

Memory consolidation promotes structured representation of novel visual objects

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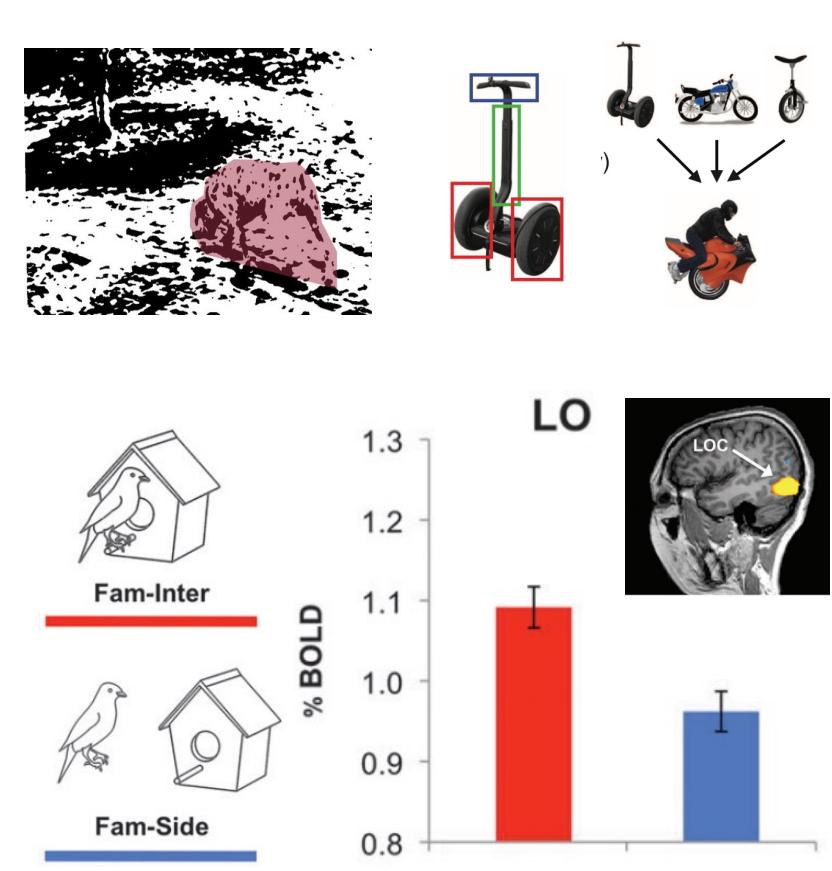
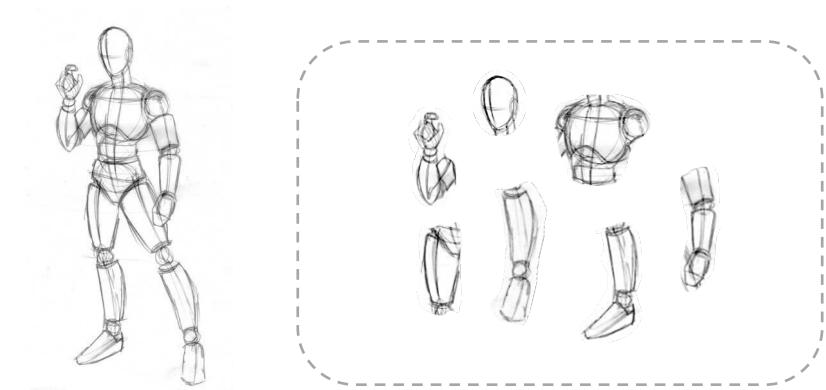
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Introduction

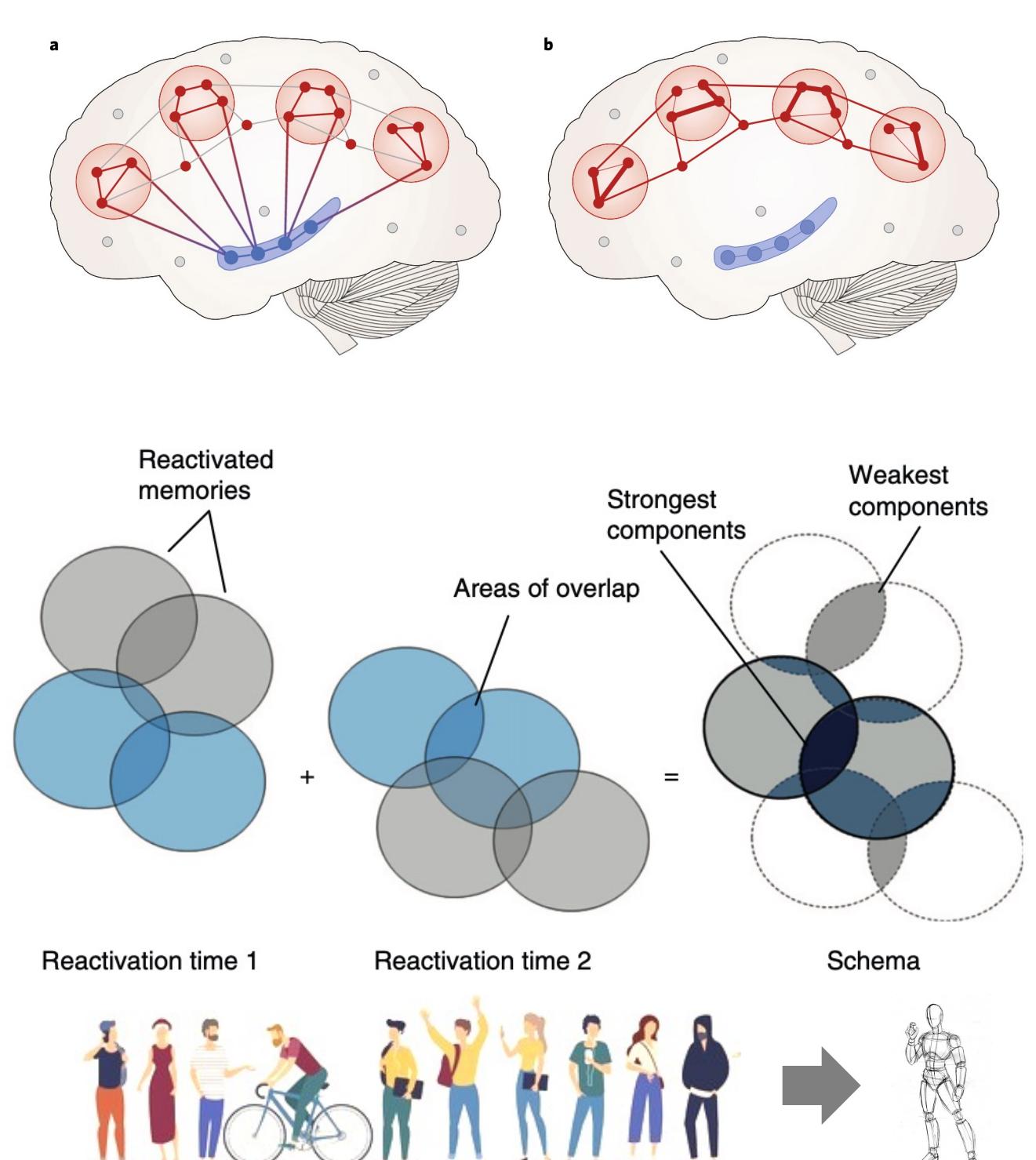
Structured Representation of Visual Objects^{1,2}

- In natural vision, objects are represented in a structured manner by the statistical relationship between essential elements.
- By forming structured representation of these objects, we can perceive them as a meaningful combination of individual elements.
- This representation facilitates object recognition in the complex natural environment and can be the basis for generating creative and novel exemplars.
- However, how the structured representation of novel objects is generated in the brain remains unclear.



