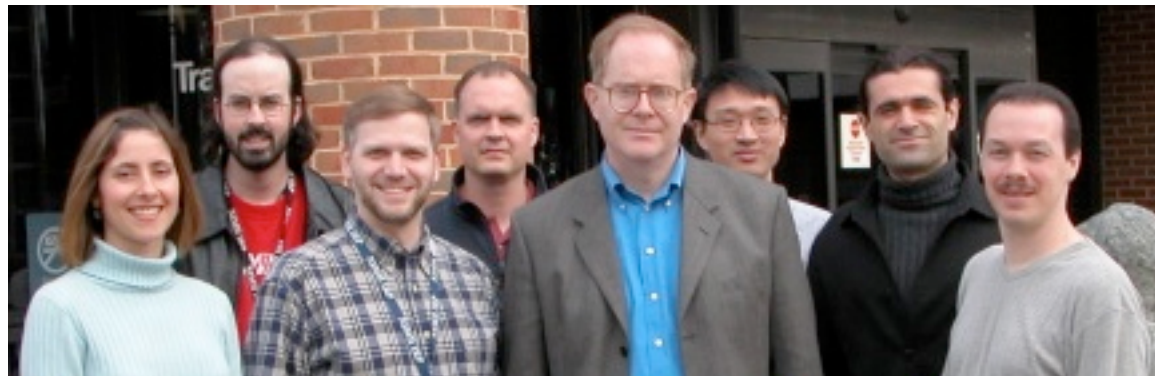
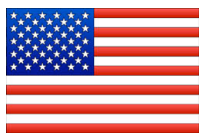


AFNI

Introduction, Concepts, Principles



Analysis of Functional NeuroImages

by

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Released under the GNU General
Public License Version 2 (GPL)

AFNI is a research tool.

*Clinical uses are **not** supported or advised.*



Alison Sanders

AFNI User



<http://afni.nimh.nih.gov/afni>

AFNI = Analysis of Functional NeuroImages

- Developed to provide an environment for FMRI data analyses
 - ★ And a platform for development of new software
- **AFNI** refers to both the program of that name and the entire package of programs and plugins (more than 100)
- Important principles in the development of AFNI:
 - ★ Allow user to stay close to the data and view it in many different ways
 - ★ Give users the power to assemble pieces in different ways to make customized analyses
 - “With great power comes great responsibility” — to understand
 - ★ “Provide mechanism, not policy”
 - ★ Allow other programmers to add features that can interact with the rest of the package

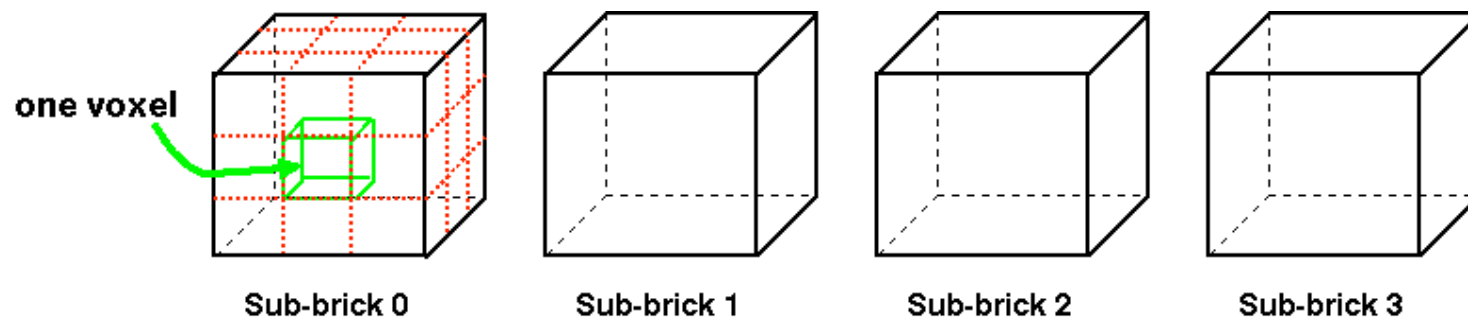
Principles We* Live By

- Fix significant bugs as soon as possible
 - ★ But we define “significant”
- Nothing is secret or hidden (AFNI is open source)
 - ★ But maybe not very well documented or advertised
- Release early and often
 - ★ All users are beta-testers for life
- Help the user (message board; consulting with NIH users)
 - ★ Until our patience expires
- Try to anticipate users’ future needs
 - ★ What we think you will need may not be what you actually end up needing



