Decoding fMRI Using SVM

Nishmar Cestero

Dataset Information

- FMRI data of Frontal Localizer (FLoc) task - Perceptual Neuroimaging Lab at Boston University
- FLoc :
  - Exercises working memory for the stimulus type presented. Indicate when the current stimulus matches the stimulus from two steps earlier in the sequence.
- Stimuli
  - Auditory
    - Cat and dog vocalizations
  - Visual
    - Male and female faces
  - Each sequence shown twice:
    - Passive condition
    - Task condition

Visual Stimuli

fMRI Basics

- Functional Magnetic Resonance Imaging (fMRI)
- Blood-oxygen-level dependent (BOLD):
  - Indirect measure of brain activity.
  - Hemodynamic responses in neurons : the rapid delivery of blood to neuronal tissues.
- Voxels:
  - 3-dimensional image of BOLD signal
  - Units representing a cube of brain tissue.
  - Each represents up to a million neurons
  - ~2 millimeters.

Preprocessing

FreeSurfer : software that provides functions for processing brain MRI images.

1. Unpack raw data from DICOM files (medical image standard)
2. Add paradigm files
   - Text files containing stimuli schedule
3. Noise reduction
   - Motion correction, smoothing, projection to average brain

Data Format

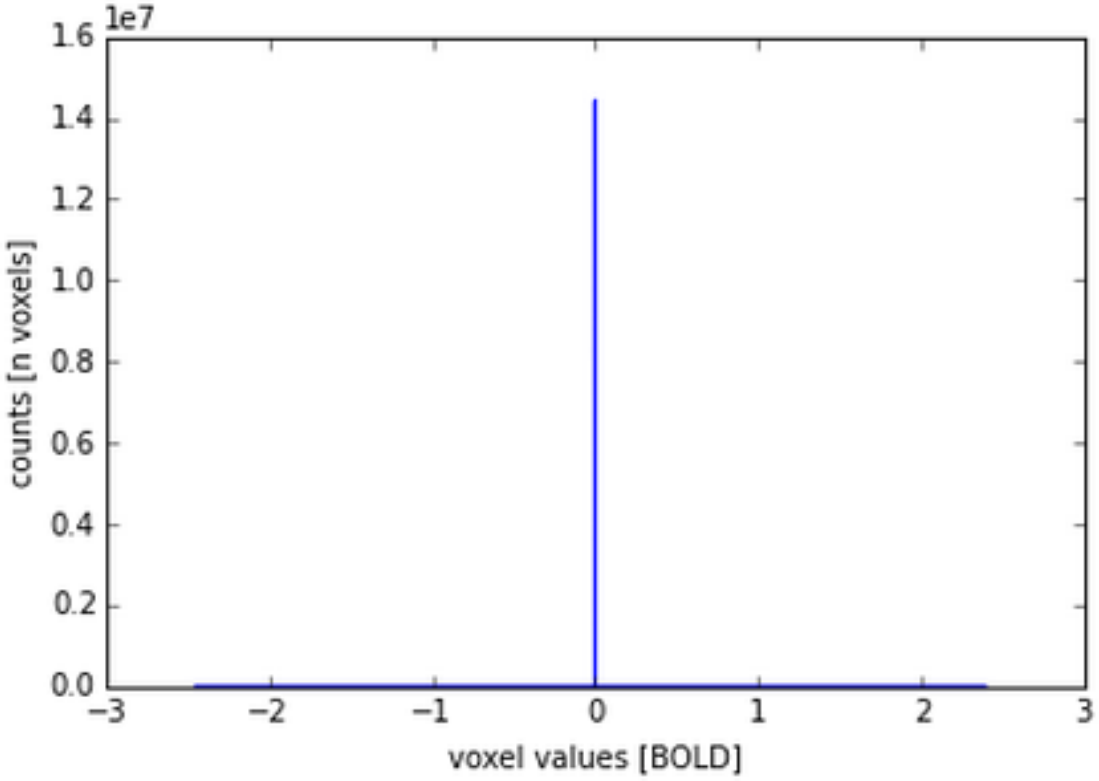
- NIfTI :
  - Standard file format for neuroimaging data.
- Access Data:
  - NiBabel and NiLearn libraries
  - 4-dimensional matrix consisting of space coordinates x, y, z in millimeters and time point units of 2 seconds.
- Standardize :
  - Convert matrix from 4D to 2D: n samples x n features.
  - Retain BOLD data for each voxel while discarding location information

