fMRI Data

WHERE'S IT COMING FROM AND WHATCHA' DOIN' WITH IT?

AFNI FOR IRTAS
02/07/14
JOHANNA M JARCHO PHD

Things I wish someone had told me...

- Learn a computer language (or two). Yesterday.
 - o A must: UNIX
 - Common: Matlab, Python, T-Shell
 - o Less Common: TCL, Perl
- Blindly trust NO ONE!
 - Don't push buttons without asking questions
- When you get stuck, use your resources wisely:
 - Ask Google before you ask your friend
 - Ask your friend before you ask your supervisor
- Think deeply about organization BEFORE you start.
 - File structure
 - Naming conventions
 - Documentation for your progress and posterity

Variety of Analysis Programs

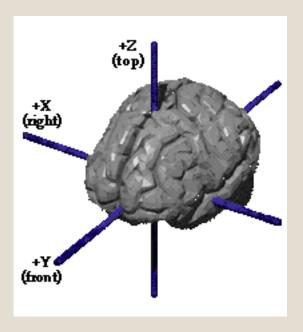
(basic preprocessing steps are more or less the same)

- AFNI
- SPM
- FSL
- BrainVoyager

Data Collection

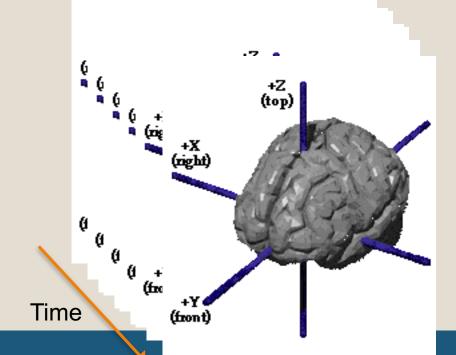
Anatomical Scan

- AKA: Structural
- Data collected without task
- o 3-D



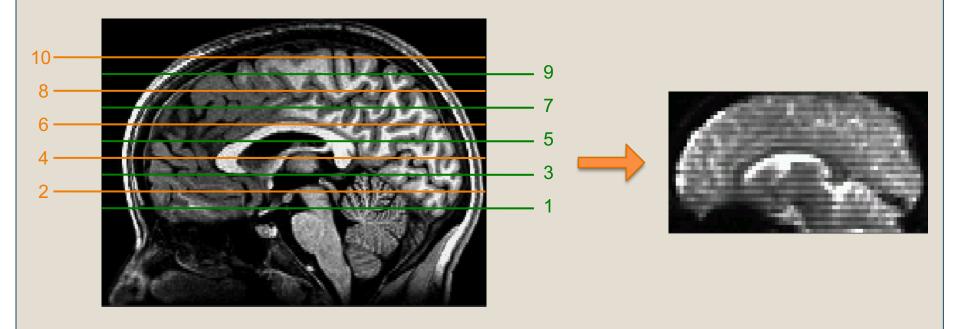
Data Collection

- Functional Scan
 - AKA: EPI (echo planar imaging)
 - Data collected during task (or resting state)
 - O 4D (3D + time)



Data Collection

- Time repetition (TR) / Single whole-brain volume
 - Amount of time required to collect an image of the whole brain
 - Comprised of interleaved slices



Data Transfer

- Raw data is temporarily stored on the scanner
- Transferred to the group's raw data repository
 - Typically via secure copy (scp) or something similar
- Compressed to save space
 - o .tar
 - o .gz
 - .tar.gz

Raw Data

- Must be de-compressed
 - o untar, unzip
 - o "open sesame"



- DICOM format
 - One folder per run
 - One file per slice (.dcm)
 - o Big ass folders!

Convert Data from DICOM to AFNI format

- AFNI format: .BRIK and .HEAD
- DICOM files from each run: 1 set / run
- DICOM files anatomical scan: 1 set
 - Use AFNI commands to do this
 - o dicom datacheck

```
File Edit View Terminal Tabs Help

[jarchoj@springsteen2 arm1]$ ls

3dmotion1.1D OutBrick_r1+orig.BRIK OutBrick_r2+orig.HEAD

3dmotion2.1D OutBrick_r1+orig.HEAD s20780_anat+orig.BRIK
AnatOrder OutBrick_r2+orig.BRIK s20780_anat+orig.HEAD
```

OutBrick_r1+orig

Information about your data...



