HD4630 Workshop I

Preprocessing & Quality Control

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Why Preprocess?

- fMRI data is acquired with physical, biological constraints
  - MRI machines aren't magic!
  - Sampling neural activity in living, breathing human beings
- We need to compare data across participants to draw (statistically) meaningful conclusions

Basic Preprocessing

- Discard pre-steady state TRs
- Slice-timing correction
- Rigid-body motion correction
- Coregistration of functional & anatomical
- Normalization to standard template
- Spatial filtering (Smoothing)

Preprocessing in AFNI

- AFNI allows you to see as little (or as much) detail as you want when preprocessing
- In this class, we'll be using `uber_subject.py`, a preprocessing GUI that hides many technical details
  - To see what's happening, we'll have to look at the generated `tcsh` script

Plan for Today

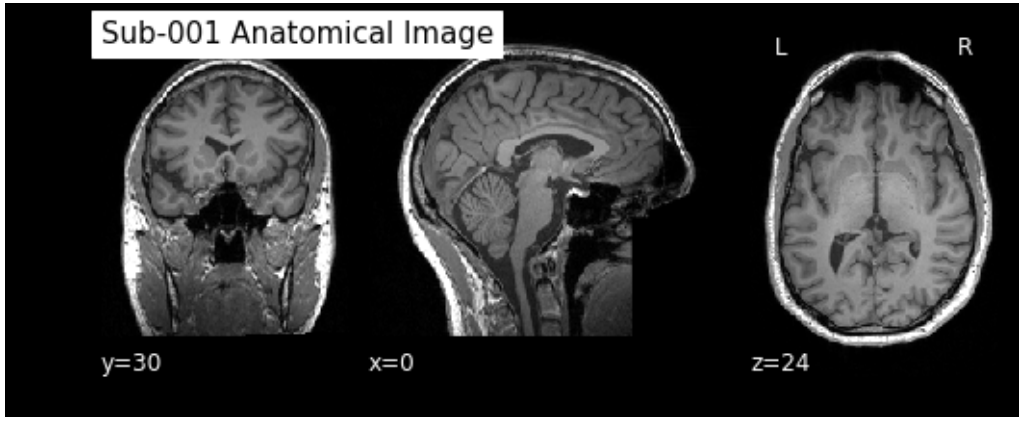
- Review, with examples, basic preprocessing
- Work along in AFNI using `uber_subject.py`
  - Preprocess a participant from OpenfMRI ds000102 (Flanker task)

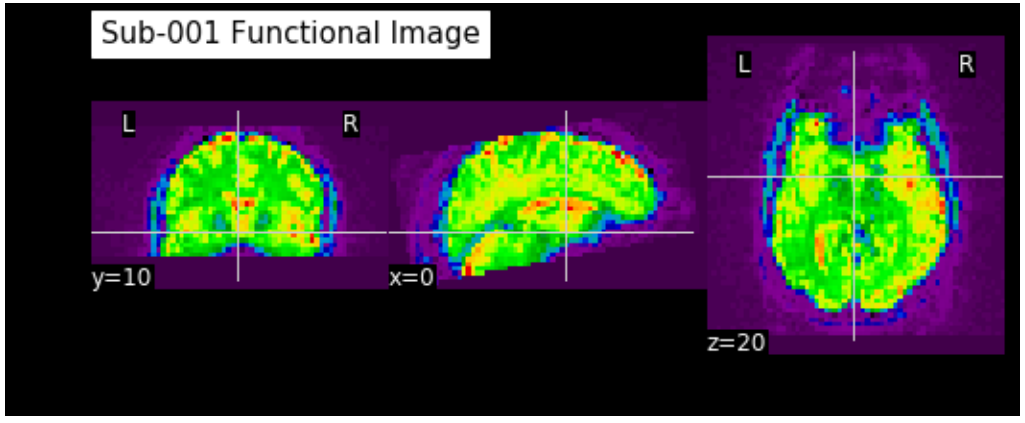
Launching the Docker Container

- We want you to run this locally, so you'll need to launch the docker image you downloaded
- The full instructions to do so are on the course website, but as a quick reminder:
  - For Mac: execute `mac_launch.sh` in a terminal with Docker running
  - For Windows: execute `windows_ip.cmd` in a command prompt. Then, supply that IP to `windows_launch.sh` in a Docker Quickstart Terminal