Basic Statistics

- Samples:
  - 1016 total samples
    - 8 subjects, 8 runs each , 2 hemispheres, 8 blocks of stimuli
  - 512 left hemisphere samples
  - 504 right hemisphere samples (one corrupted run file)

- Features:
  - 163,847 voxels
  - average of BOLD signal across 40-second block of a stimuli

Basic Statistics, cont.



Hypotheses

- Decoding: using brain image to predict external variables.

- **H1**: Auditory vs. Visual Stimuli: predict for group
- **H2**: Working Memory vs. Passive: predict for group
- **H3**: Cat vs. Dog sounds: predict for individuals
- **H4:** Cat vs. Dog sounds: unable to predict for group
- **H5:** Male vs. Female face: predict for individuals
- **H6:** Male vs. Female face: unable to predict for group

Methods

Feature Selection

- ANOVA: Univariate feature selection
  - Simple
  - Doesn't remove redundancy / pick best of highly correlated features

Classification

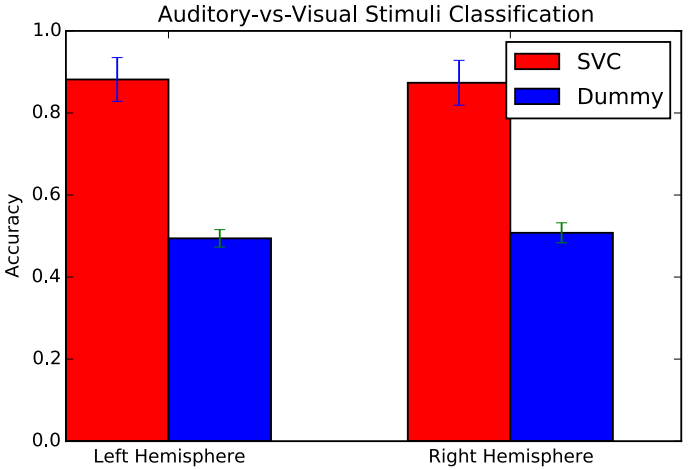
- SVM : Linear SVC
  - Effective for high dimensional data
  - Coefficients: weight vector of features

