FSL FEAT
fMRI Expert Analysis Tool

Data downloaded from: OpenfMRI.org

- single subject analysis (first level)
- group or multi-session analysis (higher level)
Stimulus Block Design (rArA)
fMRI DATA
Block Design with fMRI data

stimulus

stimulus

stimulus

ISI

ISI
Block Design

Stimulus
Sampling
BOLD signal

Event Design

Stimulus
Sampling
BOLD signal
Predicted fMRI data

stimulus presentation × hemodynamic response = predicted timeseries
Roden's fMRI simulator

fMRI Simulator

Designing an fMRI study is a daunting task. Note that with fMRI, you have to tradeoff predictability with statistical efficiency. Completely random event-related designs will inherently have low power, requiring long scanning sessions. While block designs offer optimal statistical power, the participant can anticipate the upcoming type of condition. You can download the software here:

- Windows executable
- Windows executable This version is older, and more complicated but has more features.
- Macintosh OS X application (10.6 or later, Intel CPU)
- Source code

This software can generate convolved models for a few basic designs, and also allows you to load in your own custom text files. The software uses the canonical hemodynamic response function used by SPM to convolve events, reporting efficiency as the mean variance across conditions. This efficiency is only relative - if you change the TR or number of volumes, many efficiency parameters will alter. Also note that this software generates a general efficiency value (the predictable variance of a condition), but does not calculate whether different conditions create independent signals. Finally, note that this software (like most analysis packages) assumes completely linear addition of signal from multiple events.

http://www.mccauslandcenter.sc.edu/CRNL/tools/fmririsim
Gamma HRF

http://www.mccauslandcenter.sc.edu/CRNL/tools/fmrism
Double Gamma HRF

http://www.mccauslandcenter.sc.edu/CRNL/tools/fmrisim
Fmri Simulator

Block design – Gamma HRF

http://www.mccauslandcenter.sc.edu/CRNL/tools/fmrisim
Fmri Simulator

Block design – double Gamma HRF

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
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<td>Block</td>
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http://www.mccauslandcenter.sc.edu/CRLN/tools/fmrisim
Fmri Simulator

Event related design – Gamma HRF

http://www.mccauslandcenter.sc.edu/CRNL/tools/fmrisim
Fmri Simulator

Event related design – Double Gamma HRF

http://www.mccauslandcenter.sc.edu/CRNL/tools/fmrisim
Fit with (red) and without (black) HRF convolution

www.fil.ion.ucl.ac.uk/~mgray/Presentations/Basis%20Functions.ppt
fMRI Simulator Exported Conditions

onset file for FEAT

<p>| | | | |</p>
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First Level Analysis

- Number of inputs: 1
- Select 4D data
- Output directory: data/ds017/sub001-A/TASK001-RUN001/
- Total volumes: 182
- Delete volumes: 1
- TR (s): 2.0
- High pass filter cutoff (s): 100
First Level Analysis

**Goal:** model brain response to a stimulus

**Method:** include in the model any explanatory variables (EVs) that could affect brain response to the stimulus

“rest” is not modeled as an EV because it is associated with “non-stimulus” brain response
First Level Contrasts

<table>
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<th>NO</th>
<th>MAYBE</th>
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<tr>
<td>across groups</td>
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<td>across conditions</td>
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<tr>
<td>stimulus on – stimulus off</td>
<td>X</td>
<td></td>
<td></td>
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Goal is to model brain response during stimulus presentation, including in the model any explanatory variables (EVs) that could affect brain response to the stimulus.
Examples of Higher Level Contrasts

**Second Level Examples**

1) subject 1, subject 2, subject 3, …. subject N (average)
2) subject 1-run 1 * subject 1-run 2 (average or diff)
3) subject 1-cond 1 * subject 1-cond 2 (average or diff)