First Steps: Looking at the Data

- No matter what you're doing, this is the first step!
- Here, we'll need to look at both our anatomical and functional images



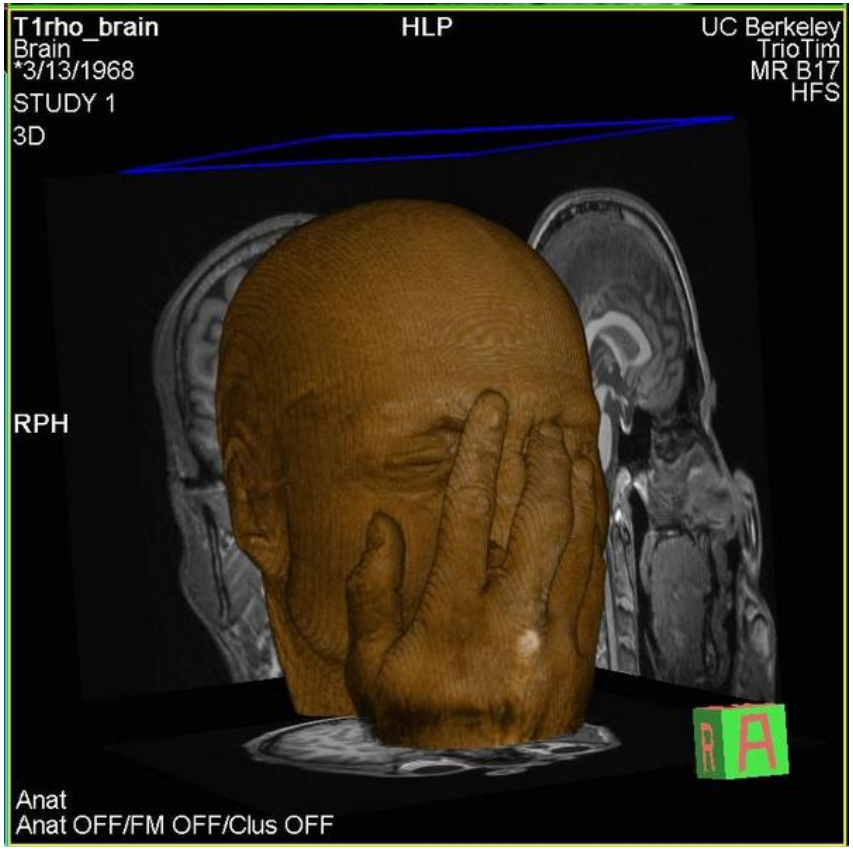


To Do: Open Data in AFNI

- Type `afni` into the terminal window to open a new session
- For sub-01 of the Flanker task:
  - Read in the `anat` directory
  - Read in the `func` directory and scroll through the time series of one run
  - Close `afni`

What Happened to My Anatomical Image?