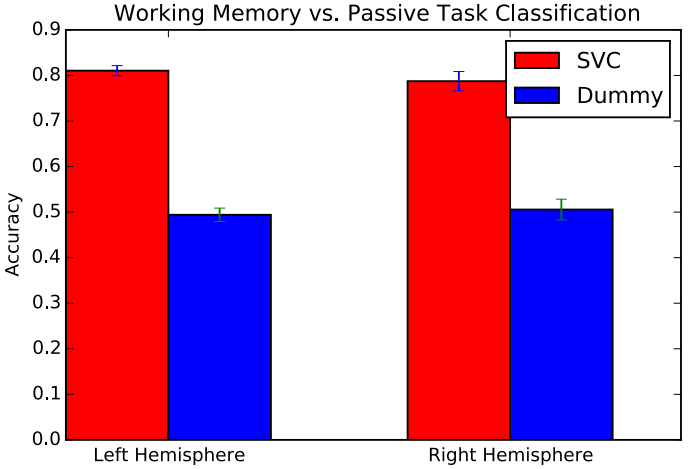
Probability Estimates

- Cross-validation
  - 10-fold

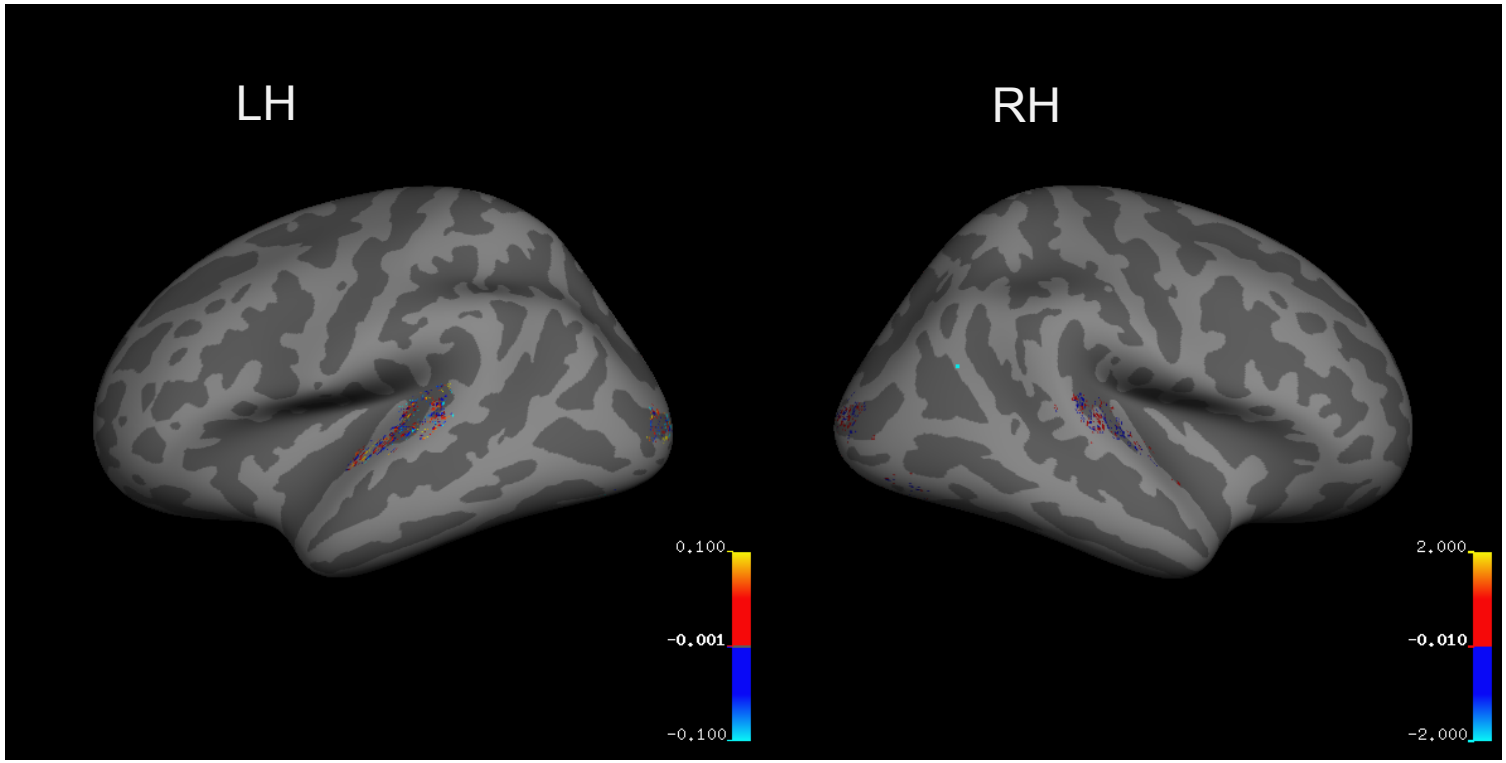
Results: H1 and H2

- Auditory vs. Visual Stimuli classification accuracy much higher than chance
  - LH: 88%
  - RH: 87%
- Working Memory vs. Passive classification Accuracy much higher than chance
  - LH: 81%
  - RH: 78%

