Introduction

How are objects represented in the brain? At least two rival hypotheses have emerged: the localized representation hypothesis and the distributed representation hypothesis. These two hypotheses have produced a large body of evidence which appears to be contradictory. We will explore two possibilities that may account for these discrepant results:

- The lack of sensitivity and validity of standard methods
- The underlying complexity of the object representation

H<sub>2</sub>: Localized Representation

Certain regions in the brain are explicitly devoted to processing a certain type of object, e.g., the fusiform face area and parahippocampal place area.

H<sub>3</sub>: Distributed Representation

Object representation is distributed across the cortex, and is stored in a pattern of activation or combinatorial code. Supported by K. Grill-Spector et al. 2006

Special populations who have difficulty with object recognition provide a means of comparing object representations across individuals while holding the stimulus constant. One such population, that of individuals with autism spectrum disorder (ASD), offers such an opportunity. A recent study of the Fusiform Face Area (FFA), presents evidence for functional heterogeneity in high-resolution imaging. In the second study, we applied classifiers to data collected from neurotypicals and ASD subjects while they were viewing faces and arrows.

Methods

We used two classifiers, a support vector machine (SVM) and a neural net. For each classifier, the following steps were performed:

1. Preprocessing the data
2. Feature selection
3. Classification

High-Resolution FFA Data

In 2006, Grill-Specter et al. claimed they found evidence for functional heterogeneity in high-resolution FFA data. Baker et al. observed the same trend in data collected by K. Grill-Specter and R. Sayre, using the same protocol and high resolution (1mm)

References


Heterogeneity in high-resolution FFA data may be due to either arrow direction or eye gaze direction. For classifiers, data were z-scored within their time series and clusters were selected if they satisfied z ≥ 3 at some point in their time series.

Conclusions

- A more sensitive method of analysis than the current standard is crucial in fMRI data analysis
- These results support a distributed object representation in the cortex
- In future work, object recognition studies in special populations may provide insights into object representation in the cortex

Results: Autism Data

Linear SVM produced poor results (cross-validation 44%), possibly due to noise in the data or high nonlinearity near margins.

Alternatively, the neural net was able to classify the data in the training set with 100% accuracy. The following are the results of a split-halves cross-validation test:

<table>
<thead>
<tr>
<th>ASD</th>
<th>Person</th>
<th>Person</th>
<th>ASD</th>
<th>NT</th>
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<td>D</td>
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<td>9</td>
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A weight-based sensitivity analysis, calculated from the weights of each input node of the trained neural net, shows the voxels that most strongly influence classification. We can directly compare the neural net results with the previously performed GLM results.

Results: HR FFA Data

A noise-based sensitivity analysis was performed: noise was added to one voxel at a time, and the resulting classification error for each class is measured. Shown are voxels which, after noise was added, decreased the model’s ability to accurately classify a category by >20%.

Data collected by K. Grill-Specter and R. Sayre, 2006

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Data collected by K. Grill-Specter and R. Sayre, 2006

Continuing work includes performing a noise-based sensitivity analysis on these data, to determine which condition the significant voxels are selective for.

Results: Autism Data

Neurotypical:

GLM Results

ASD Results

Neural Net Results

ASD subject: