Power & Sample Size Maps for Neuroimaging Studies by Non-Central Random Field Theory (319-TH-AM)

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How many subjects do we need to scan in our study?
Motivation

- Neuroimaging data analysis
  - Voxel-by-voxel basis (massively univariate)
- Calculating power – difficult due to
  - Massive multiple comparisons
  - Spatial correlation
  → No effective power calculation method
- Random field theory (RFT)-based method
  - Accounting for multiple comparisons
Statistical Power

- Power $\leftarrow$ distributions under $H_0$ and $H_A$

Under $H_0$

No signal

Under $H_A$

Signals in some areas

Threshold (p<0.05, FWE corr.)

To control family-wise error (FWE) rate
Modeling Signals

• Finding distribution under $H_A$
  - Defining $H_A$ explicitly
  - Signal areas and effect size

• Non-central T- or F-random field
  - To describe 3D nature of signals
  - Analogous to non-central random variable

Effect size $d=1.2$
Power Calculation Formula

Power can be calculated by

\[ \text{Power} \approx \sum_{i=0}^{3} \mu_i(B) \rho_i'(\mu_c; \delta) \]

- Resel count (describing)
- Resel density (non-central T- or F-field)
- Non-centrality parameter (describing effect size)
- FWE-corrected threshold
Power Curves

- Information required
  - Signal area ← *a priori* hypothesis
  - Effect size ← Pilot data, literature
- Example: auditory fMRI experiment

<table>
<thead>
<tr>
<th>Areas of anticipated signals</th>
<th>Left auditory cortex</th>
<th>Right auditory cortex</th>
<th>Left &amp; right auditory cortices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect size</td>
<td>1.15</td>
<td>0.99</td>
<td>1.07</td>
</tr>
</tbody>
</table>
Multiple Power Curves

- With a pilot data set
  - Effect size → power curve
  - Small neighborhood around each voxel

Power curves → displayed as a 3D image
Power Maps

- Shows local variability in sensitivity
- Example: auditory fMRI experiment
  - Power with different sample sizes
Sample Size Maps

- Visualizing sample size N
  - To detect signals at given power
  - Tool for study planning

Power=70%  Power=80%  Power=90%

Sample size

N=11  N=13  N=15
Application

• Mock pilot data set
  – Auditory fMRI experiment
  – 5 contrast images from original N=41
  – Activation (white noise > silence)

• Objective: how many subjects?
  – Determined from mock pilot data (N=5)
Mock Pilot Data

- Intra-subject analyses
  - Activations in L/R auditory cortices

- Group analysis
  - No activation
  - Low df (=4)
Power & Sample Size Maps

Sample size (80% power)

13+ subjects needed for ≥80% power

Elevated power in auditory cortices

Group analysis (N=15)

Significant activations as predicted
Conclusion

- **RFT-based power calculation**
  - Power corrected for multiple comparisons
- **Power & sample size maps**
  - Local variability in sensitivity
  - Generated with small sample size
- **Useful study planning tool**
In the Future

- Poster on Thursday (319-TH-AM)
- To appear in NeuroImage
- Software tool for power calculation
- Visit our web site
  http://www.fmri_wfubmc.edu/
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