Fundamental AFNI Concepts

- Basic unit of data in AFNI is the dataset
 - ★ A collection of 1 or more 3D arrays of numbers
 - Each entry in the array is in a particular spatial location in a 3D grid (a voxel)
 - Image datasets: each array holds a collection of slices from the scanner
 - ➔ Each number is the signal intensity for that particular voxel
 - Derived datasets: each number is computed from other dataset(s)
 - ➔ e.g., each voxel value is a *t*-statistic reporting “activation” significance from an fMRI time series dataset, for that voxel
 - ★ Each 3D array in a dataset is called a sub-brick
 - There is one number in each voxel in each sub-brick



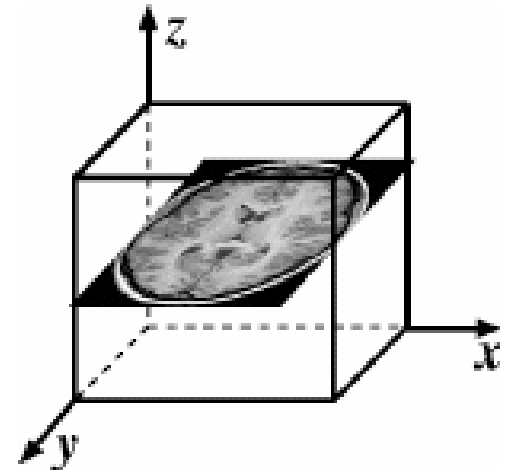
Dataset Contents: Numbers

- Different types of numbers can be stored in datasets
 - ★ 8 bit bytes (e.g., from grayscale photos)
 - ★ 16 bit short integers (e.g., from MRI scanners)
 - Each sub-brick may also have a floating point scale factor α attached, so that “true” value in each voxel is actually $\alpha \cdot (\text{value in dataset file})$
 - ★ 32 bit floats (e.g., calculated values)
 - ★ 24 bit RGB color triples (e.g., from your digital camera!)
 - ★ 64 bit complex numbers (e.g., for the physicists in the room)
- Different sub-bricks are allowed to have different numeric types
 - ★ But this is **not** recommended
 - ★ Will occur if you “catenate” two dissimilar datasets together (e.g., using **3dTcat** or **3dbucket** commands)

and I mean this

Dataset Contents: Header

- Besides the voxel values, a dataset also contains auxiliary information, including (some of which is optional):
 - ★ *xyz* dimensions of each voxel (in mm)
 - ★ Orientation of dataset axes;
for example, *x*-axis=R-L, *y*-axis=A-P, *z*-axis=I-S
⇒ axial slices
 - ★ Location of dataset in scanner coordinates
 - Needed to overlay one dataset onto another
 - ★ Time between sub-bricks, for [3D+time](#) datasets
 - Such datasets are the basic unit of fMRI data (one per imaging run)
 - ★ Statistical parameters associated with each sub-brick
 - e.g., a *t*-statistic has the degrees-of-freedom parameter stored
 - e.g., an *F*-statistic has 2 DOF parameters stored



Dataset Files - I

- AFNI formatted datasets are stored in 2 files
 - ★ The [.HEAD](#) file holds all the auxiliary information
 - ★ The [.BRIK](#) file holds all the numbers in all the sub-bricks
- Datasets can be in one of 3 coordinate systems (AKA [views](#))
 - ★ Original data or [+orig](#) view: from the scanner
 - ★ AC-PC aligned or [+acpc](#) view:
 - Dataset rotated so that the anterior commissure and posterior commissure are horizontal, the AC is at $(x,y,z)=(0,0,0)$, and the hemispheric fissure is vertical
 - ★ Talairach or [+tlrc](#) view:
 - Dataset has been rescaled to have its 12 sub-regions conform to the Talairach-Tournoux atlas
 - [Talairach](#) or [Stereotaxic](#) coordinates
 - Not quite the same as MNI coordinates, but very close

Dataset Files - II

- AFNI dataset filenames consist of 3 parts
 - ★ The user-selected prefix (almost anything)
 - ★ The view (one of +orig, +acpc, or +tlrc)
 - ★ The suffix (one of .HEAD or .BRIK)
 - ★ Example: **BillGates+tlrc.HEAD** and **BillGates+tlrc.BRIK**
 - ★ When creating a dataset with an AFNI program, you supply the prefix; the program supplies the rest
- AFNI programs can *read* datasets stored in several formats
 - ★ ANALYZE (.hdr/.img file pairs); i.e., from SPM, FSL
 - ★ MINC (.mnc); i.e., from mnitools
 - ★ CTF (.mri, .svl) MEG analysis volumes
 - ★ NIfTI-1 (.nii) — a new standard format that AFNI, SPM, FSL, and BrainVoyager have agreed upon (real soon now)
 - ★ ASCII text (.1D) — numbers arranged into columns