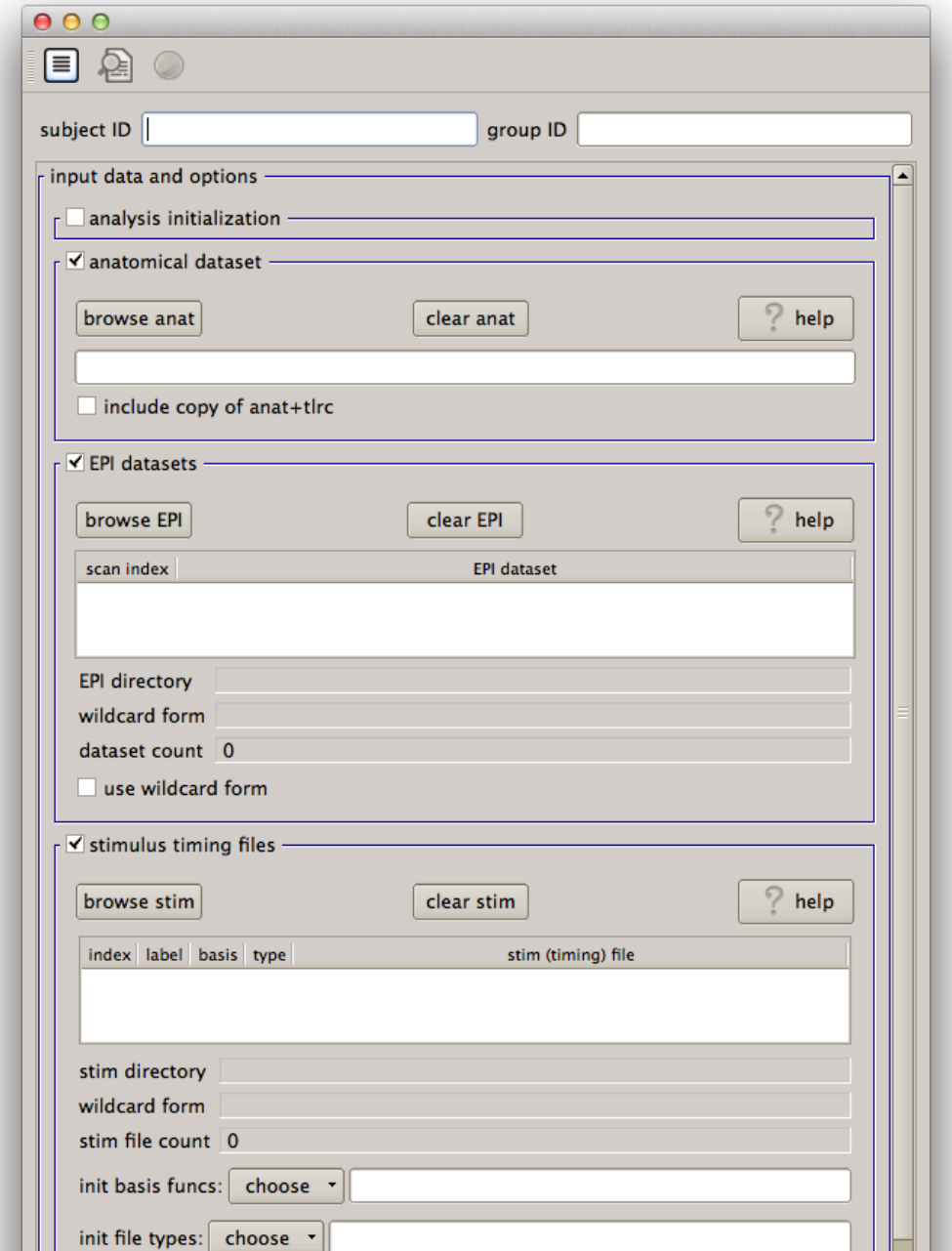
- Defacing is a common step in publicly available MRI data
- Intended to reduce the risk of participant identification