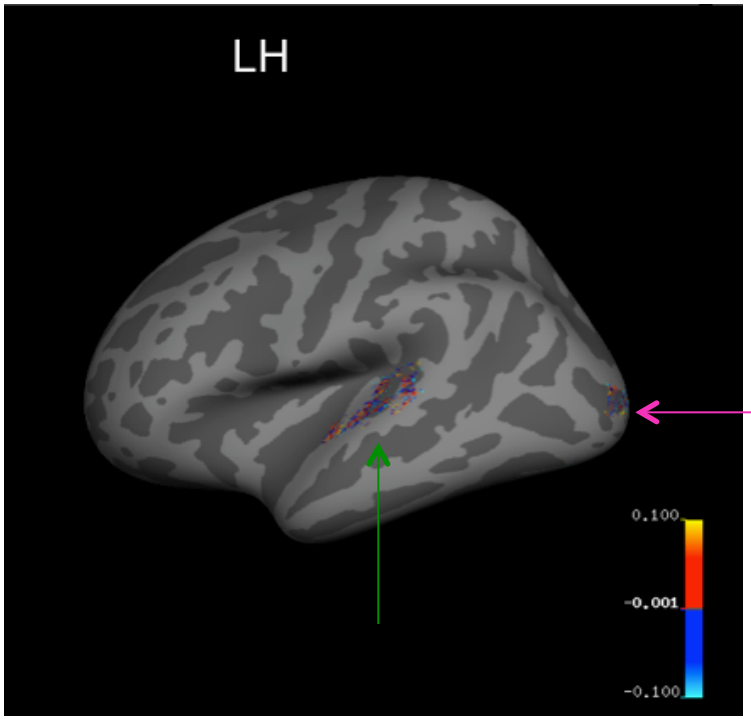


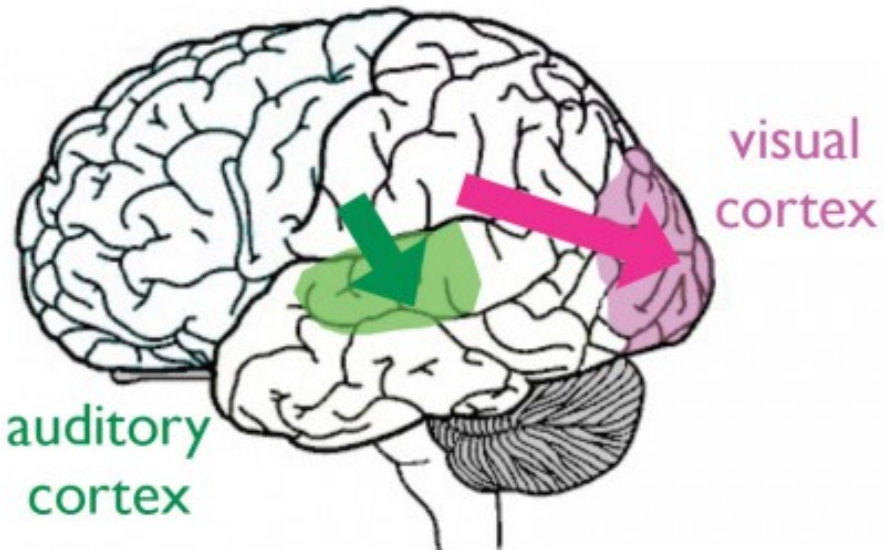


Auditory vs. Visual Features

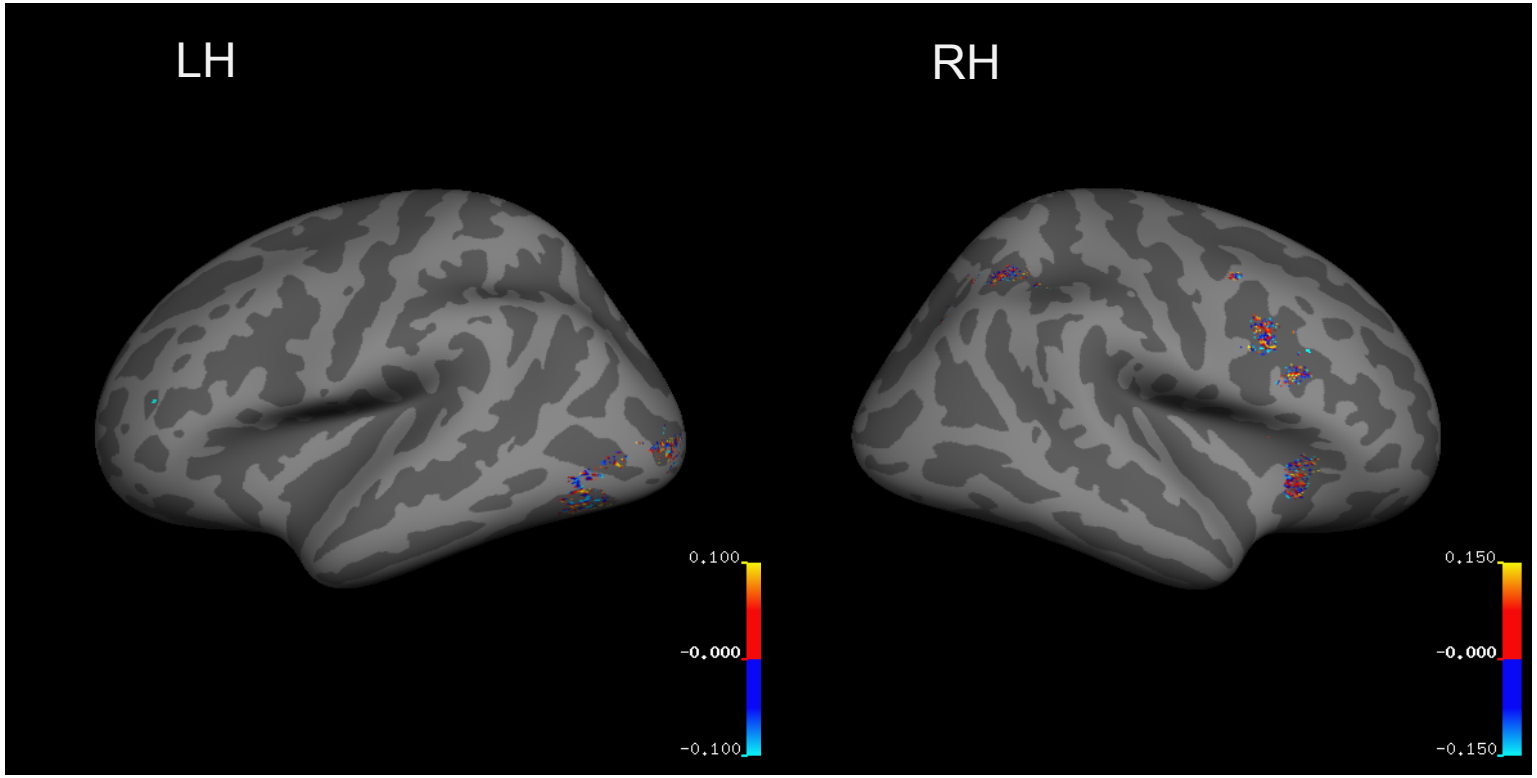


