Neural Correlates of Visual Episodic Encoding: an fMRI Analysis

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INTRODUCTION

- Memory is often parsed into three stages: **encoding, consolidation,** and **retrieval**[1].
- The neural network responsible for these stages is extensive and still under exploration.
- Regions of the **medial temporal lobe (MTL)** have been shown clinically and experimentally to be heavily involved in each stage of memory[2], but several other neural components throughout the brain are predicted to be involved as well[3].
- For example, a 2017 review by Bubb *et. al.* sought to establish an anatomical guide to memory and emotion, and their memory network involved heavy interaction between the **hippocampus, diencephalic regions, and the cingulate cortex**[4].
- ***Clinical relevance:*** Identifying key components of the neural memory network is essential to correctly associating amnesic patients' symptoms with their brain lesions.
- ***Objective:*** Examine neural correlates in response to a complex-scene viewing task to identify which neuroanatomical regions are associated with successful visual encoding.

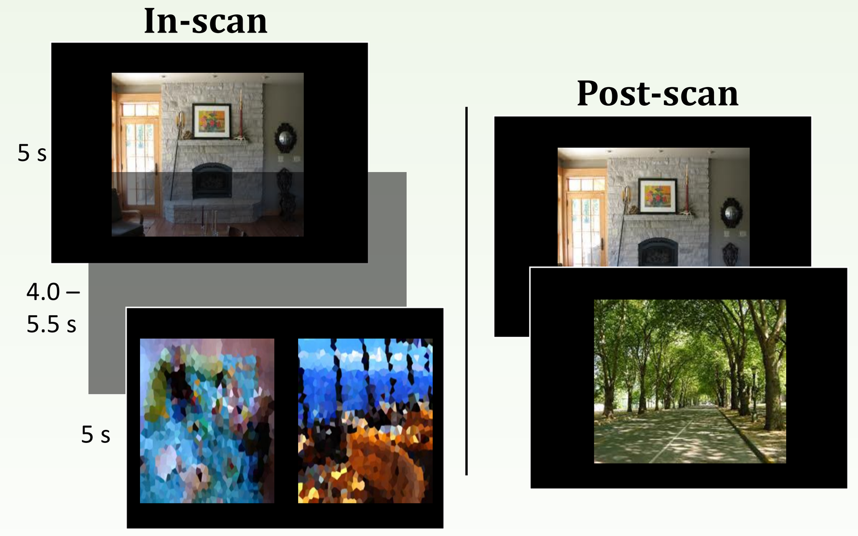
METHODS

Participants + Materials

- 9 healthy native English-speakers with no history of neurological or psychiatric disorders
- 68 visual stimuli evenly distributed across 2 conditions, each with 2 variables:
  - Scenes
    - Indoor
    - Outdoor
  - Patterns
    - Same
    - Different

Procedure

- *In-scan encoding phase*
  - Images presented in event-related design, participant asked to respond to stimuli via button-press.
    - **'Scene' condition**: participant decides whether an image depicts an indoor or outdoor scene.
    - **'Pattern' condition**: participant decides whether two images of pixelated patterns are identical or different.



- *Post-scan retrieval phase*
  - 18 images from 'Scene' condition + 18 foil images presented, participant asked to respond via keyboard-press whether or not each image was shown earlier in the scanner. Of those images from the 'Scene' condition, correct responses were categorized as 'hits' and incorrect responses as 'misses.'

MRI scan details

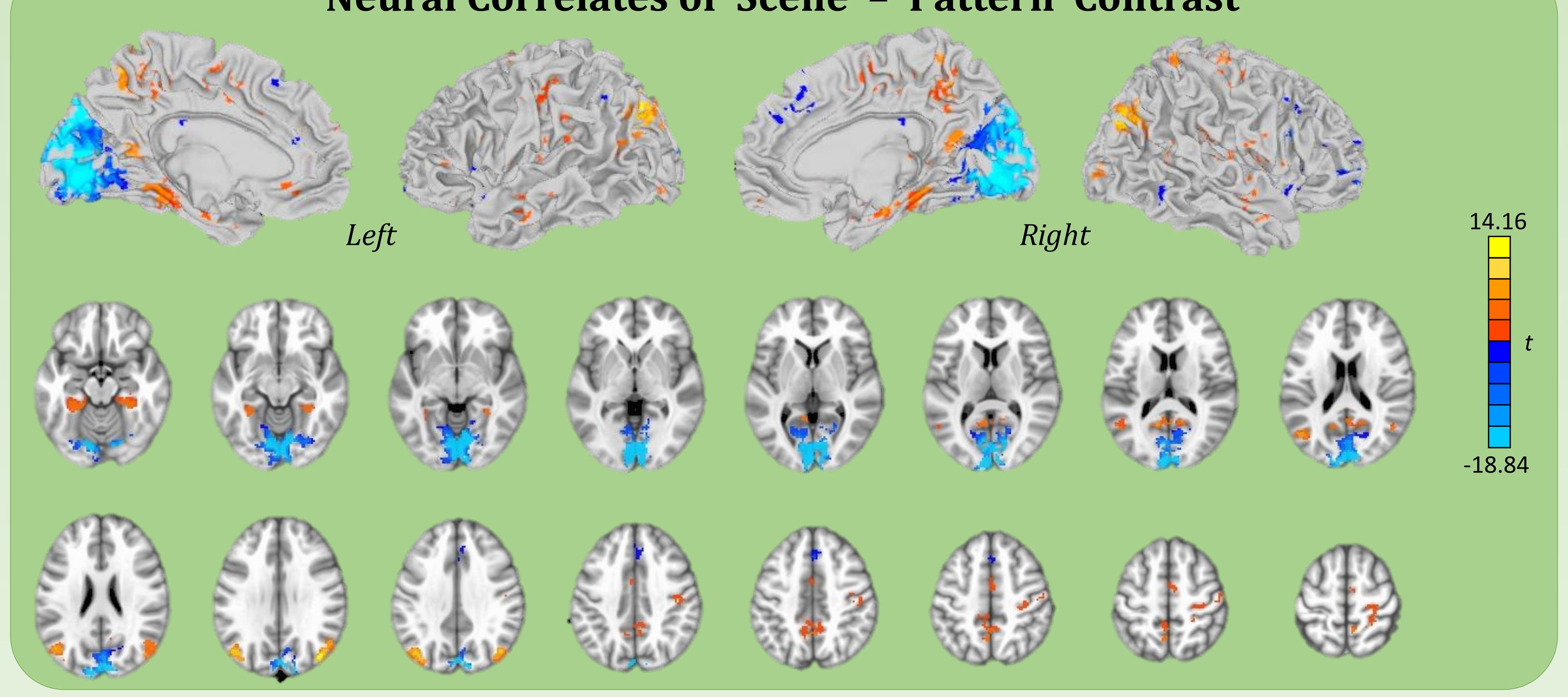
- Functional T_2*-weighted images obtained in 3T SIEMENS MAGNETOM Prisma scanner | Scan duration: 11:22 | Voxel size: 3.8×3.8×4.0 mm | TR/TE : 2000 ms / 35.0 ms

Data processing

- All data processed in AFNI and FSL. Anatomical images were preprocessed and co-registered to functional images, which were then motion and slice-time corrected. Brain volumes were standardized to MNI space and spatially smoothed (6mm FWHM), and nuisance regressors (6 rigid-body motion corrections, signal from white matter and ventricles) were accounted for and incorporated into Generalized Linear Model (GLM).
- GLM computed using generalized least squares method.
- Group-level analyses were performed for each subject across 'Scene' and 'Pattern' conditions as well as 'hits' and 'misses.'
- Statistical maps were generated via two-sample paired t-tests for both contrasts.

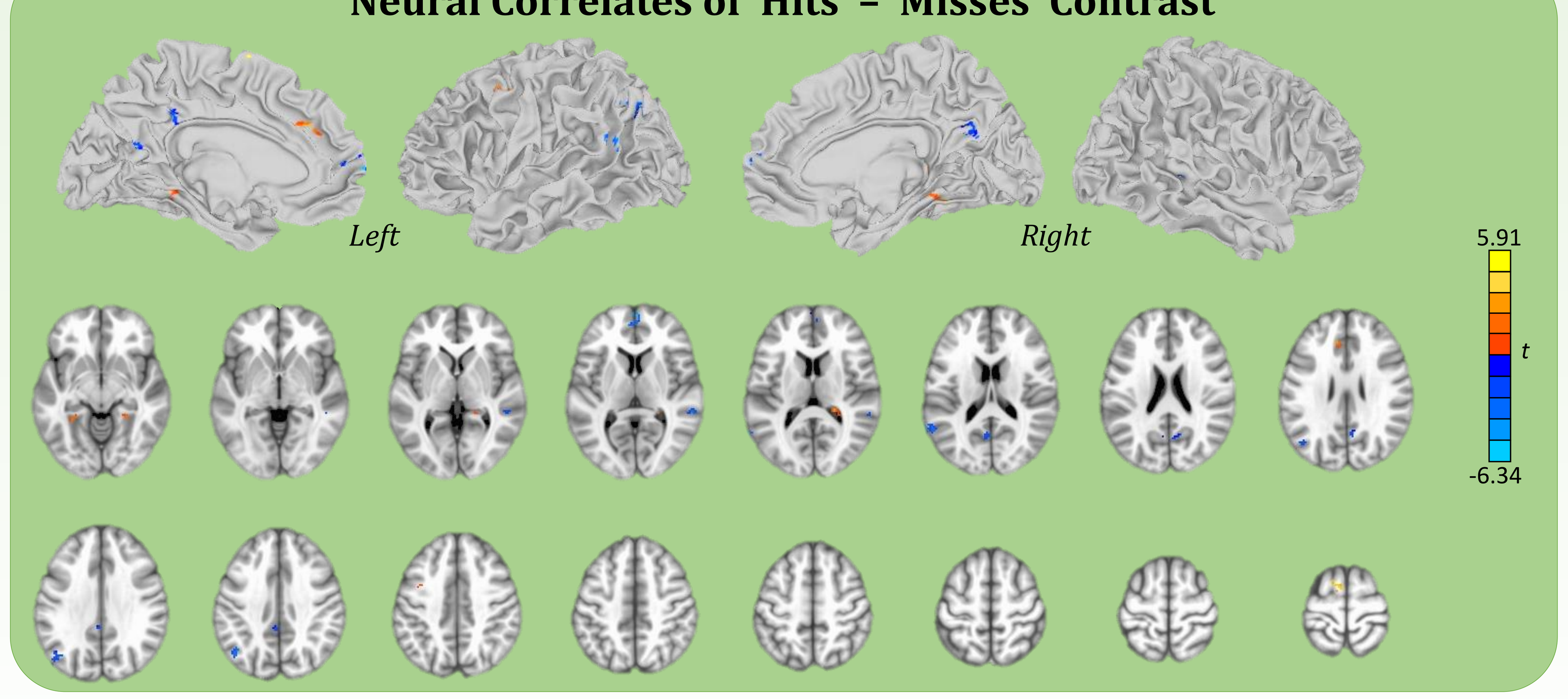
RESULTS

Neural Correlates of 'Scene' – 'Pattern' Contrast



- **Scene > Pattern:** Bilateral angular gyrus, R postcentral gyrus, R superior parietal lobule, Bilateral precuneus, Bilateral middle occipital gyrus, Bilateral fusiform gyrus, Bilateral middle cingulate cortex, L premotor cortex, Bilateral para-hippocampal gyrus *(p = 0.005 corrected)*
- **Pattern > Scene:** Bilateral calcarine gyrus, Bilateral lingual gyrus, Bilateral cuneus, Bilateral superior medial gyrus *(p = 0.005 corrected)*

Neural Correlates of 'Hits' – 'Misses' Contrast



- **Hits > Misses:** Bilateral fusiform gyrus, R hippocampus, L premotor cortex, Bilateral para-hippocampal gyrus, L anterior cingulate cortex, L precentral gyrus *($p < 0.05$ uncorrected)*
- **Misses > Hits:** L angular gyrus, R superior temporal gyrus, L superior medial gyrus, L middle temporal gyrus, Bilateral precuneus, L posterior cingulate cortex *($p < 0.05$ uncorrected)*

Post-scan Performance Results

Image Type	Response	% trials (std. dev)
scene	Hit	81.94 (12.51)
	Miss	18.05 (12.51)
foil	Correct rejection	90.97 (7.82)
	False approval	9.02 (7.82)

DISCUSSION

- The 'Scene' – 'Pattern' contrast reveals the neural correlates of **potential encoding.**
  - Areas of increased activation according to this contrast include the **fusiform gyrus, superior parietal lobule** of the posterior parietal cortex, and **para-hippocampal gyrus** within the MTL, each of which is implicated by Kim (2011) in the neural network responsible for the encoding process[5]:
    - **Fusiform gyrus** – content processing | **MTL** – storage operations | **Posterior parietal cortex** – attention during encoding
- Given the event-related design rather than previously performed block-design[6], a more accurate measure of the neural correlates involved in successful encoding is possible via the 'Hits' – 'Misses' contrast.
  - These neural correlates include the **hippocampus, para-hippocampal gyrus**, and **anterior cingulate cortex**. Each of these areas is implicated in Bubb *et. al's* memory network[4].
- Several regions exhibited increased activity in association with **unsuccessful encoding**, *i.e.* during 'Scene' trials that would ultimately result in 'Misses' during the post-scan task.
  - This suggests that **successful visual encoding demands a particular allocation of neural resources to the encoding network**—these resources could potentially become less available in response to several factors.
- ***Conclusion:*** The memory network is complex and spans several neuroanatomical components. Knowledge of these components is necessary to accurately identify the root cause of a memory-related dysfunction, but it is also necessary to consider which regions outside of the memory network may be hoarding neural resources and ultimately causing memory failure.

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