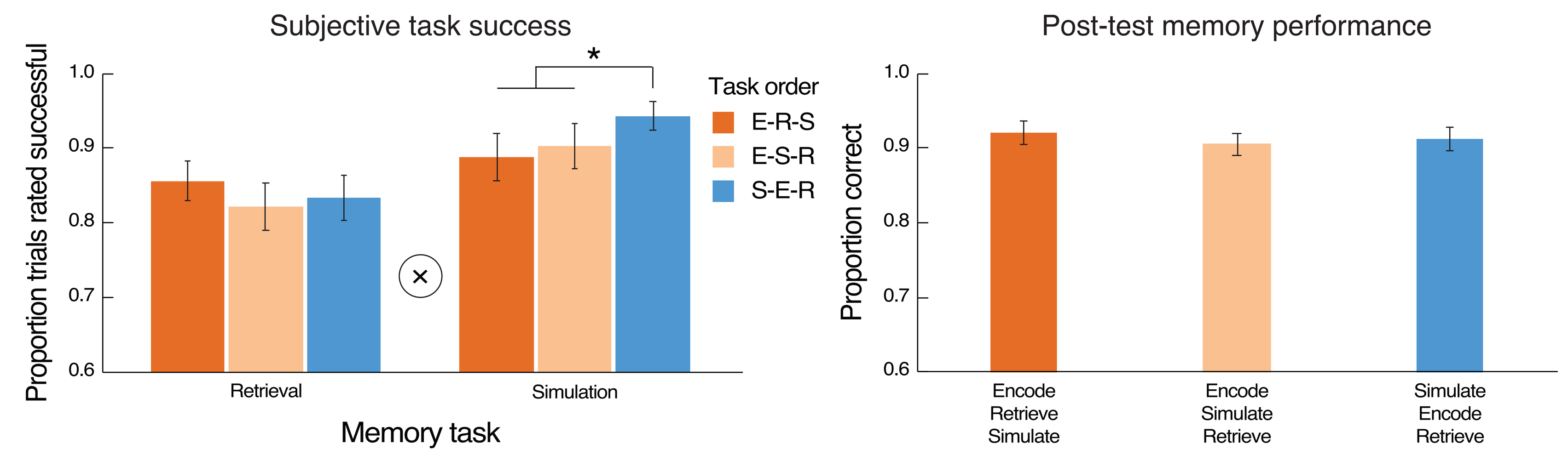
- Three scanning runs per task order, ten trials per task per run
- Trials blocked by task within each scanning run

Post-scanning memory test

To confirm participants successfully remembered the movies, they completed a memory test that included screenshots from the movies and visually similar foil images.



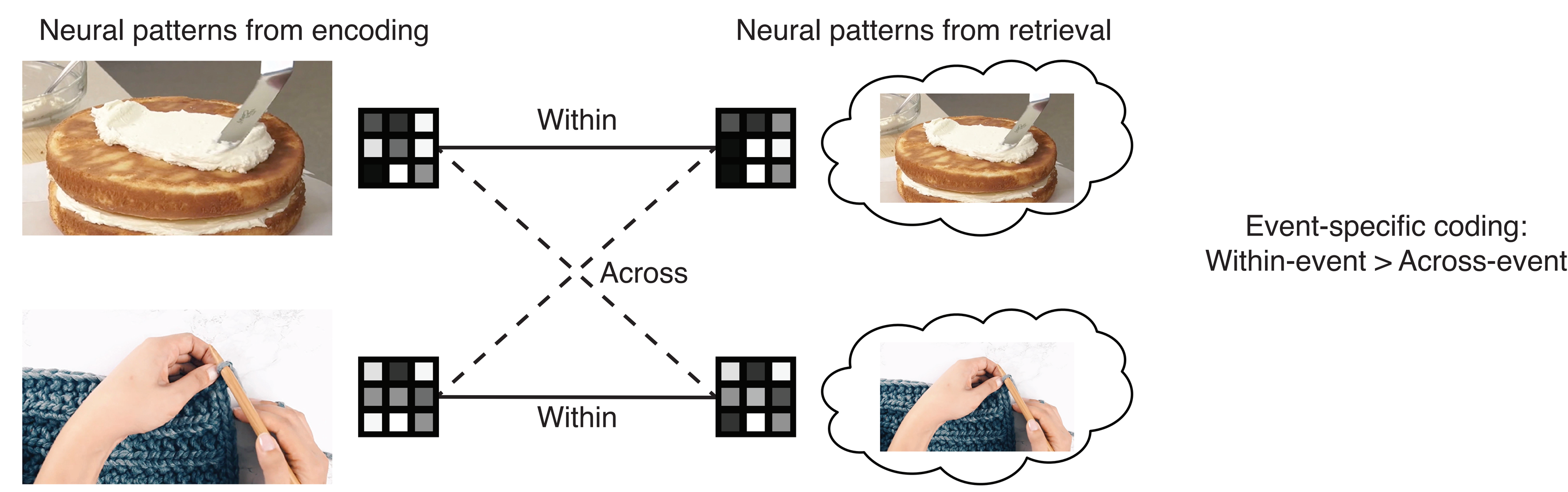
Task success and subsequent memory



- Effect of task ($p < 0.001$)
- Task x task order interaction ($p = 0.02$)
- No effect of task order ($p = 0.615$)

