



Computer Science and Artificial Intelligence Laboratory

Technical Report

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Preliminary MEG decoding results

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CBCL, McGovern Institute for Brain Research, MIT

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Introduction

Decoding analysis has been applied to electrophysiology and fMRI data to study the visual system, however, this method has only been applied to MEG visual data in a few instances [1]. Here we use the Neural Decoding Toolbox for Matlab [2] to show that it is possible to decode visual stimuli based on MEG data.

Stimuli

- 25 scene images (stanford.edu/fmriscenes/resources.html) from five categories (highway, beach, buildings, forest, mountain)
- Images are presented at approximately 5x7 degrees for 50 ms, 50 times each



Example stimuli from the above image set

Experimental setup

Unless otherwise noted, the following experimental setup was used:

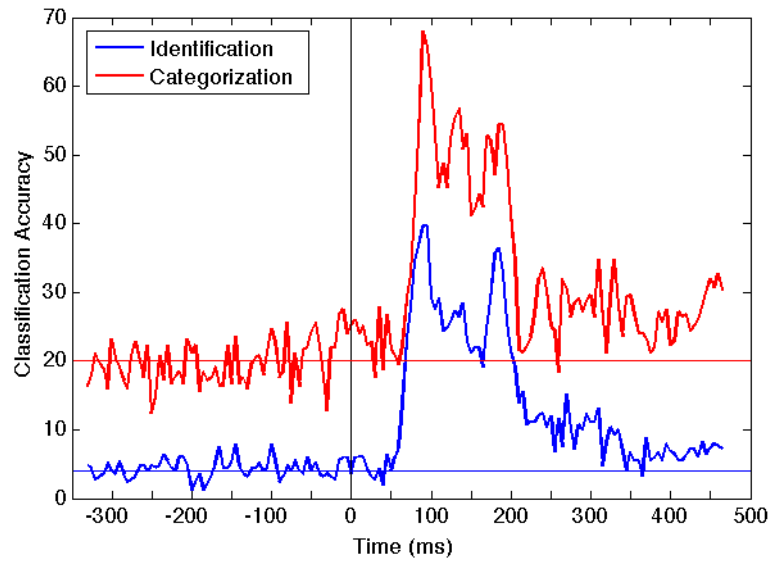
- Images presented at approximately 4x5 degrees, for 50ms
- Each image presented 50 times
- Images presented in the center of the screen with a fixation cross centered on the image
- Subjects performed an orthogonal task related to the color of the fixation cross

Parameters

Unless otherwise noted, the following parameters were used for data pre-processing and decoding analysis:

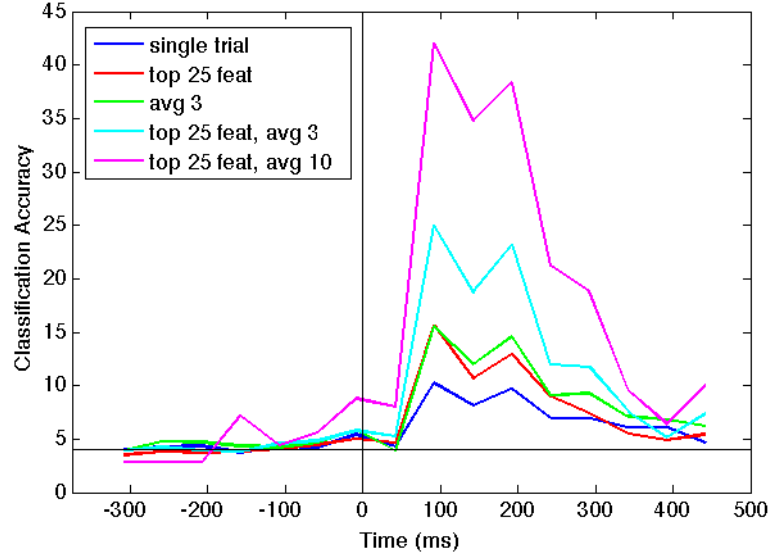
- Signal Space Projection (SSP) applied with Brainstorm software [3]
- Bandpass filtered from 2-100 Hz
- Each channel (306 total) used as a feature (value in Tesla)
- Averaged over 5ms time bins
- Each channel data is z-score normalized
- Averaged (across 10 trials)
- Select most selective channels in training (here 25 were selected)
- Maximum correlation coefficient classifier
- Train/test on 5 cross-validation splits

Identification and categorization results



Parameter optimization

- Averaging: Decode with single trial, 3 trials averaged, or 10 trials averaged
- Feature selection: Select 25 (similar results for 50 or 10) most selective features in training, and use only those features in testing

