HD4630 Workshop II

First- & Second-Level Analysis

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Workshop I Recap

- Preprocessing
  - Discard pre-steady state TRs
  - Slice-timing correction
  - Rigid-body motion correction
  - Coregistration of functional & anatomical
  - Normalization to standard template
  - Spatial filtering (Smoothing)
- Quality Control
  - Visual inspection
  - Censoring or ”scrubbing” motion

Plan for Today

- Discuss first- and second-level analyses in a traditional general linear model (GLM) framework
- Conduct a first-level, fixed-effects analysis in AFNI using `uber_subject.py`
- Conduct a second-level, random-effects analysis in AFNI using `uber_ttest.py`

First-level Analysis

- First-level analysis involves estimating the β-matrix in

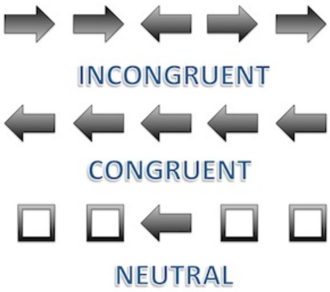
$$Y = X\beta + \epsilon$$

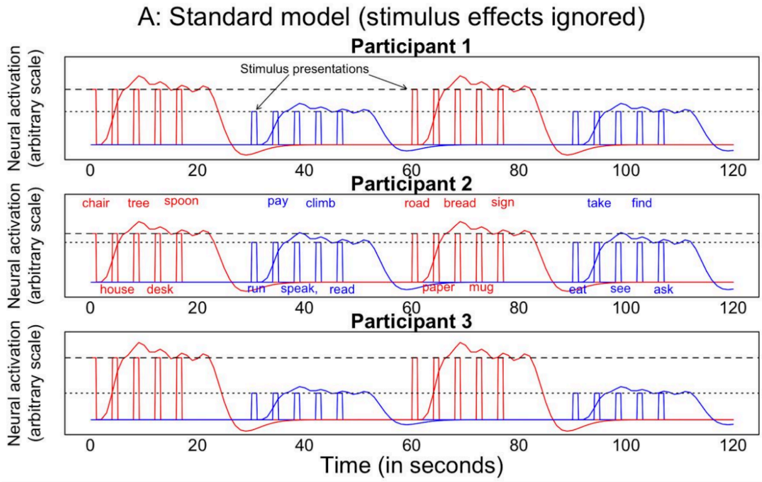
  by constructing the contrast matrix X

- A great review of the math underlying this is available from Mumford Brain Stats

First-Level Analysis, *cont.*

- We need to input the stimulus timing for each of the conditions in our task
  - We'll collapse the two Flanker 'congruent' and 'incongruent' conditions, ignoring participant accuracy





Westfall, Nichols, & Yarkoni
bioRxiv

Second-Level Analysis

- Second-level analysis as implemented in fMRI takes a summary-statistics approach

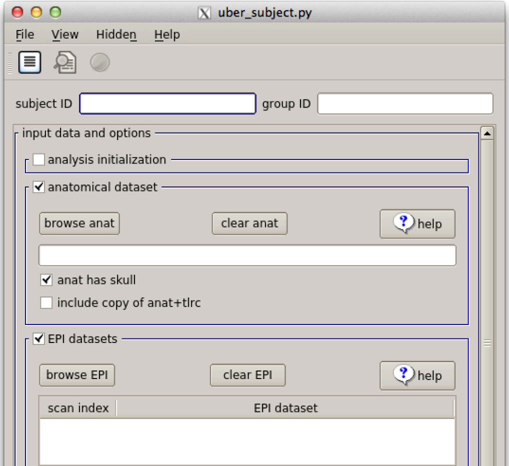
$$\hat{\beta} = X_g \beta_g + \eta^*$$

  where beta-hats for each contrast, for each subject are carried forward from the first-level

- A great review of the math underlying this is available from Mumford Brain Stats

To Do: Set Preprocessing Options

- These were discussed in the last workshop
  - For a review, see last week's slides on the course website

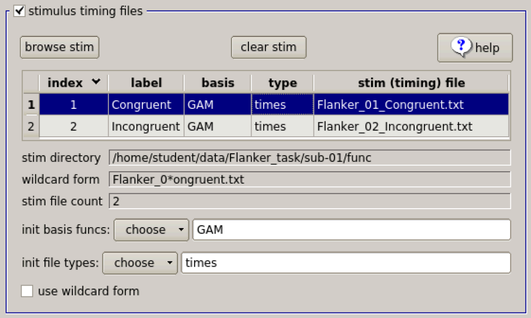


Stimulus Timing Information

- All stimulus timing information is included in the `*events.tsv` files for each run
  - However, we need to convert this information into text files that AFNI will accept
- You'll be provided with a folder containing
  - A Python script to convert these files
  - The created text files themselves