Discard Pre-Steady State TRs

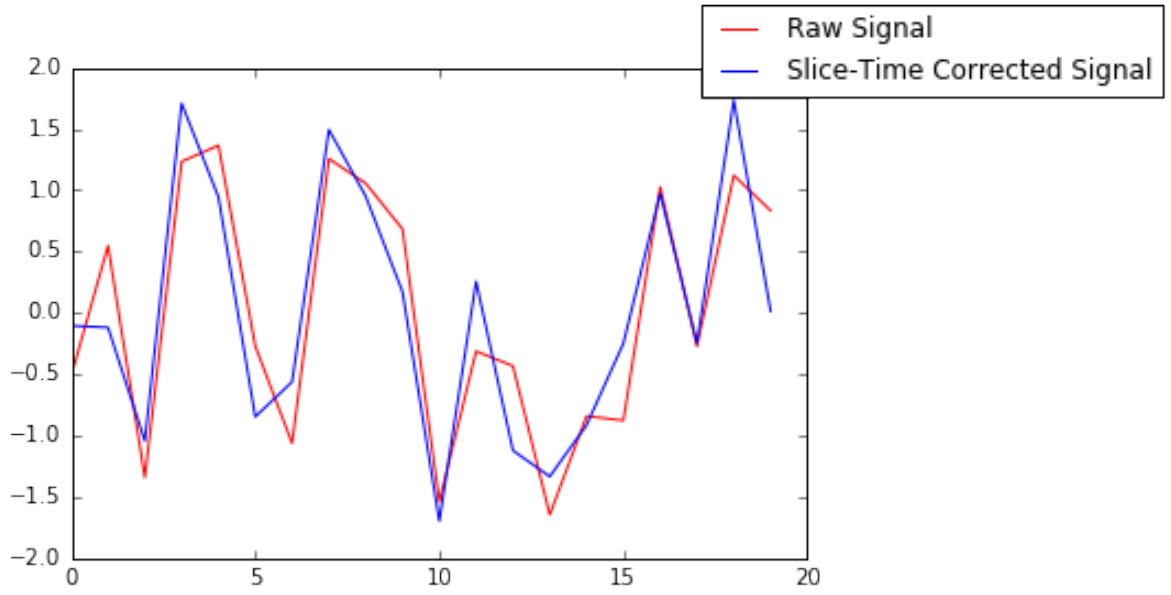
- Pre-steady state or unsaturated volumes show vastly different properties from the rest of an EPI series
- Because of this, some scanners do not reconstruct these ”dummy scans” by default
  - Both of our OpenfMRI datasets exclude pre-steady state volumes, so we will not discard any TRs

To Do: Open `uber_subject.py`



Slice Timing Correction

- In single-shot EPI, each slice in a volume is acquired at a different time
- In our Flanker task, slices were acquired over a 2000ms TR in an interleaved fashion