• 3dinfo....

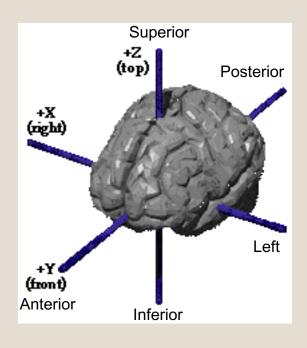
```
Terminal
File Edit View Terminal Tabs Help
[jarchoj@springsteen2 afni]$ 3dinfo OutBrick_rl+orig.
++ 3dinfo: AFNI version=AFNI 2011 12 21 1014 (Aug 9 2012) [64-bit]
Dataset File:
                OutPrick rl+orig
IdentConnection Information hu5taPOpFI7WUjJsanW8Mw Creation Date: Thu Feb 17 10:53:43
2011
Template Space: ORIG
Dataset Type:
                 Echo Planar (-epan)
Bvte Order:
                LSB FIRST [this CPU native = LSB FIRST]
Storage Mode:
                 BRIK
Storage Space:
                193,757,184 (194 million) bytes
Geometry String: "MATRIX(2.5,0,0,-119.35,0,2.5,0,-153.965,0,0,2.6,-7.76829):96,9
6.36"
Data Axes Tilt: Plumb
Data Axes Orientation:
 first (x) = Right-to-Left
 second (y) = Anterior-to-Posterior
 third (z) = Inferior-to-Superior [-orient RAI]
R-to-L extent: -119.350 [R] -to- 118.150 [L] -step-
                                                           2.500 mm [ 96 voxels]
A-to-P extent: -153.965 [A] -to-
                                     83.535 [P] -step-
                                                           2.500 mm [ 96 voxels]
                 -7.768 [I] -to-
                                     83.232 [S] -step-
I-to-S extent:
                                                           2.600 mm [ 36 voxels]
Number of time steps = 292  Time step = 2.30000s  Origin = 0.00000s  Number time
-offset slices = 36 Thickness = 2.600
 -- At sub-brick #0 '#0' datum type is short:
                                                          0 to
                                                                       19482
 -- At sub-brick #1 '#1' datum type is short:
                                                          0 to
                                                                       12831
  -- At sub-brick #2 '#2' datum type is short:
                                                          0 to
                                                                       10722
** For info on all 292 sub-bricks, use '3dinfo -verb' **
----- HISTORY -----
[szuhanyk@springsteen2.nimh.nih.gov: Thu Feb 17 10:53:35 2011] to3d -prefix OutB
rick rl -time:zt 36 292 2.3sec alt+z mr 0009/anon 00001.dcm mr 0009/anon 00002.d
cm mr 0009/anon 00003.dcm ... mr 0009/anon 10511.dcm mr 0009/anon 10512.dcm
```

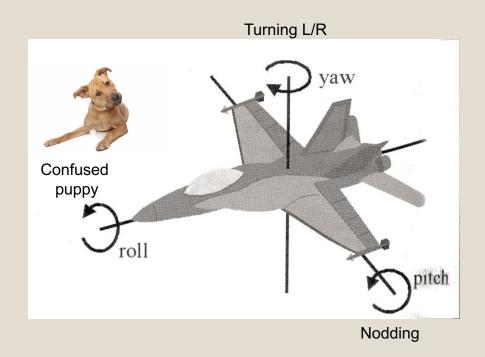
Information about your data...

- BRIK
 - File that contains data
- HEAD
 - Text file that contains attributes about the data