- Encoding the movies first made subsequent simulation more difficult
- Participants formed robust memories of the movies and could differentiate from similar foils

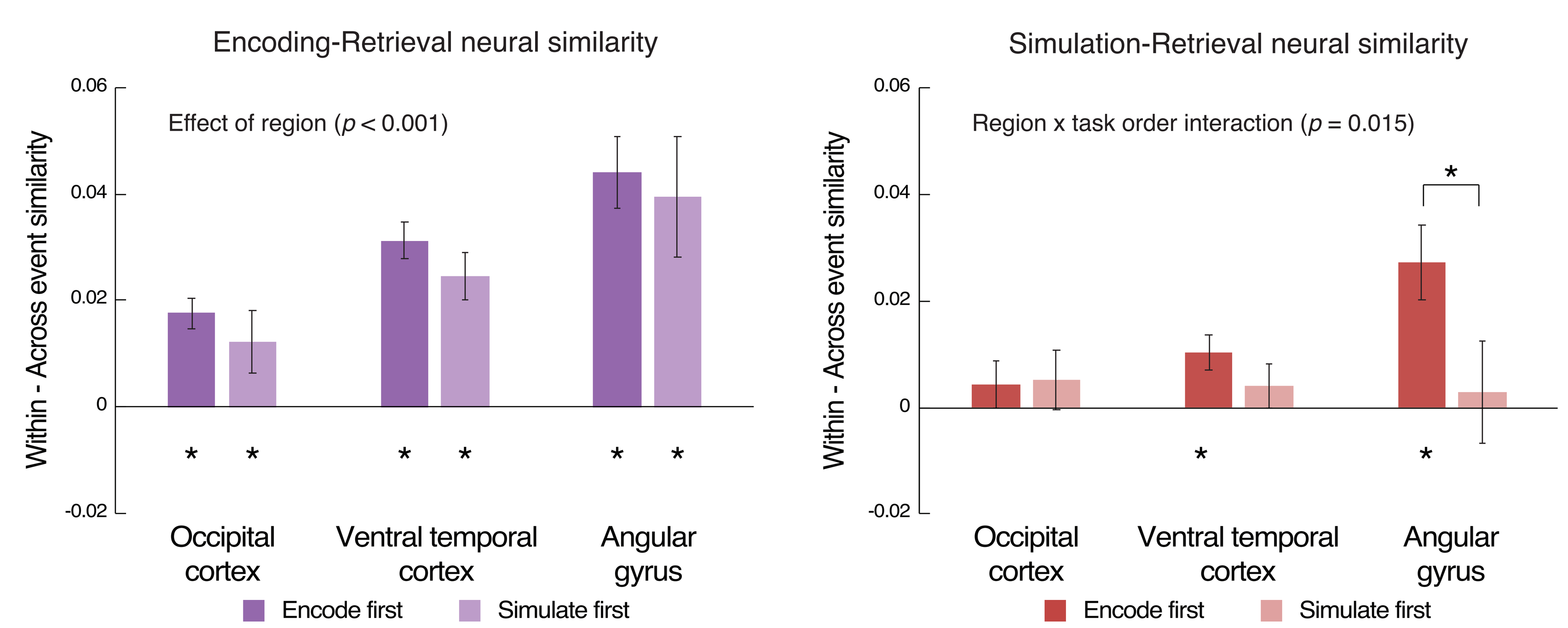
Measuring event-specific neural coding



Analysis strategy: using representational similarity analysis[6], event-specific neural coding was indexed by calculating the difference between within-event and across-event similarity for neural patterns (trial-level GLM β from the same run) from encoding, retrieval, and simulation.

Neural coding in anatomical regions of interest

Similarity for encoded, retrieved, and simulated events was compared in ROIs associated with memory reactivation[7-9] and effects of task order (encode first, simulate first) were interrogated.



- Robust, event-specific Encoding-Retrieval similarity with varying strength across regions of interest, consistent with memory reactivation during retrieval
- Encoding-Retrieval similarity was uninfluenced by task order, mirroring task success
- Event-specific Simulation-Retrieval similarity was relatively strongest in angular gyrus, particularly when encoding preceded simulation

Subjective descriptions of simulations

After scanning, participants provided brief descriptions of their simulations. These descriptions were then compared with annotations describing the actions and elements within each movie.

cake

"Baking a cake in my grandparents' house."