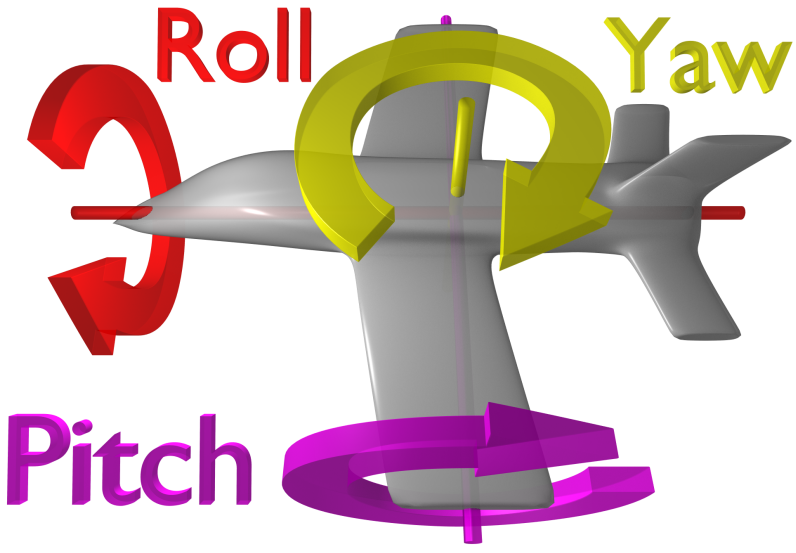


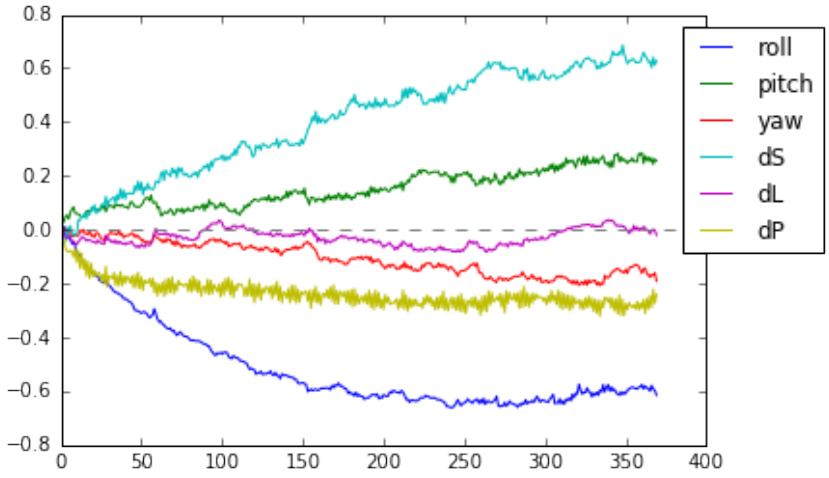
To Do: Slice Timing

- By default, AFNI will check the image header for slice timing information
- You can change the default interpolation used, but we won't address that in this workshop

Rigid-Body Motion Correction

- AFNI will estimate and correct for movement across the entire scan





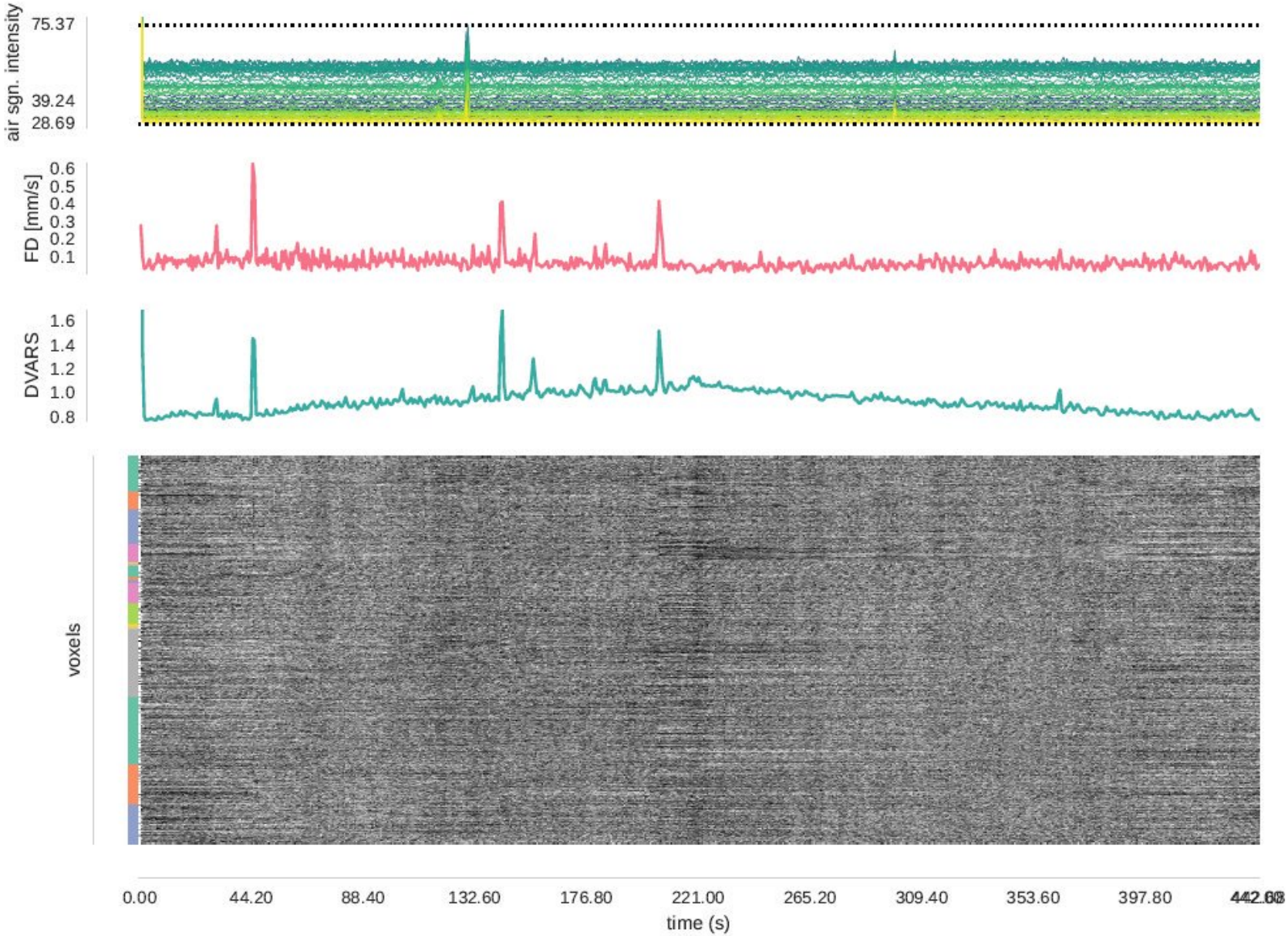
This is a well-behaved participant!