Memory Consolidation and Schema^{3,4}

- Recently learned experiences are transformed into stable long-term memory by the interaction between the hippocampus and the neocortex during a time-dependent consolidation process.
- During the rest period, memories are repeatedly reactivated, and commonalities and statistical regularities between them are extracted. Through this process, a cognitive schema is formed.
- Schema for the object category may provide structural knowledge of novel exemplars from the same category.

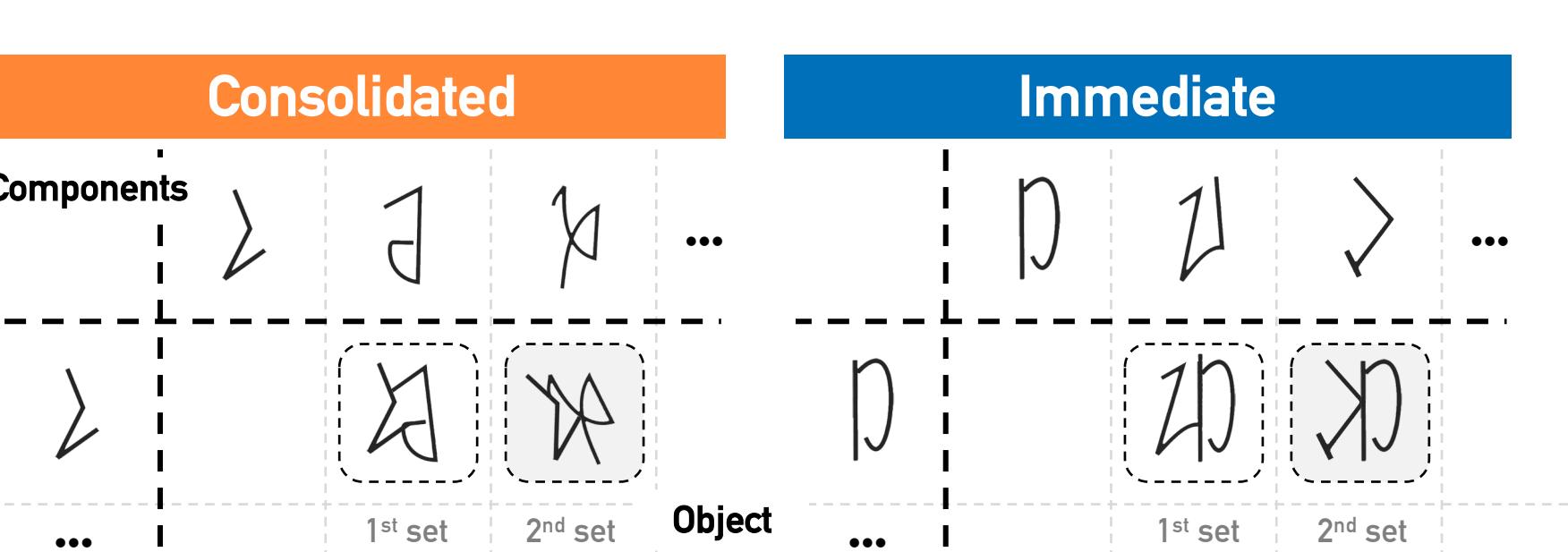


What is the role of memory consolidation in the structured representation of novel objects?