Dataset Directories

- Datasets are stored in directories, also called [sessions](#)
 - ★ All the datasets in the same session, in the same view, are presumed to be aligned in xyz-coordinates
 - Voxels with same value of (x,y,z) correspond to same brain location
 - ★ Can overlay (in color) any one dataset on top of any other one dataset (in grayscale) from same session
 - Even if voxel sizes and orientations differ
 - ★ Typical AFNI contents of a session directory are all data derived from a single scanning session for one subject
 - Anatomical reference (SPGR or MP-RAGE volume)
 - 10-20 3D+time datasets from EPI functional runs
 - Statistical datasets computed from 3D+time datasets, showing activation (you hope and pray)
 - Datasets transformed from +orig to +tlrc coordinates, for comparison with datasets from other subjects

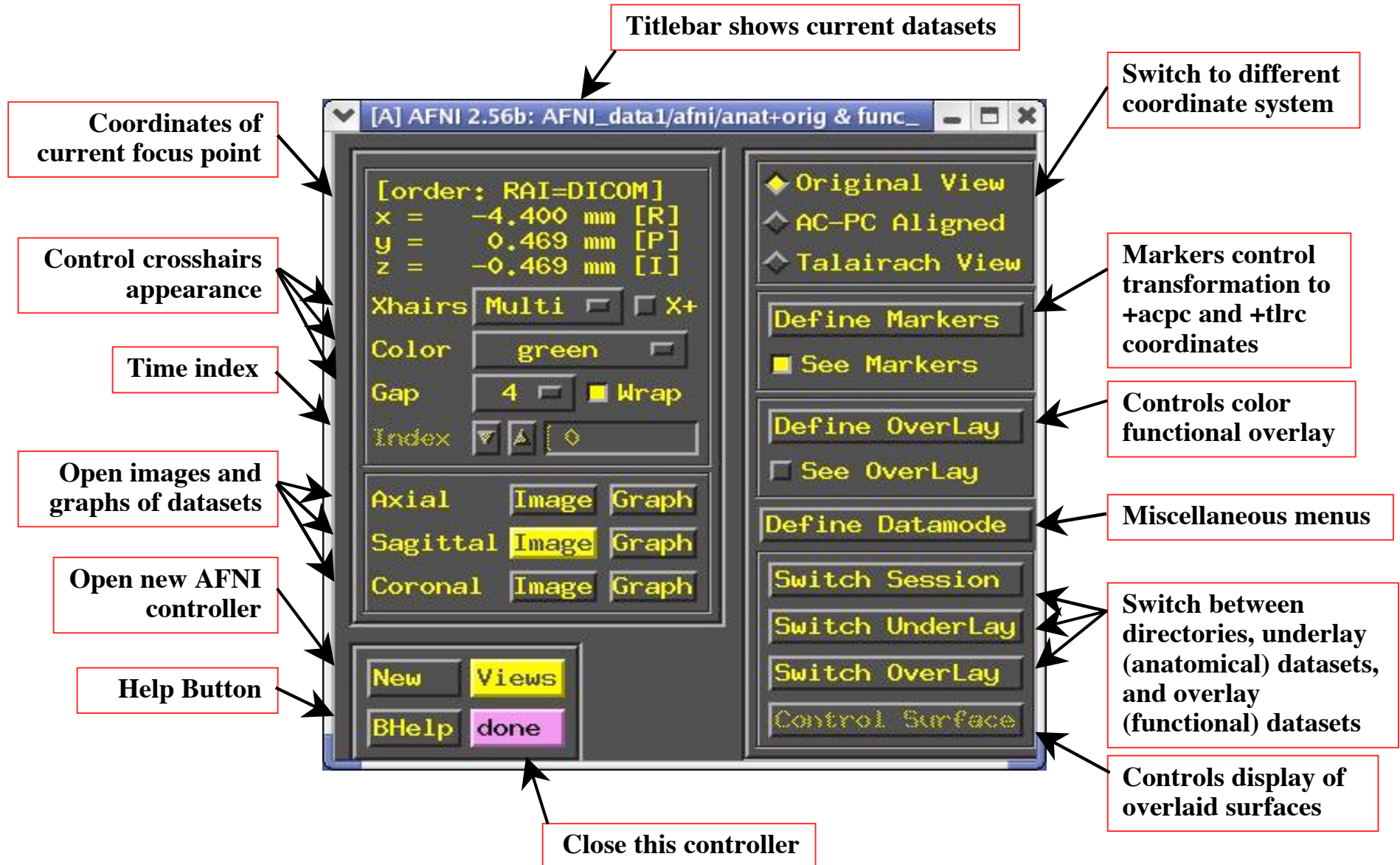
Getting and Installing AFNI

- AFNI runs on Unix systems: Linux, Sun, SGI, Mac OS X
 - ★ Can run under Windows with Cygwin Unix emulator
 - This option is really just for trying it out — not for production use
- **If you are at the NIH:** SSCC can install AFNI and update it on your system(s)