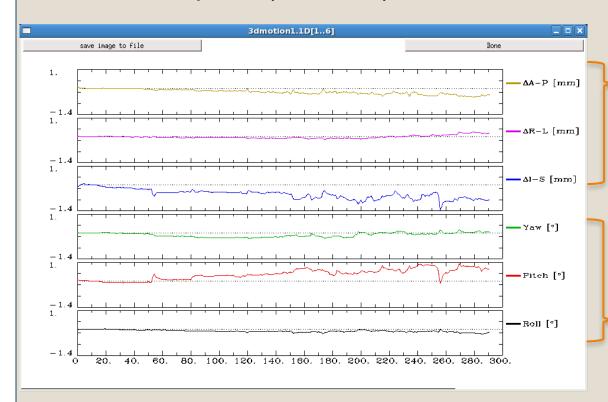
```
Terminal
<u>File Edit View Terminal Tabs Help</u>
type = string-attribute
name = HISTORY NOTE
count = 236
[szuhanyk@springsteen2.nimh.nih.gov: Thu Feb 17 10:53:35 2011] to3d -prefix OutBrick r1 -time:zt 36 292 2.3sec al
t+z mr 0009/anon 00001.dcm mr 0009/anon 00002.dcm mr 0009/anon 00003.dcm ... mr 0009/anon 10511.dcm mr 0009/anon 1
0512.dcm~
type = string-attribute
name = TYPESTRING
count = 15
'3DIM HEAD ANAT~
type = string-attribute
name = IDCODE STRING
count = 27
'XYZ hu5taP0pFI7WUjJsanW8Mw~
type = string-attribute
name = IDCODE DATE
count = 25
'Thu Feb 17 10:53:43 2011~
type = integer-attribute
name = SCENE DATA
count = 8
0 2 0 -999 -999
 -999 -999 -999
```

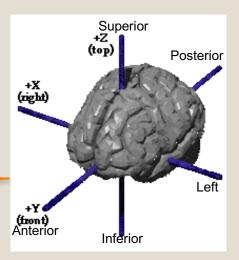
Basic idea about motion

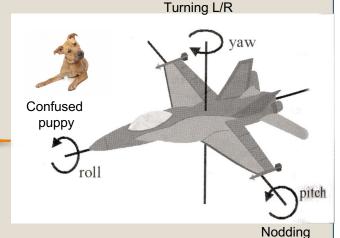




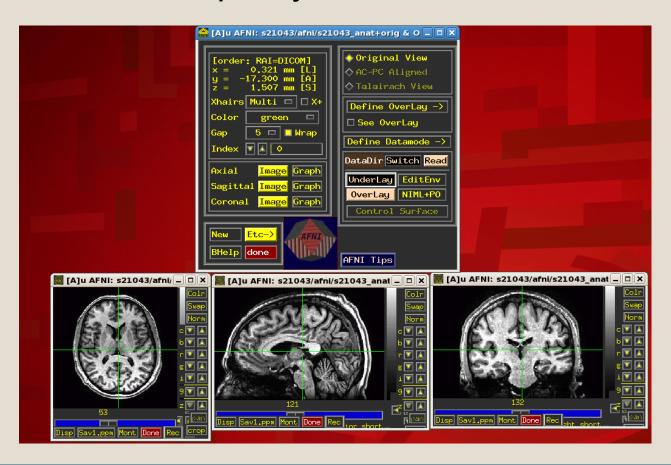
- Basic idea about motion
 - Motion plots (.1D files)