Method

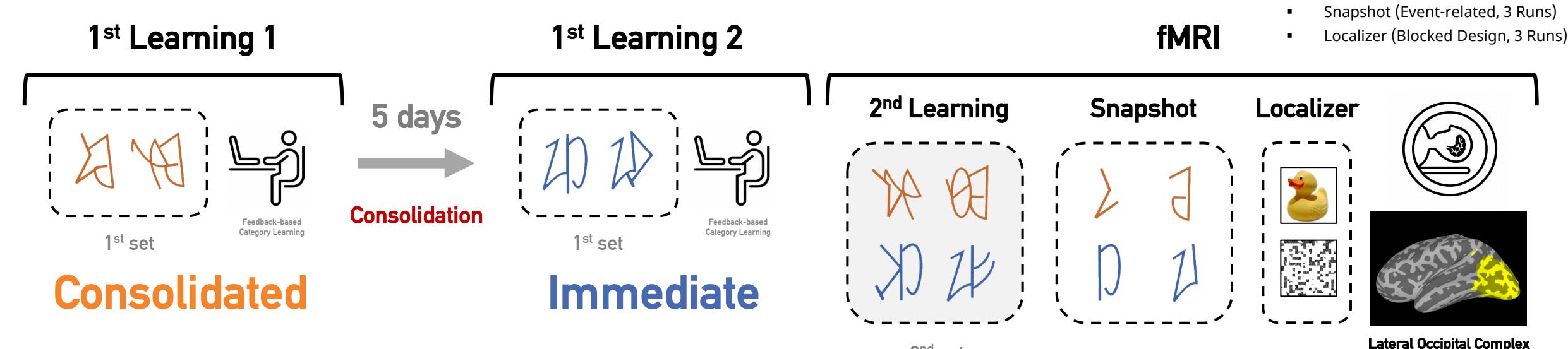
Stimuli: unfamiliar, novel object images

- Artificial Language System
- 4 object categories (2 Consolidated vs. 2 Immediate)
- 12 Components & 66 Objects in each category
- Objects were generated by horizontally combining two components.



Procedure

- Behavior & fMRI Experiments; Within-Subject Design (Consolidated vs. Immediate)



Analysis & Hypothesis

- Region of Interest - Lateral Occipital Complex

Univariate Contrast

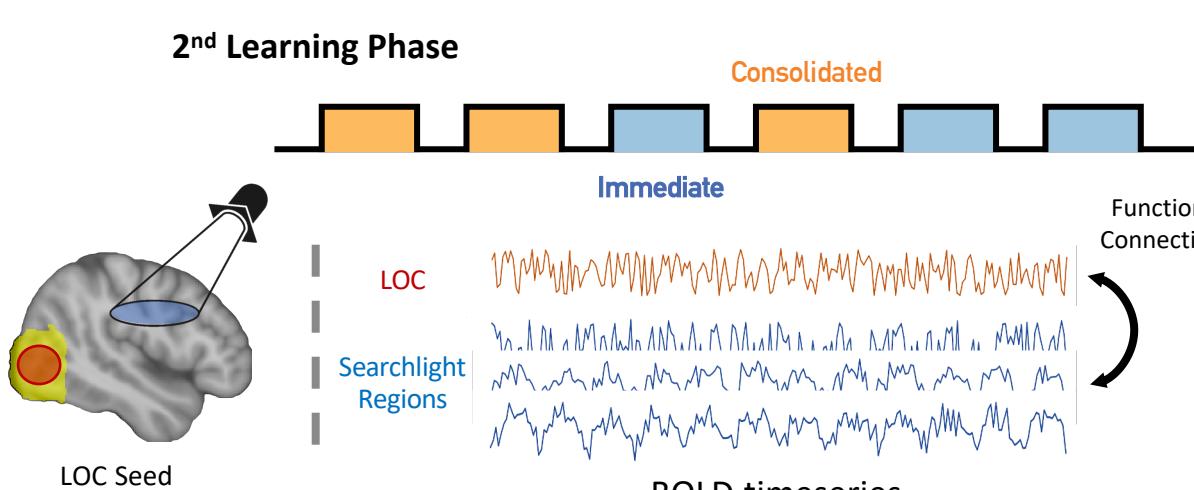
- General Linear Model with canonical HRF