 - ★ You must give us an account with *ssh* access
- You can download precompiled binaries from our Website
 - ★ <http://afni.nimh.nih.gov/afni>
 - ★ Also: documentation, message board, humor, ...
- You can download source code and compile it
- AFNI is updated fairly frequently, so it is important to update occasionally
 - ★ We won't help you with old versions!

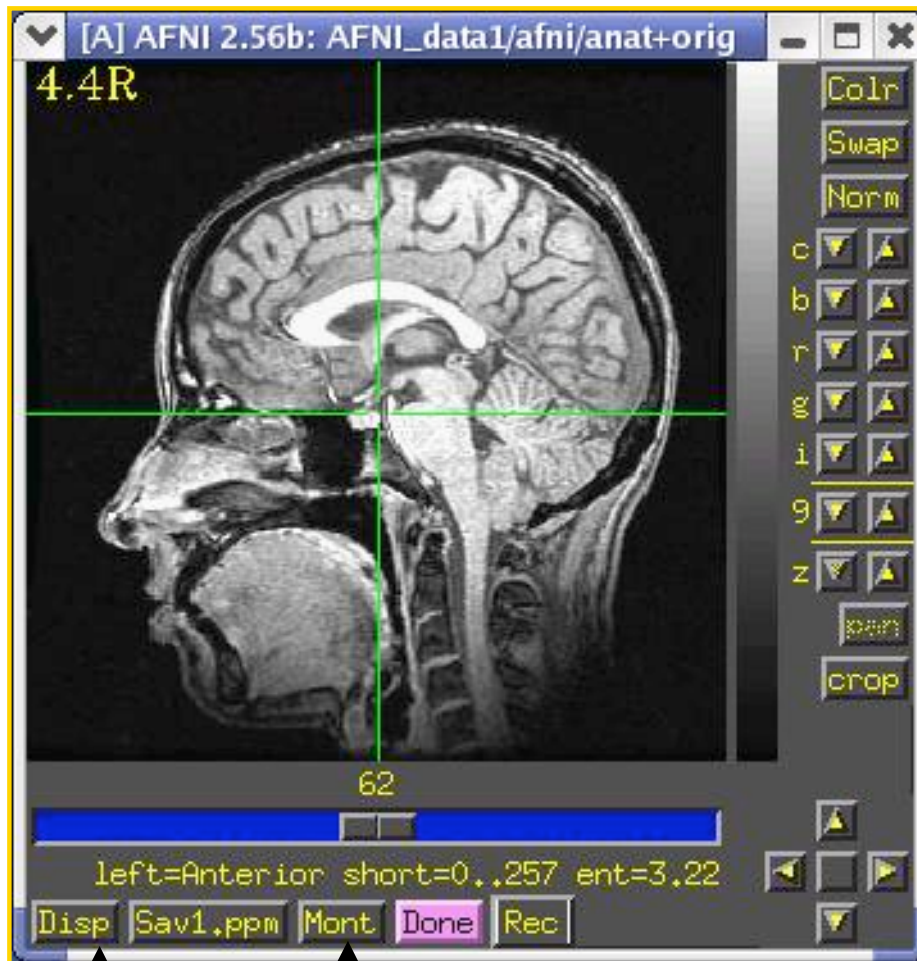
A Quick Overview of AFNI

- Starting AFNI from the Unix command line
 - ★ **afni** reads datasets from the current directory
 - ★ **afni dir1 dir2 ...** reads datasets from directories listed
 - ★ **afni -R** reads datasets from current directory and from all directories below it
- AFNI also reads a file named **.afnirc** from your home directory
 - ★ Used to change many of the defaults
 - Window layout and image/graph viewing setup; popup hints; whether to compress .BRIK files
 - cf. file README.environment in the AFNI documentation
- Also can read file **.afni.startup_script** to restore the window layout from a previous run
 - ★ Created from **Define Datamode->Misc->Save Layout** menu
 - cf. file README.driver for what can be done with AFNI scripts

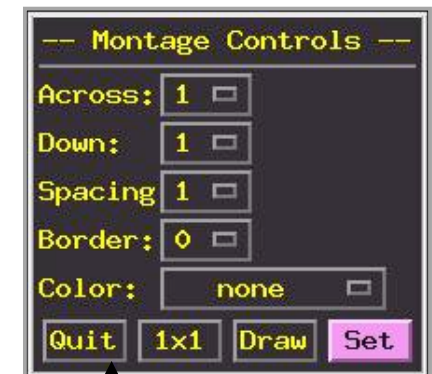
AFNI controller window at startup



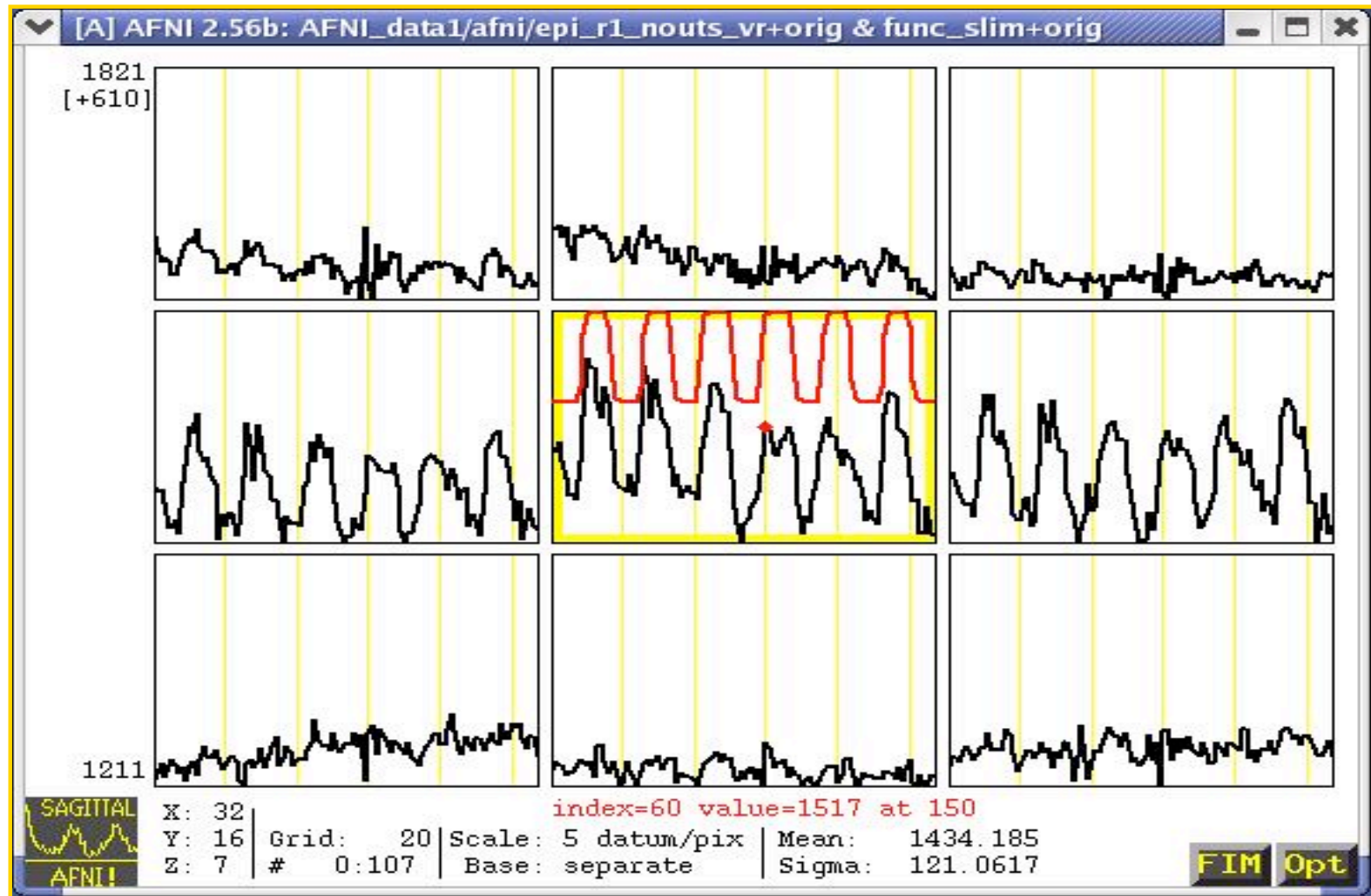