**Third Level Examples**

4) avg [s1r1 + s1r2], avg [s2r1 + s2r2], avg [s3r1 + s3r2], …
5) diff [s1c1 – s1c2], diff [s2c1 – s2c2], diff [s3c1 – s3c2], …
First Level Type of Analyses

- First-level analysis
- Full analysis

[Box with settings]
- Number of inputs: 1
- Output directory: /data/ds017/sub001-A/TASK001-RUN001/
- Total volumes: 182
- TR (s): 2.0
- High pass filter cutoff (s): 100

[Menu]
- Full analysis
  - Pre-stats
  - Pre-stats + Stats
  - Stats
  - Stats + Post-stats
  - Post-stats

[Options]
- Go
- Save
- Load
- Exit
- Help
- Util
Higher Level Analysis

The image shows a user interface for higher-level analysis in a software application. The interface includes options for selecting inputs and specifying output directories. The interface is designed to process 3D images from FEAT directories, with specific fields for the number of inputs and output directory selection.
Type of Analysis

The image shows a GUI interface with options for different types of analysis. The highlighted option is 'Stats + Post-stats'. The interface includes fields for specifying inputs and output directories.
First Level Data Selection

BOLD 4D file for a single subject (can be betted or not)
Higher Level Data Selection

Inputs are 3D cope images from FEAT directories

Number of inputs: 2
Select cope images

Output directory: [file selection]

Inputs are lower-level FEAT directories
Inputs are 3D cope images from FEAT directories

[GUI interface with buttons: Go, Save, Load, Exit, Help, Utils]
multiple subjects can be processed at the same time using same FEAT parameters
Higher Level Number of Analyses

- Number of inputs: 2
- Select cope images
- Output directory

number of subjects to compare
First vs Higher Level of Analysis

First-level analysis

- Number of inputs: 1
- Output directory: /data/ds017/sub001-A/TASK001-RUN001/
- Total volumes: 182
- TR (s): 2.0
- High pass filter cutoff (s): 100

Go | Save | Load | Exit | Help | Utils

Full analysis

Higher-level analysis

- Inputs are 3D cope images from FEAT directories
- Number of inputs: 2
- Output directory: [blank]

Go | Save | Load | Exit | Help | Utils
First Level Number of Scans

- Number of inputs: 1
- Select 4D data
- Output directory: "-data/ds017/sub001-A/TASK001-RUN001/"
- Total volumes: 182
- Delete volumes: 1
- TR (s): 2.0
- High pass filter cutoff (s): 100

This will be set from the image header.
First level TR setting

This may NOT be set automatically.
First Level Delete Volumes

Remove initial scans if desired
First Level High Pass Filter

rA or rArB cycle for block designs – no less than 50s for event related designs
First Level Pre-stats

- motion correction
- correct field inhomogeneities
- correction for slice timing
- brain extraction
- smoothing
- intensity normalization
- highpass filtering
- ICA
Stats (first & higher level)

A model can be created with either a wizard or full model specification.
Stats (first & higher level model)
Stats (first & higher level)
Stats (first & higher level)

Number of variables to use in modelling the data – variables that explain changes in the time-series data

NOTE: rest is not included as an EV – only activation associated with a stimulus is modelled

shifts waveform in time for better fit
applies same temporal filtering to model as used with data
First Level FEAT Wizard
FEAT Full Model Setup

- Use FIML prewhitening
- Add motion parameters to model
- Add additional confound EVs

Model setup wizard

Full model setup

General Linear Model

EVs

Contrasts & F-tests

Number of original EVs

1

2

EV name: stim

Basic shape: Square

Skip (s): 0

Off (s): 0.08

On (s): 1.42

Phase (s): 0

Stop after (s): -1

Convolution: Gaussian

Phase (s): 0

Sigma (s): 2.8

Peak lag (s): 5

Orthogonalise

Add temporal derivative

Apply temporal filtering

View design

Efficiency

Done
FEAT Full Model Contrast Setup

Original EVs

Real EVs

EVs  Contrasts & F-tests

Setup contrasts & F-tests for

Contrasts 4  F-tests 1

<table>
<thead>
<tr>
<th>Paste</th>
<th>Title</th>
<th>EV1</th>
<th>EV2</th>
<th>F1</th>
</tr>
</thead>
<tbody>
<tr>
<td>OC1</td>
<td>A</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>OC2</td>
<td>B</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>OC3</td>
<td>A&gt;B</td>
<td>1</td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>OC4</td>
<td>B&gt;A</td>
<td>-1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

