



# Pattern Classification of Memory Encoding Tasks

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## Background and Research Objectives

### Retrieval Orientation and Source Monitoring

• **Retrieval orientation** is a top-down cognitive state that facilitates successful recovery of memories (e.g., Herron & Wilding, 2004; Herron & Rugg, 2003; Marsh & Hicks, 1998).

• **Source monitoring** is the act of identifying the origin of memories (e.g., Johnson et al., 1993; Marsh & Hicks, 1998).

### Current Objectives

• Isolate neural correlates of distinct **encoding states** with fMRI and multi-voxel pattern classification.

• Test the prediction that the frontal cortex contains encoding task representations.

### Long-term Objectives

• Assess whether orienting retrieval to a particular encoding task involves reinstating PFC task representations that were present at study.

## Experimental Paradigm

### Overview

• Participants completed 8 runs of studying & retrieving words.

• Independent Variables: (a) encoding task (2: **artist**, **function**); (b) retrieval orientation (2: orient to **artist**, orient to **function**)

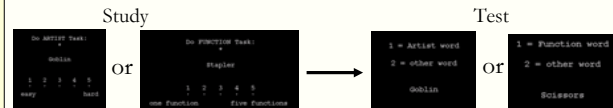
• Dependent Variables: whole-brain event-related fMRI images, behavioral accuracy, & reaction times.

### Encoding Tasks

• **Artist**: Imagine drawing the object. Was the object easy or hard to draw?

• **Function**: Come up with concrete uses for the object. How many did you come up with?

### Procedure



• At study, participants learn words using the artist and function tasks in two mini-blocks each consisting of 12 words per encoding task.

• At test, participants see all studied and 12 new words, and identify **source** while orienting to **artist** or **function** info.

• Retrieval orientation was manipulated by varying the test instructions.

## Multi-Voxel Pattern Classification

### Pre-Classification Procedure

• Analyses were conducted using the Princeton Multi-Voxel Pattern Analysis Toolkit (currently in public beta testing: [www.csmbm.princeton.edu/mvpa](http://www.csmbm.princeton.edu/mvpa))

• An ANOVA was applied to individual voxels to select those whose activity best discriminates between **artist** and **function** study periods.

### Training and Testing the Network

• Train a neural network classifier using the backpropagation algorithm to discriminate between brain volumes that correspond to different cognitive states (e.g., Polyn et al., 2004)

• Subject-by-subject analysis

• Assess classifier's performance at determining whether participants engaged in the **artist** or **function** tasks for individual time points (TR = 2 sec) during the study period.

• N-1 generalization procedure

• Only a subset of the study period data is used to train the classifier, and the withheld portion is used for testing.

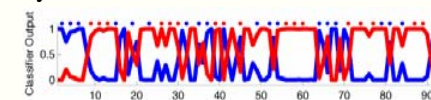
## Contextual Reinstatement at Retrieval

### Hypothesis and Procedure

• Assess whether participants reinstate activity from study phase to do the source memory task.

• Use classifier trained on data from the **study phase** to predict **instructed retrieval orientation** during the test phase.

### Preliminary Results



• Participant 1: the classifier was 62.50% correct in determining retrieval orientation,  $p = 0.028$ .

— Reinstatement of Artist Task PFC Pattern (From Study)  
— Reinstatement of Function Task PFC Pattern (From Study)  
• Instructed Artist Retrieval Orientation Item Presentation  
• Instructed Function Retrieval Orientation Item Presentation

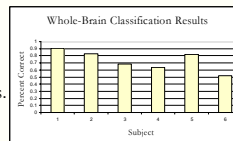
## Whole-Brain Study Phase Classification Results

### Results

• Distributed Voxel Pattern:

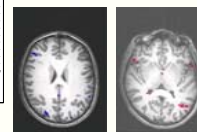
• **Artist**: Bilateral inferior parietal lobule, & superior parietal lobule. Right posterior cingulate, precuneus.

• **Function**: Left middle temporal gyrus, caudate, anterior cingulate, precentral gyrus, BA47, BA10, & superior frontal gyrus.



### Brain Maps

Artist Function



## Task Representations in the Frontal Cortex

### Research Question

• Test the hypothesis that the frontal cortex contains top-down task-set information by restricting the analysis to data from the frontal lobes.

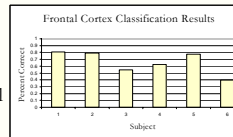
### Results

• Distributed Voxel Pattern:

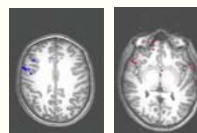
• **Artist**: Bilateral inferior frontal gyrus, right middle frontal gyrus.

• **Function**: Bilateral inferior frontal gyrus & middle frontal gyrus.

• Chance Performance = 50%



Artist Function



## Future Directions

• What can account for the variance in classifier performance?

• Do fluctuations in classifier performance correlate with changes in behavior, such as accuracy or reaction time?

• Modify experimental design to facilitate testing the contextual reinstatement account of retrieval orientation.

## References

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