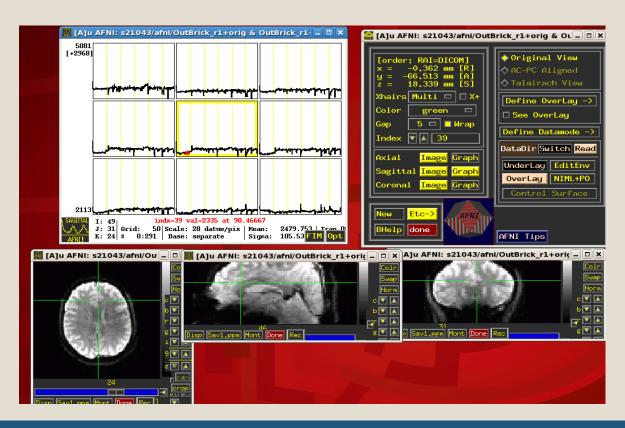




Basic idea about quality of anatomical scan



- Basic idea about quality of functional data
 - EPI (echo-planar imaging) data

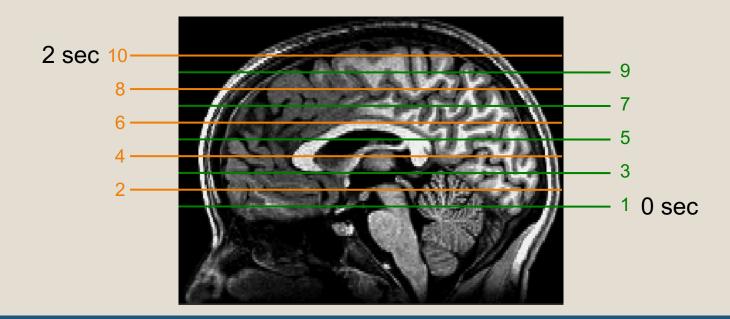


Preprocessing

- Choice of parameters is often subjective
- There is no "right" answer, but some are righter than others...
- For AFNI, specified with afni_proc.py
- Basic preprocessing steps ("blocks" in AFNI)
 - Slice timing correction (3dTshift)
 - Align EPI to anatomical scan (align_epi_anat.py)
 - Warp data into standard space (done manually or @auto_tlrc)
 - Volume registration (volreg)
 - Spatial smoothing by blurring (blur)
 - Scaling

Slice Timing Correction

- Shifts start time of each slice to have the same temporal origin (e.g., 0 sec)
- Allows more straightforward analysis of event-related studies



Align EPI to Anatomical Scan

- Aligns the two datasets in space
- Works best when data are in similar space
 - This is why you determine if the anatomical was collected before or after the EPI
- Computes the alignment between EPI and anatomical scans
 - Transformation matrix
- Applies the transformation matrix to anatomical scan
 - Anatomical is now in the same space as EPI data

Warp Data Into Standard Space

- Everyone has a different brain
- For group analyses, everyone's brain needs to standardized
- Spatially warp brains into standard space
 - Talairach-Tournoux Atlas Space
 - Space of a specific, single subject (TT_N27+tlrc)
- Warping is applied to EPI and anatomical data
 - Generates files with +tlrc suffix

Volume Registration

- Register (align) all EPI volumes
 - Align them so they are the same across all runs, different scan days, etc.
- Think of each EPI volume as a piece of paper
 - These pieces of paper are in a messy stack
 - They are messy because of movement
 - ▼ The subject was in one position for one volume, then another position for next volume
 - They are messy because of repositioning across scans
 - The subject was placed in a slightly different spot for each scan

Volume Registration (cont'd)

- Volume registration does a good job of correcting for motion correction by straightening up this stack
- If some volumes are too far away from the rest of the stack, registration may fail
 - Eliminate subject because they moved too great of a distance
- There is no way to correct for motion that occurs within a TR – that volume will be noisy
 - Censor TRs with too much within TR motion
- How define too much motion? A difficult decision to make...

Spatial Smoothing by Blurring

- Helps eliminate noise
- Helps further normalize brains so they are more similar to one another

Scaling

- Converts activation map to % signal change
 - Everyone on the same "scale"
- Allows for pooling of subjects for group analyses