To Do: Set Volume Registration Base

- To perform rigid body motion correction, we need to select a volume to which to register all other volumes
- Since we did not remove any pre-steady state TRs, we can set this option to ’first’

The Limits of Motion Correction

- Movement is a *major* concern in fMRI analysis
- Participants who show high levels of movement may not be usable
  - Even when correcting for motion, subtle differences may remain



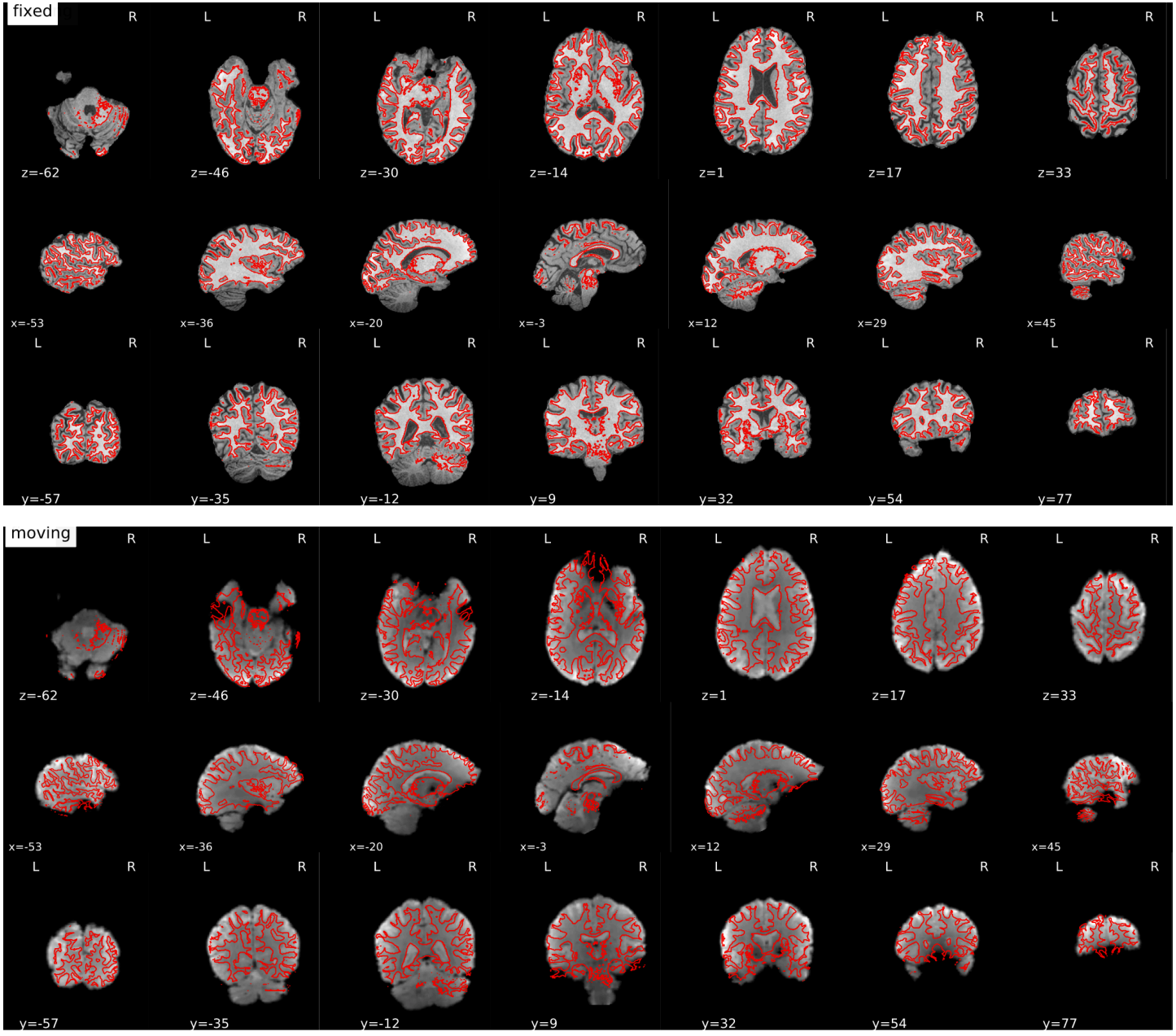
Visualization from MRIQC

To Do: Set Motion Censoring

- 'Motion censor limit' sets the maximum amount of motion allowed in any one TR
- TRs showing motion higher than this limit are 'scrubbed' from the time series

Coregistration

- We need to get the functional and anatomical images into the same space