Multivariate Pattern Analysis

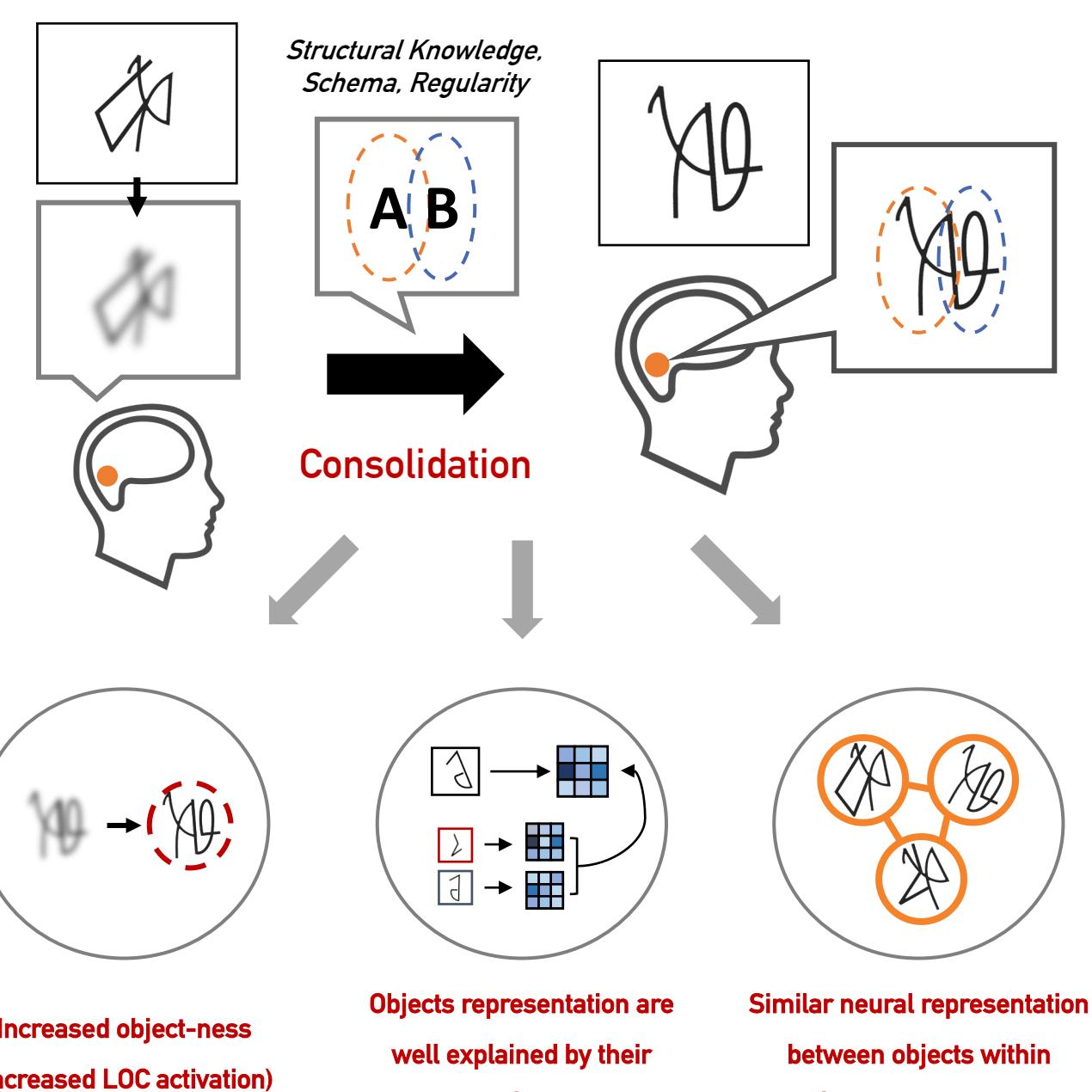
- Constituents Explainability Analysis
- Representational Similarity Analysis