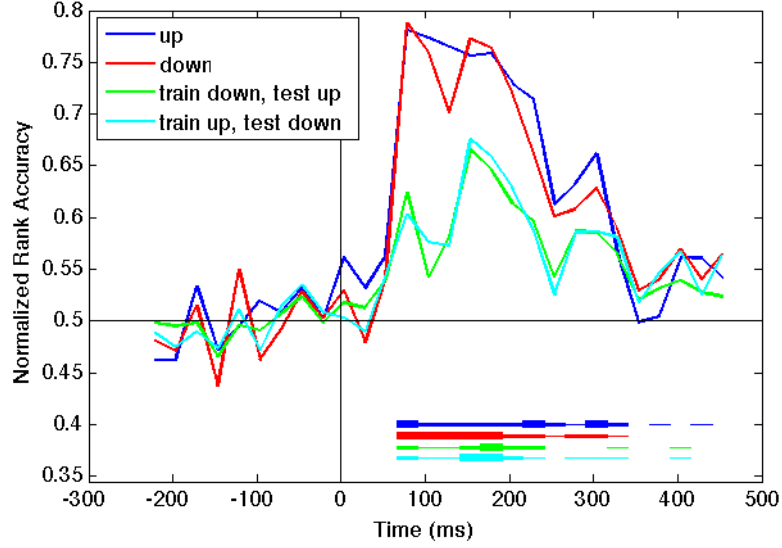


Position invariance

Stimuli: Four (one subject) or ten scenes (two subjects) from the above dataset, were presented at approximately 3x5 degrees and at two different positions: -2, +2 degrees vertically.

For both invariance cases, features selection was performed with a mix of (non-test) data from both image positions. Training, however, was performed using only data from the opposite position as testing.

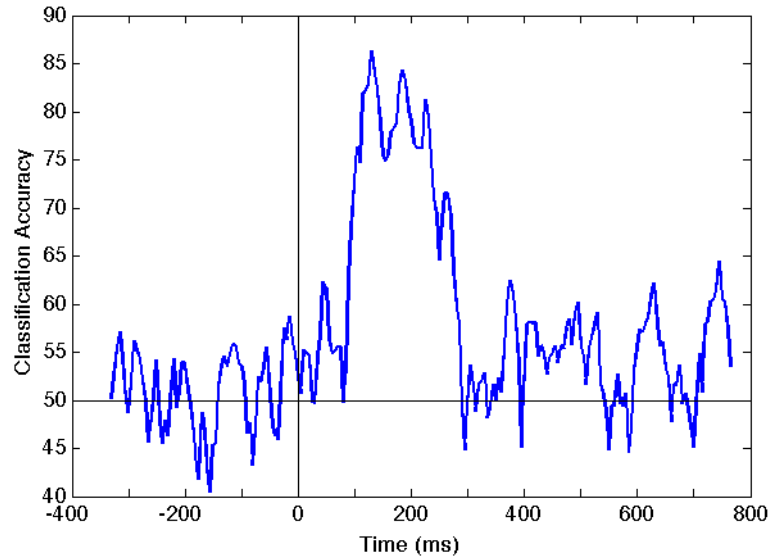
The below plot shows the average of the decoding results for three subjects. The classifier performance is measured in terms of normalized rank (based on an ordered list of predictions from the classifier.) The lines at the bottom of the plot indicate time points when the decoding results were significantly above chance ($p < 0.005$). The width of the line indicates how many of the three subjects' decoding results are significant at that time (thinnest is one subject, thickest is all three subjects.)



Decoding scrambled vs. normal images

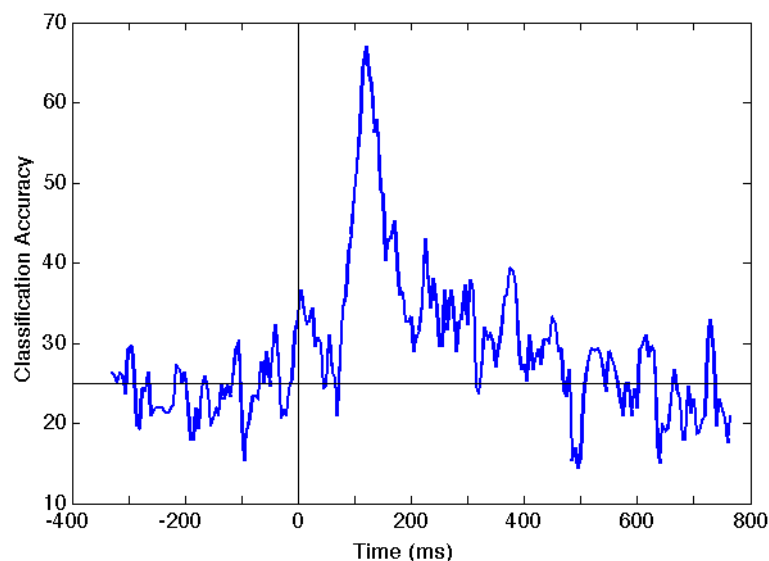
Stimuli: Four grayscale scenes from the above dataset and their scrambled counterparts, generated with a texture synthesis algorithm [4].

The classifier was trained to decode the four normal images from their scrambled counterparts.



Letter stimuli

Stimuli: Four different black letters ('A', 'B', 'C', 'D') on a white background.



References

- [1] Carlson, Hogendoorn, Kanai, Mesik, and Turret. High temporal resolution decoding of object position and category. *The Journal of Vision* 11.10 (2011): 1-17.
- [2] Meyers, E. (in preparation). The Neural Decoding Toolbox for Matlab.
- [3] Tadel F, Baillet S, Moshier JC, Pantazis D, Leahy RM. Brainstorm: A User-Friendly Application for MEG/EEG Analysis. *Computational Intelligence and Neuroscience* , vol. 2011, Article ID 879716, (2011): 1-13.
- [4] Portilla, J and Simoncelli, E. A Parametric Texture Model Based on Joint Statistics of Complex Wavelet Coefficients. *International Journal of Computer Vision* 40.1 (2000): 49-71.