- By default, these are likely to be out of alignment as participants move between scans
  - After motion correction, all of our functional images should be aligned to one another
  - Aligning these to the anatomical image should therefore be a one step correction



Visualization from fMRIPrep

To Do: Extra Alignment Options

- 'Local Pearson Correlation' is the default coregistration option
  - This is appropriate for T1 to EPI registration, but may need to be changed for other modalities
- Select 'use giant_move' to allow AFNI to align anatomical and functional images where participants have moved substantially

Normalization

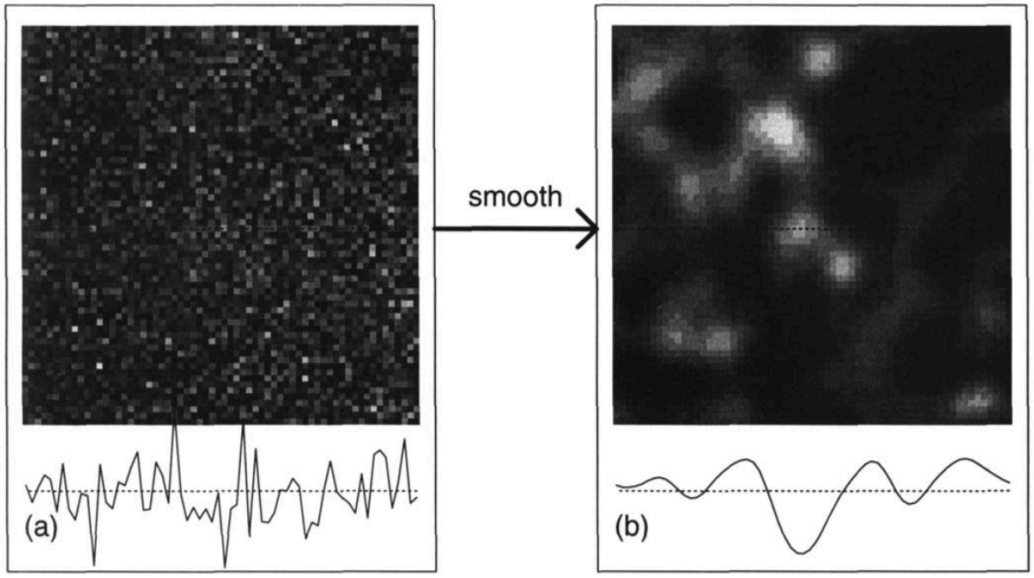
- Standard templates currently in use include Talaraich and MNI
  - MNI based on many living subjects rather than one post-mortem
  - Several different versions of the MNI are in use!