To Do: Enter Stimulus Timing

- In `uber_subject.py`, select the provided text files in the section 'Stimulus Timing Files'
- You can also specify the basis function and the file 'type' (see `3dDeconvolve -help` for relevant options)

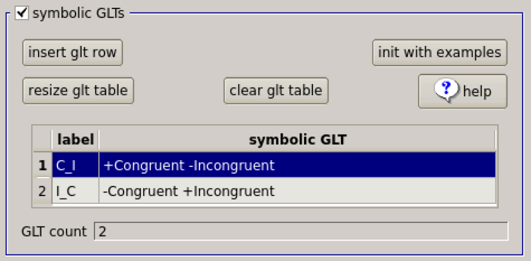


General Linear Tests (GLTs)

- AFNI refers to contrasts between conditions as General Linear Tests (GLTs)
  - This is because we're working in the General Linear Model (GLM)
- We'll need to specify what tests we would like to conduct
  - *Congruent* > *Incongruent*
  - *Incongruent* > *Congruent*

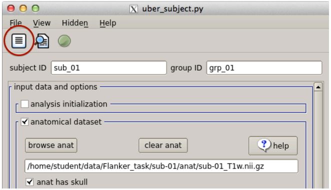
To Do: Specify GLTs

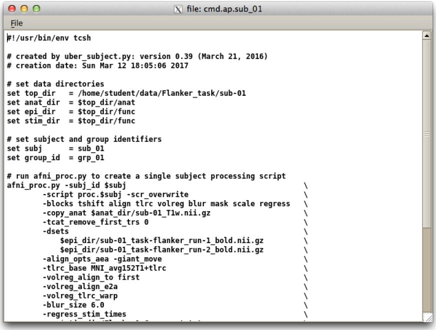
- When inputting stimulus timing files, AFNI will automatically associate each condition with your provided label
- You can use those labels to enter your desired GLTs
  - Select 'init with examples' to see example GLTs with your conditions



To Do: Review Processing Script

- Once you've entered all relevant parameters for preprocessing and first-level analysis, we can review and run the associated script
- Estimated run time is 40 minutes per subject





The Design Matrix

- All of the information we have entered thus far will form the X or 'design' matrix
- This is entered into the model

$$Y = X\beta + \epsilon$$

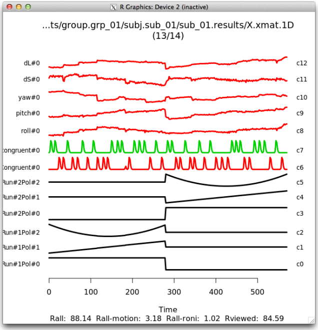
  and will allow us to estimate the β-matrix for each participant

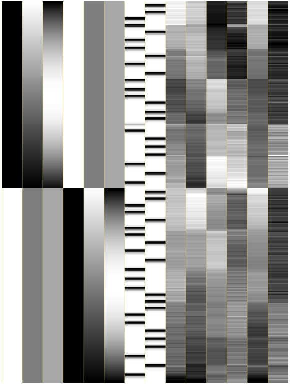
The Design Matrix, *cont.*

- After `uber_subject.py`, the design matrix is output as a `*.xmat.1D` file
- Multiple versions of this file exist, including
  - A list of input stimulus timings (`X.stim.xmat.1D`)
  - A full design matrix with no motion censoring (`X.nocensor.xmat.1D`)
  - A full design matrix with motion censoring (`X.xmat.1D`)
- In this class, we'll be working with the `X.xmat.1D` file

To Do: Review the Design Matrix

- `ExamineXmat` reads in the generated `*.xmat.1D` file to visualize the time series of the design matrix
- `1dgrayplot` reads in the generated `*.xmat.1D` file to visualize a graph of the design matrix





Viewing First-Level results

- We need to carry forward the beta coefficients from the first- to second-level
  - We'll need their index in the created stats file to do that
- To get the correct index, we can view our first-level results in AFNI

Second-Level Analysis

- Once we're confident at the first-level, we can move forward to second-level analysis
- AFNI also provides a GUI to do this!
  - `uber_ttest.py`