Multivariate analysis of a previously collected fMRI data set

Team Tool Time

Conor Wild, Scott Macdonald, Nevena Savija & Jason Gallivan

Affordances - Gibson
**Stimuli**

**Tools**
- Tool right
- Non-tool left
- Non-tool right
- Tool left

**Non-tools**
- Tool left

---

**Design & timeline**

- Tools *passively* viewed during 2 s viewing window
Tool & Reaching/Grasping Networks

- PMd
- M1
- aIPS
- cIPS
- SPL
- MTG

TOOL NETWORK

REACHING & GRASPING NETWORK

Univariate Results

Main effect of Tool (Tool vs. Non-tool)

LH
RH
Univariate Results

Main effect of Orientation (left vs. right)

Univariate Results

Interaction Tool x Orientation
Might there be more information represented in the data?

- We can attempt to extract more detailed spatial information in the data....
  - Multivariate analysis methods

Pipelining

- 12 subjects x 3 hours = a lot of data
- “Manual” preprocessing time consuming
- Adapted pipeline to batch process
  - Automatic Analysis
    https://github.com/rhodricusack/automaticanalysis/wiki
Preprocessing steps

1. Slice timing
2. Motion correction/Affine registration
3. Coregistration
4. Normalization estimation
5. Smooth (univariate only)
Spatial pre-processing

Goals:

(1) To match all scans of individual subjects

(2) To match all scans of subjects into standard space

Spatial pre-processing

• Slice timing correction: all volumes at the same time

• Realign: *rigid body* transformation, translations and rotations

• Coregistration: match scans of different modalities (functional to structural)
Spatial pre-processing

- Normalization: remove variability between brain shapes
- Smooth function is the final step in spatial pre-processing: it blurs the functional images.

GLM: \[ Y = Xb + e \]
Representational Similarity Analysis
(basically, MVPA) (Kriegeskorte et al., 2008)

Spatial patterns of activity

Repetitions

1 2 k

A

B

Neural Similarity Matrix

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.8</td>
<td>0.1</td>
</tr>
<tr>
<td>B</td>
<td>0.1</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Similarity between spatial patterns is measured with correlation.

Searchlight Analysis

Neural Similarity Matrix

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.8</td>
<td>0.1</td>
</tr>
<tr>
<td>B</td>
<td>0.1</td>
<td>0.8</td>
</tr>
</tbody>
</table>
Hypothesized matrix - diagonal

RSA Searchlight Results

Diagonal Matrix

LH RH

P<0.001

1 x 10^{-6}

Uncorr.

P<0.001
### Hypothesized matrix - Items

<table>
<thead>
<tr>
<th>LH</th>
<th>RH</th>
</tr>
</thead>
<tbody>
<tr>
<td>LO</td>
<td>P&lt;0.001 x 10^-6</td>
</tr>
</tbody>
</table>

### RSA Searchlight Results

#### Item Matrix

- LH
- RH

- 1 x 10^-6
- Uncorr.
- P<0.001
LO activity

Item Matrix

Localizer Stimuli

- Bodies
- Objects
- Tools
- Scrambled

LO (Tool data)
LO (Localizer defined)
Objects > Scrambled

Hypothesized matrix – tools vs. non-tools

- Red: Item (Tool data)
- Blue: LO (Localizer defined)
- Objects > Scrambled
RSA Searchlight Results

Tool Matrix

Hypothesized matrix – left vs. right orientation
RSA Searchlight Results

Orientation (L vs. R) Matrix

Hypothesized matrix – tool x orientation interaction
RSA Searchlight Results

Tool x Orientation Interaction

- LH: Left Hemisphere
- RH: Right Hemisphere
- Anterior IPS
- Early visual cortex

Tool & Reaching/Grasping Networks

- PMd
- M1
- SPL
- PMv
- aIPS
- cIPS
- MTG

TOOL NETWORK

REACHING & GRASPING NETWORK
Questions?

Extra Slides
The standard approach

• Each voxel considered in ISOLATION

• Massive univariate testing
The standard approach

- Massive univariate (GLM) testing at each voxel

\[ Y = Xb + e \]
GLM: \[ Y = Xb + e \]

- Apply this independently to each voxel in turn (many 1000’s)
- Define a contrast (t-test)
- Make some correction for multiple comparisons
- To facilitate detection, we’ll smooth across data (increase signal:noise)

***Implicit acknowledgement that it doesn’t make sense to consider each voxel independently!!!***
Hypotheses for Scott for right hand….

Hypotheses for Scott for left hand….