Seed-based Searchlight Functional Connectivity

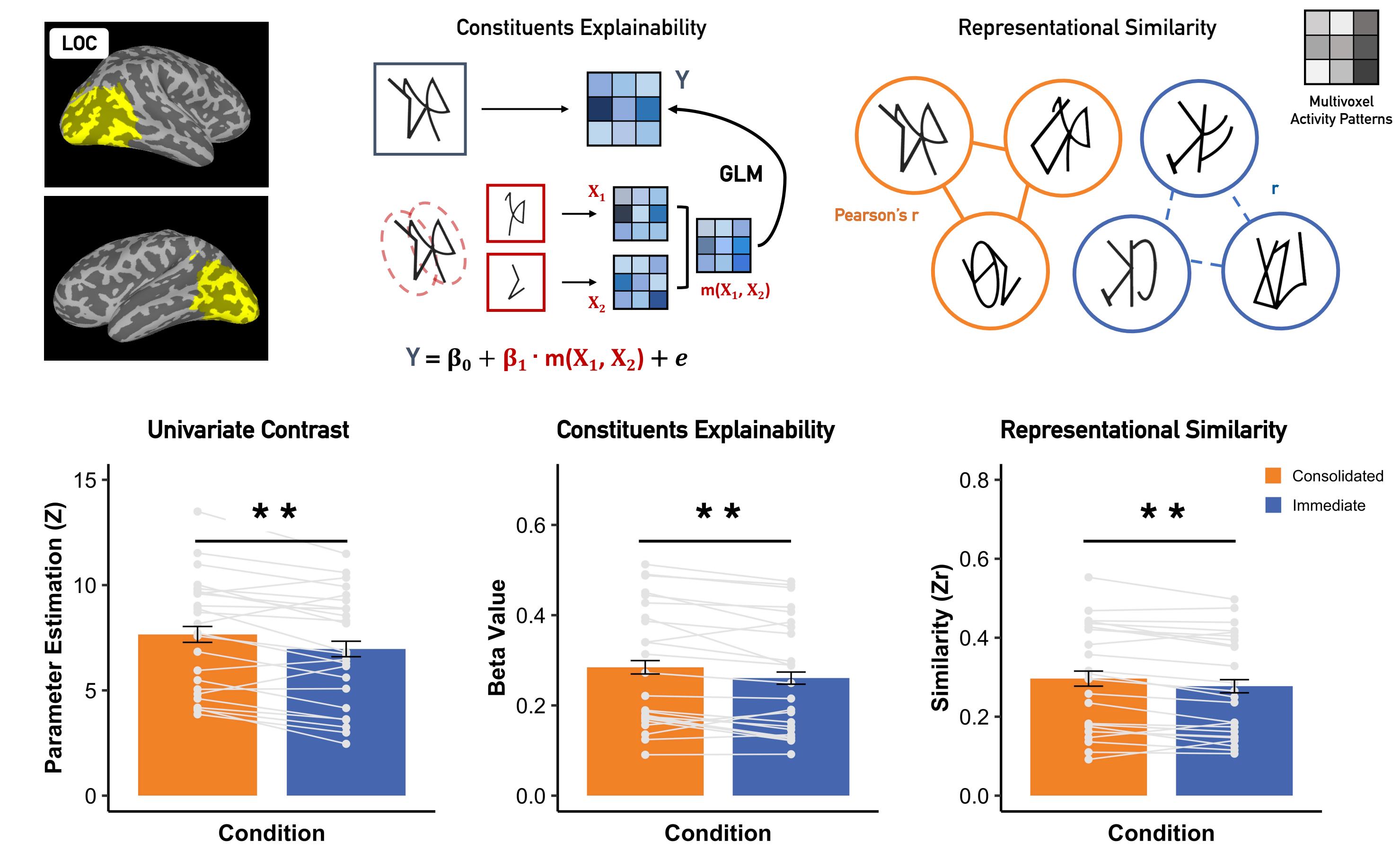
- Background Connectivity Approach



As schema for object categories is formed through the consolidation, structured representation of similar objects will be acquired.