< FRONT – BACK – FRONT>

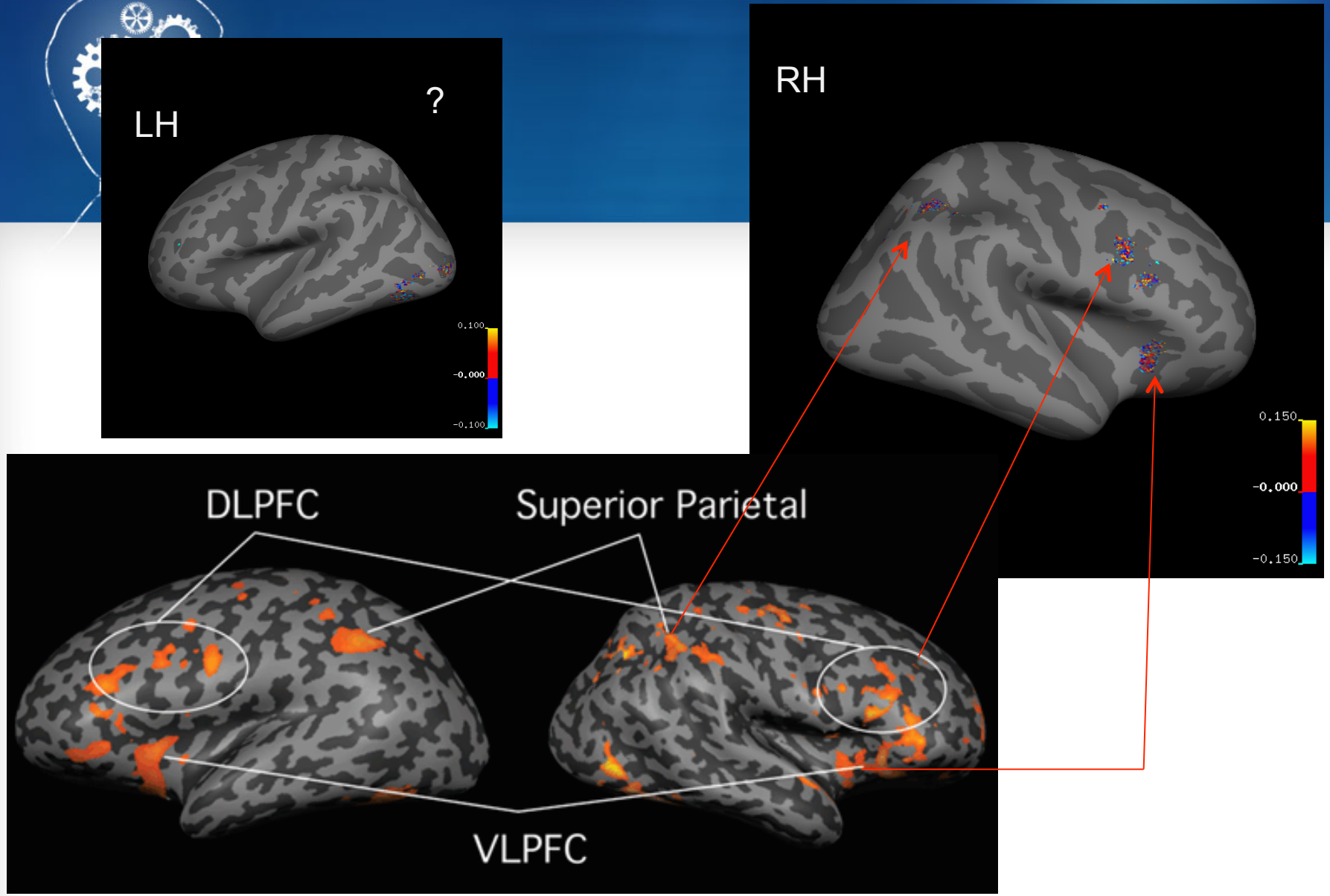




WM vs. Passive Features



< FRONT – BACK – FRONT>



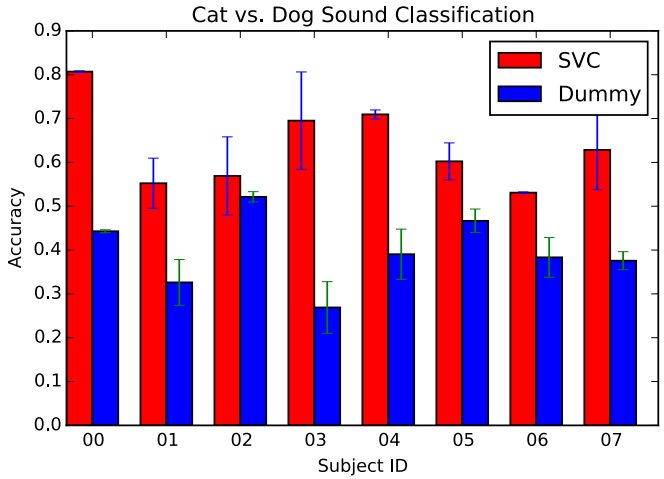
The Multi-Source Interference Task: an fMRI task that reliably activates the cingulo-frontal-parietal cognitive/attention network