To Do: Extra TLRC Options

- 'TLRC' is short for Talaraich, the default normalization space in AFNI
- Change this to `MNI_avg152T1` to align our subject to MNI space
  - This corresponds to the MNI 2009c nonlinear template

Spatial Filtering (Smoothing)

1. Increases signal-to-noise ratio
2. Helps to ameliorate residual anatomical variability
3. Allows data to meet assumptions of Gaussian Random Field theory
   - A fun introduction to this is provided in Worsley, 1996

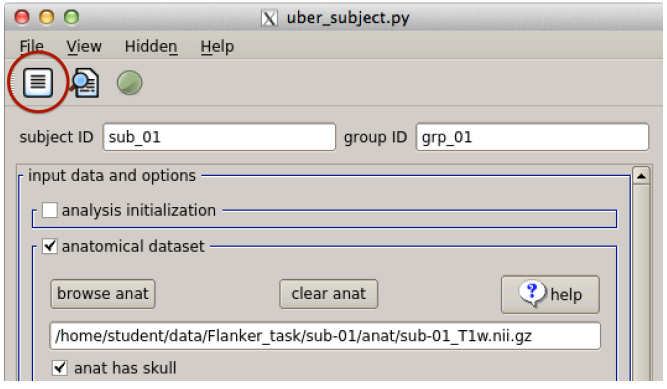


To Do: Set Blur Size

- We need to specify the FWHM (Full-Width at Half-Maximum) of our Gaussian kernel
- 4mm is the default, but we'll increase this to 6mm (FWHM $\geq$ 2x voxel size)

Inspecting our Script

- Now that we have preprocessing set up, we can look at the parameters for our example subject



file: cmd.ap.sub_01

File

```
#!/usr/bin/env tcsh

# created by uber_subject.py: version 0.39 (March 21, 2016)
# creation date: Mon Mar  6 03:38:06 2017

# set data directories
set top_dir   = /home/student/data/Flanker_task/sub-01
set anat_dir  = $top_dir/anat
set epi_dir   = $top_dir/func

# set subject and group identifiers
set subj      = sub_01
set group_id  = grp_01

# run afni_proc.py to create a single subject processing script
afni_proc.py -subj_id $subj                                    \
        -script proc.$subj -scr_overwrite                      \
        -blocks tshift align tlrc volreg blur mask scale regress \
        -copy_anat $anat_dir/sub-01_T1w.nii.gz                 \
        -tcat_remove_first_trs 0                               \
        -dsets                                                 \
            $epi_dir/sub-01_task-flanker_run-1_bold.nii.gz     \
            $epi_dir/sub-01_task-flanker_run-2_bold.nii.gz     \
        -align_opts_aea -giant_move                            \
        -tlrc_base MNI_avg152T1+tlrc                           \
        -volreg_align_to first                                 \
        -volreg_align_e2a                                      \
        -volreg_tlrc_warp                                      \
        -blur_size 6.0                                         \
        -regress_censor_motion 0.3                             \
        -regress_est_blur_epits                                \
        -regress_est_blur_errts
```