C1     | A     | 1   | 0   | 0   | 0   |
| C2     | B     | 0   | 0   | 1   | 0   |
| C3     | A>B   | 1   | 0   | -1  | 0   |
| C4     | B>A   | -1  | 0   | 1   | 0   |
FEAT Model

EV “A” model (e.g., word presentation)

EV “B” model (e.g., tone presentation)
**FEAT Model**

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>A</th>
<th>B</th>
<th>B</th>
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<tr>
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<td>0</td>
</tr>
<tr>
<td>C2</td>
<td>0</td>
<td>0</td>
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<td>C3</td>
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<td>C4</td>
<td>B&gt;A</td>
<td>-1</td>
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</tr>
</tbody>
</table>

- **EV “A” temporal derivative (Gaussian HRF model)**
- **EV “B” model (Gaussian HRF model)**
FEAT Post-stats
Choosing Data for Higher Level

number of lower level analyses to be used

choice of lower level contrasts to be used

Inputs are lower-level FEAT directories
Number of inputs: 2
Use lower-level capes: 1
Output directory: /home/cat/FSL-course512-data/ds017/sub0
Higher Level Effects Model

Fixed effects
Mixed effects: Simple QLS
Mixed effects: FLAME 1
Mixed effects: FLAME 1+2

[Diagram of user interface showing options for Higher-level analysis, Stats + Post-stats, Misc, Data, Pre-stats, Stats, Post-stats, Registration, Mixed effects: FLAME 1, Use automatic outlier de-weighting, Model setup wizard, Full model setup, Go, Save, Load, Exit, Help, Utils.]
Higher Level Wizard

- single group average
- two groups, unpaired
- two groups, paired

Options:
- Mixed effects: FLAME 1
- Use automatic outlier de-weighting

Buttons:
- Model setup wizard
- Full model setup
Higher Level Full Model Setup

EVs | Contrasts & F-tests
--- | ---
Number of main EVs | 2
Number of additional, voxel-dependent EVs | 0

Paste | Group | EV1 | EV2
--- | --- | --- | ---
Input 1 | 1 | 1 | 0
Input 2 | 1 | 0 | 1.0

Setup orthogonalisations

Contrasts | F-tests
--- | ---
4 | 0

Paste | Title | EV1 | EV2
--- | --- | --- | ---
C1 | group A > gr | 1 | 1
C2 | group B > gr | -1 | 1
C3 | group A mec | 1 | 0
C4 | group B mec | 0 | 1

Stats + Post-stats

Mixed effects: FLAME 1
Use automatic outlier de-weighting
Model setup wizard
Full model setup

Go | Save | Load | Exit | Help | Util
Higher Level Post-stats

use to restrict area of analysis (ROI selection) – can be binary mask or stats mask

use contrasts to select voxels of interest
If you want to run any custom registrations outside of FEAT then you should do the following in order to re-generate the FEAT registration images and co-ordinate tables:

- run FEAT including the normal FEAT registration.
- replace `example_func2highres.mat`, `highres2standard.mat`, `example_func2standard.mat` with custom mat files
- run `updatefeatreg <featdir.feat> -pngs` to generate all the other transforms and registration summary images
- start Feat and change the mode to run Post-stats only. Select the FEAT output directory as input. Go into the registration tab and turn off all registration. Press GO. This will regenerate the tables with activation co-ordinates in them.