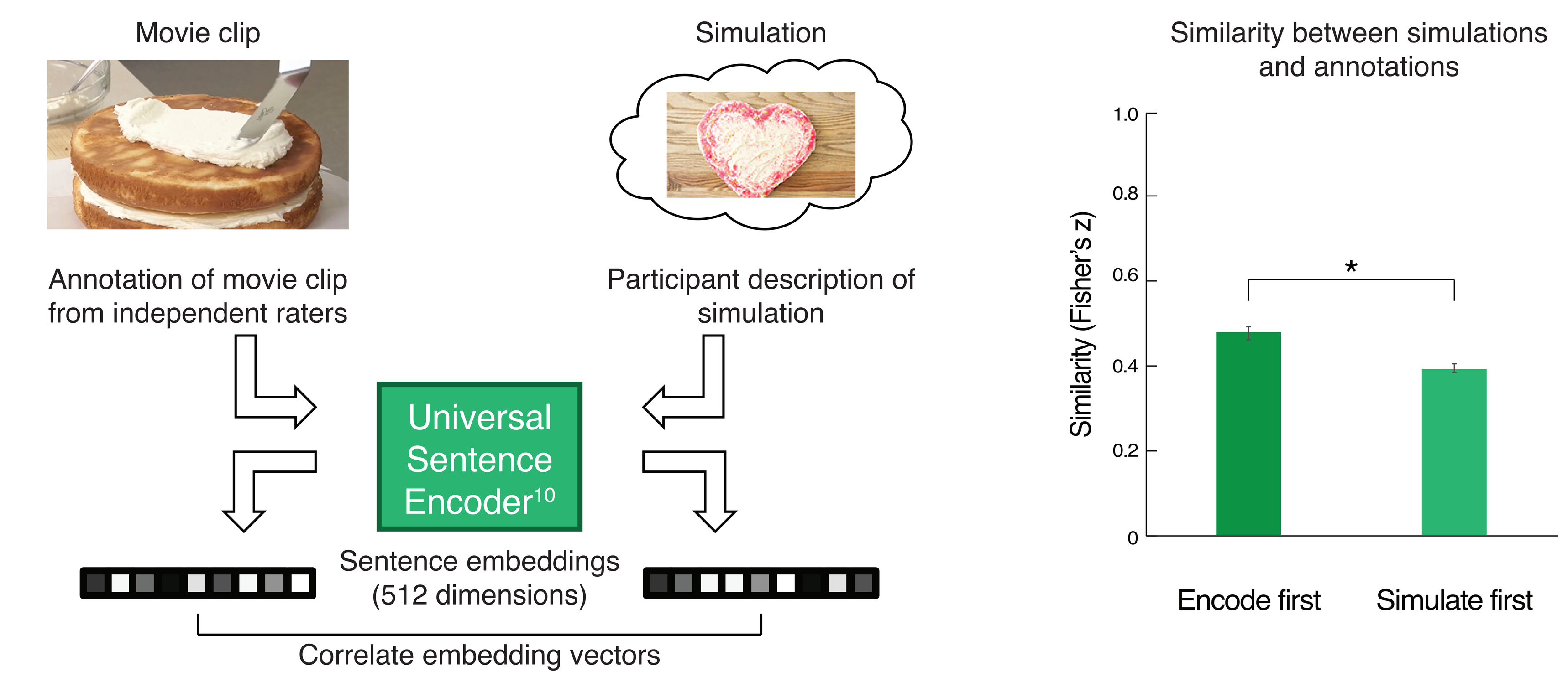
"I held a whole cake with my hands and took a big bite out of it."

"I would be baking a heart shaped cake."

"A massive cake exploded into a bunch of little cakes with little legs."

Analyzing semantic content of simulations

Semantic similarity between participant descriptions of simulations and movie annotations from naive raters were compared by calculating sentence embeddings.



- Participants' descriptions of simulations were more similar to movie annotations when the simulations followed encoding of the movie

Conclusions

- fMRI pattern similarity analysis showed that simulated representations resembled retrieved representations when encoding occurred before simulation, consistent with the hypothesis that simulation samples from memory[2]
- Event-specific coding of simulated and retrieved representations in angular gyrus, highlighting the critical role this region plays in representing memory content during both episodic simulation and memory retrieval[7]
- Text-based analyses provided converging evidence that episodic simulation sampled from memory
- Together, these findings show that episodic simulation samples from recent experiences and that neural representations of simulated events share a similar format to representations of retrieved events

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