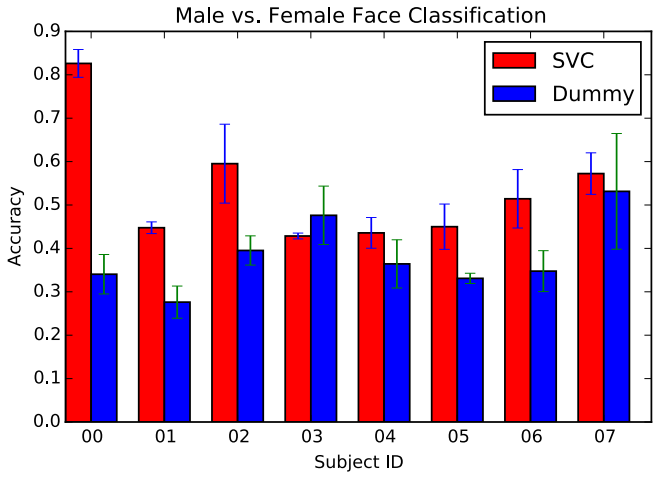
George Bush & Lisa M Shin

Nature Protocols **1**, 308 - 313 (2006)

Results: H3 and H5

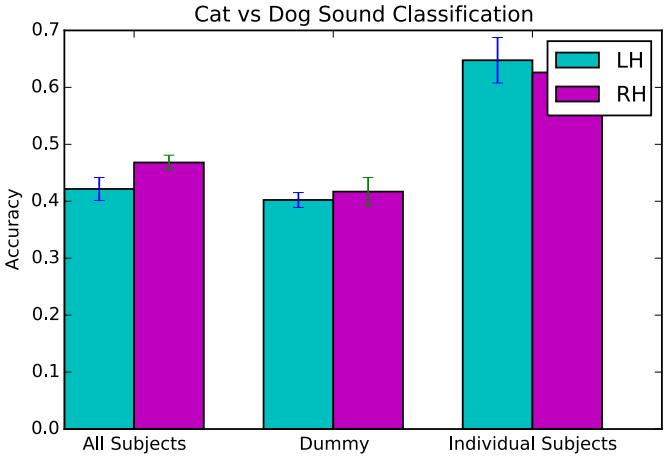
- Separate classifiers for each individual
- Cat vs. Dog sound classification accuracy higher than chance for most subjects
- Male vs. Female face classification accuracy borderline higher than chance in most subjects

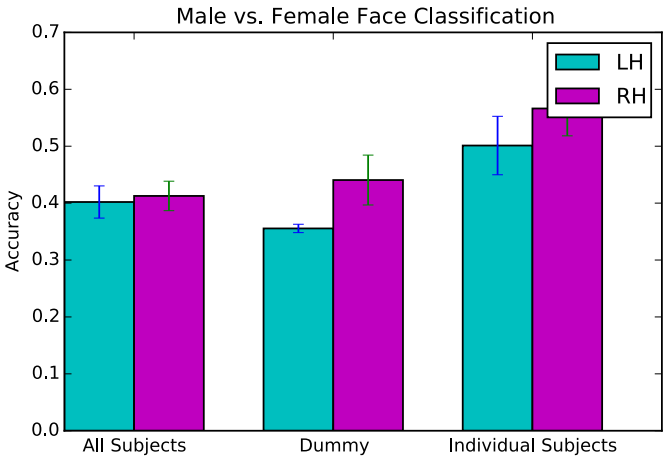




Results: H4 and H6

- Classifiers attempting to predict specific stimuli
  - Sound: 42%, 47%
  - Face: 40%, 41%
- Object representations in the brain vary widely across individuals
- Cat vs. Dog sound classification for individual classifiers better
  - LH: : 65%
  - RH: 63%
- Male vs. Female face classification for individuals only slightly better





Future Work

- Train individual classifiers with more samples
  - Improve accuracy
  - Visualize
- Project coefficients for individual brains to visualize differences in object representations
- Compare results of using feature selection to using a brain mask
- Investigate positivity/negativity of SVC weights
- Confirm results of visualizing the working memory vs. passive SVC coefficients