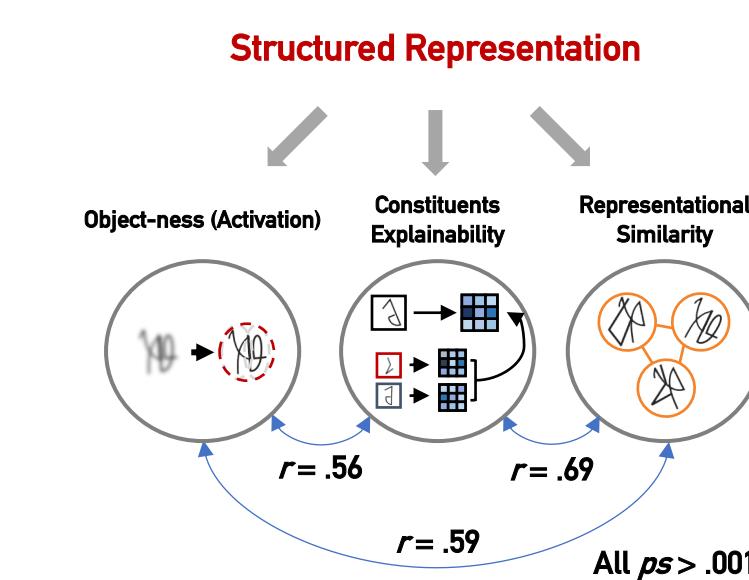


Results

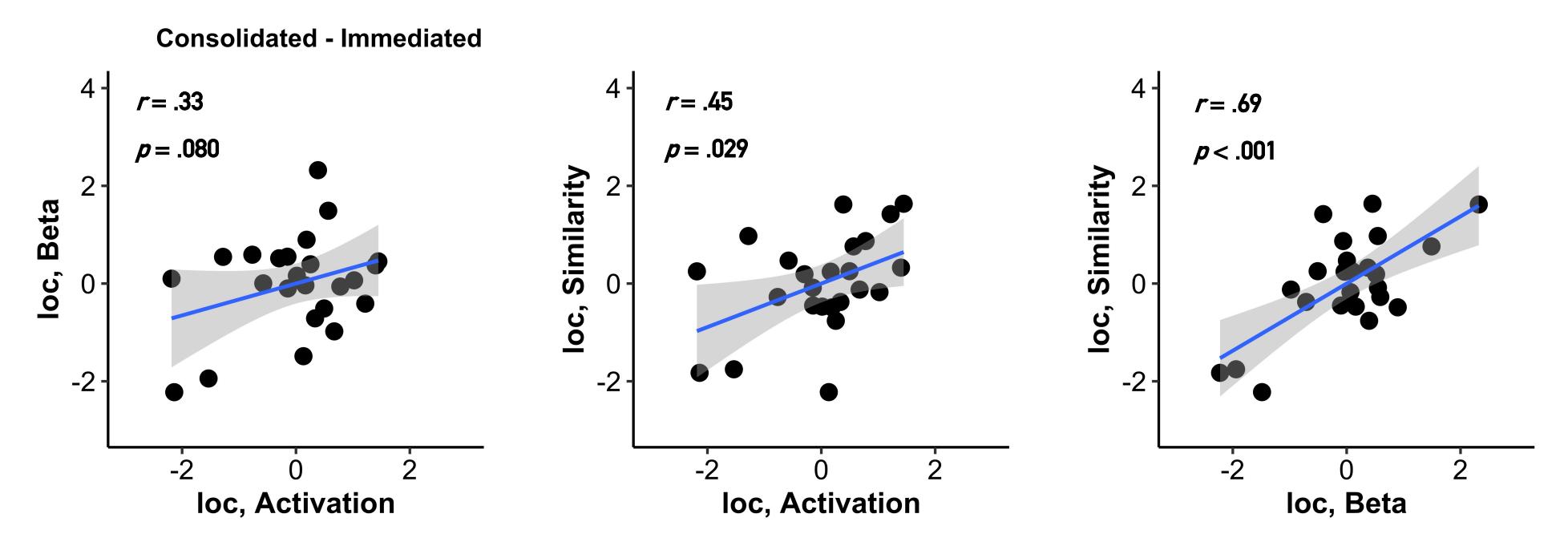


- Compared to the immediate condition, 1) new objects from the consolidated category showed higher LOC activation, and 2) the neural patterns of these objects were more well explained by those of their components. 3) The neural representation of objects within the category, which shared their constituents and combination relationship, was more similar in the consolidated condition.