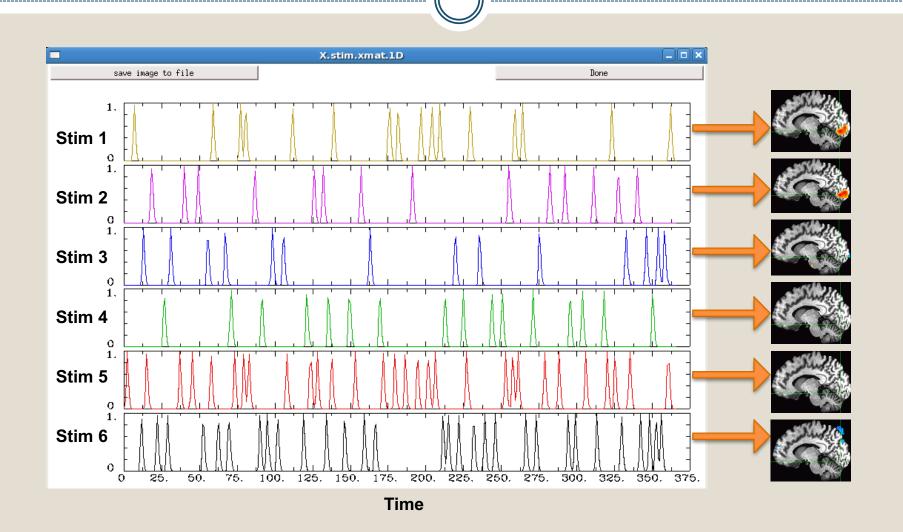
Model Subject's Data

- After pre-processing all EPI data are in a single set of BRIK and HEAD files, typically within a directory called: sdan.results
 - pb04.sdan.r01.scale+tlrc.BRIK
 - pb04.sdan.r01.scale+tlrc.HEAD
- Obtain onset times for each type (class) of stimulus from the subject's Edat file
 - Typically with Excel, SPSS, Matlab, TCL
 - Each type of stimulus is parsed into its own .txt file
 - Each .txt file has a row of timing information for each run the subject completed

Model Subject's Data (cont'd)

- Model (deconvolve, regress) the EPI data by binning the subject's brain activity by stimulus type (AKA: class type, event type)
 - We know what brain activity is associated with each stimulus type from the onset time files

Model Subject's Data (cont'd)

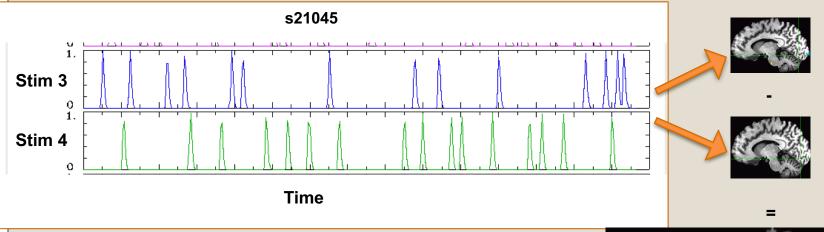


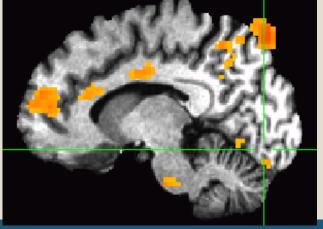
Individual Level Analysis

- AKA first level analysis
- Now that we've binned data by stimulus type we can generate contrasts for that subject:

Individual Level Analysis (cont'd)

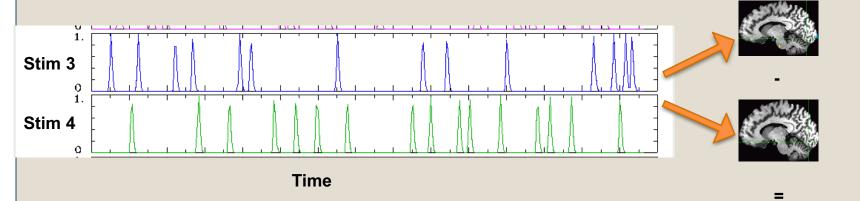
Is there greater activity for Stim 3 vs Stim 4?





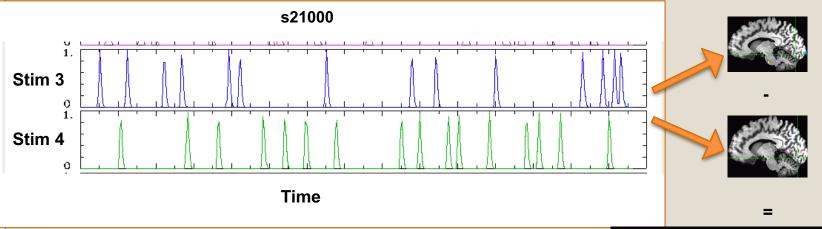
Individual Level Analysis (cont'd)

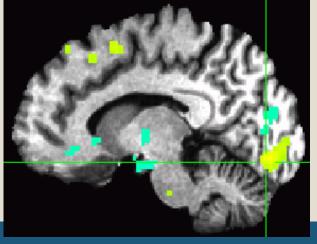
Is there greater activity for Stim 3 vs Stim 4?



Individual Level Analysis (cont'd)

Is there greater activity for Stim 3 vs Stim 4?





Group Level Analyses

 Do anxious subjects, compared with healthy subjects, have more activity for Stim 3 than Stim 4?