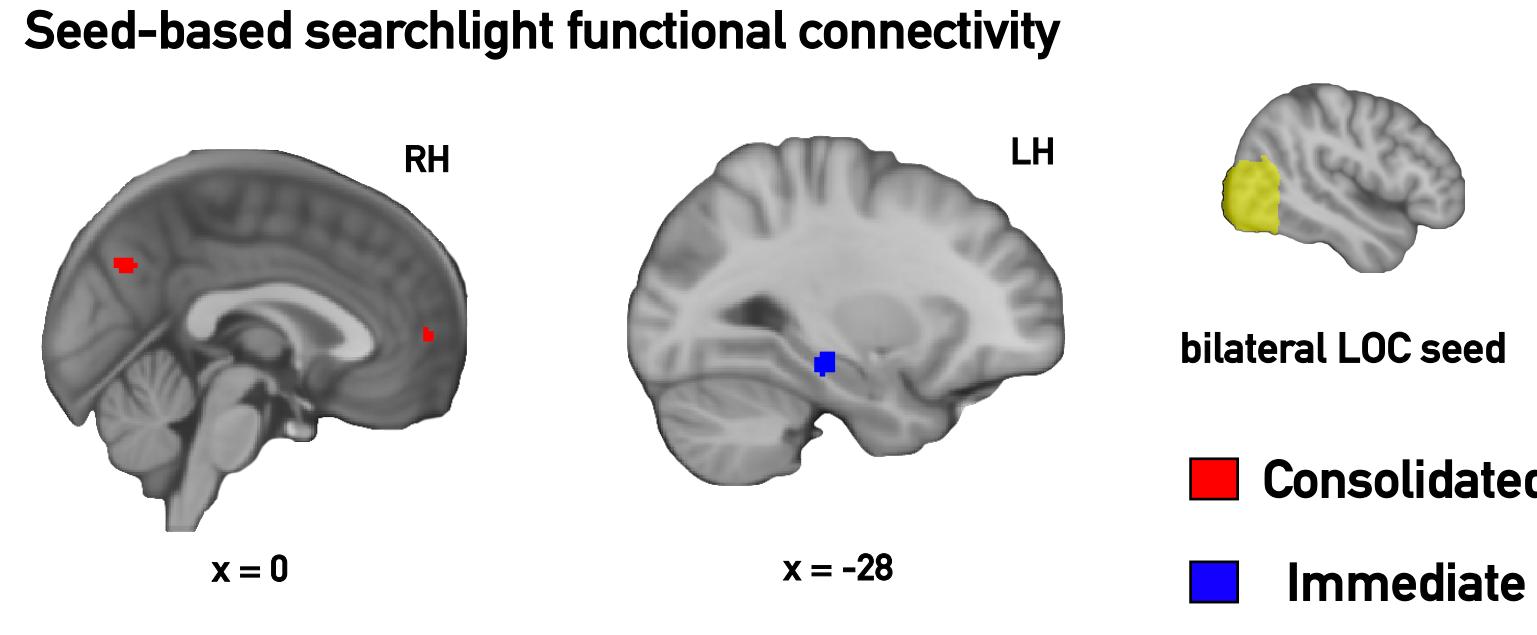
Item-level Correlation Analysis



Subject-level Correlation Analysis



Seed-based searchlight functional connectivity



- mPFC, Precuneus, and PCC showed greater functional connectivity with the LOC under the consolidated condition.

- Hippocampus showed greater connectivity with the LOC under the immediate condition.

Summary

- We tested the relationship between memory consolidation process and structured representation of novel visual objects through a human fMRI experiment.
- We found that consolidation enhanced structured representation in object-selective regions (LOC): increased activation, constituents explainability, and representational similarity.
- During the perceiving of consolidated object category, LOC showed stronger functional connectivity with the schema-related brain regions (mPFC, precuneus, and PCC).
- These findings support our hypothesis that memory consolidation might promote the structured perception of visual objects.

Reference

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