AFNI Image Viewer



Disp and Mont
control panels



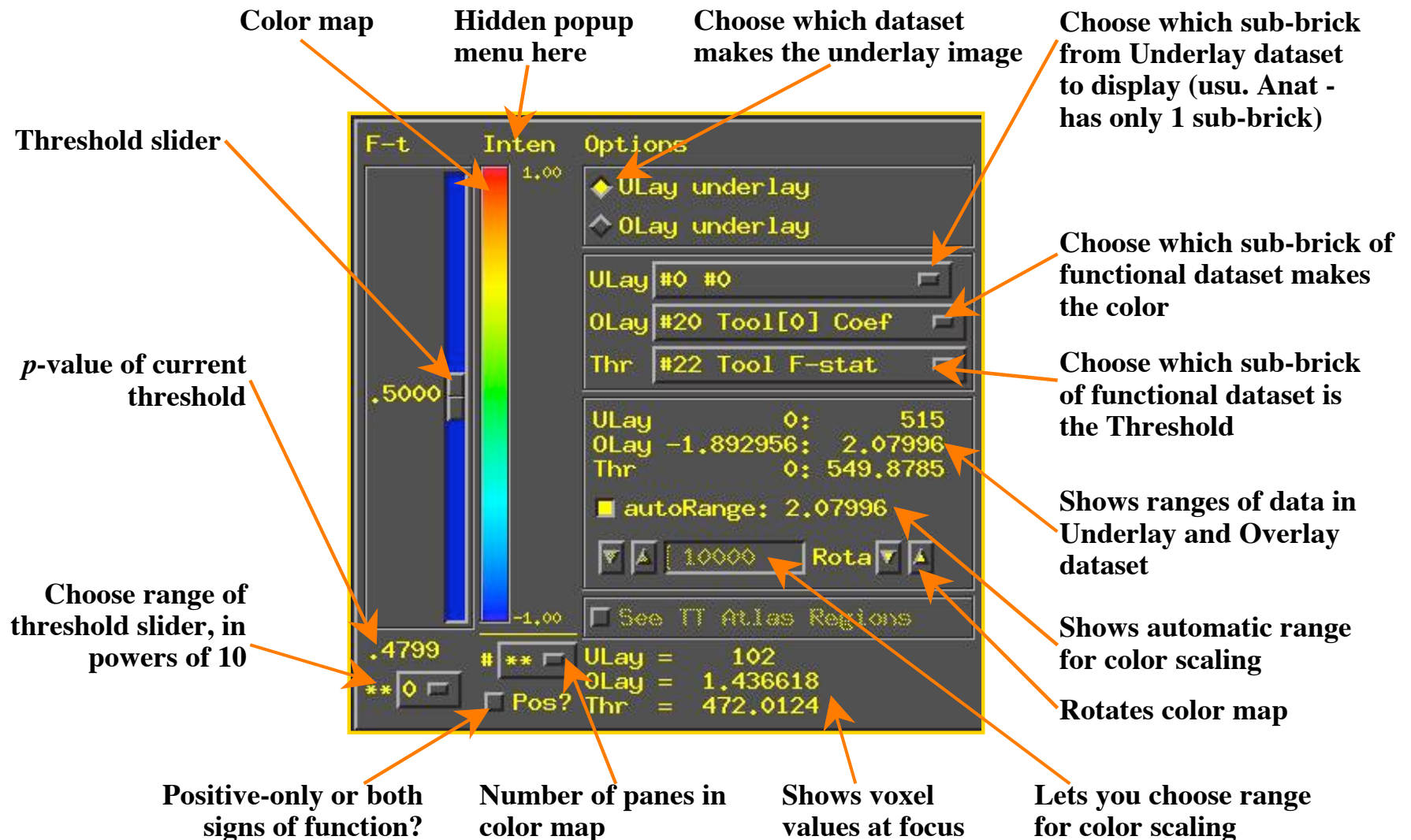
AFNI Time Series Graph Viewer



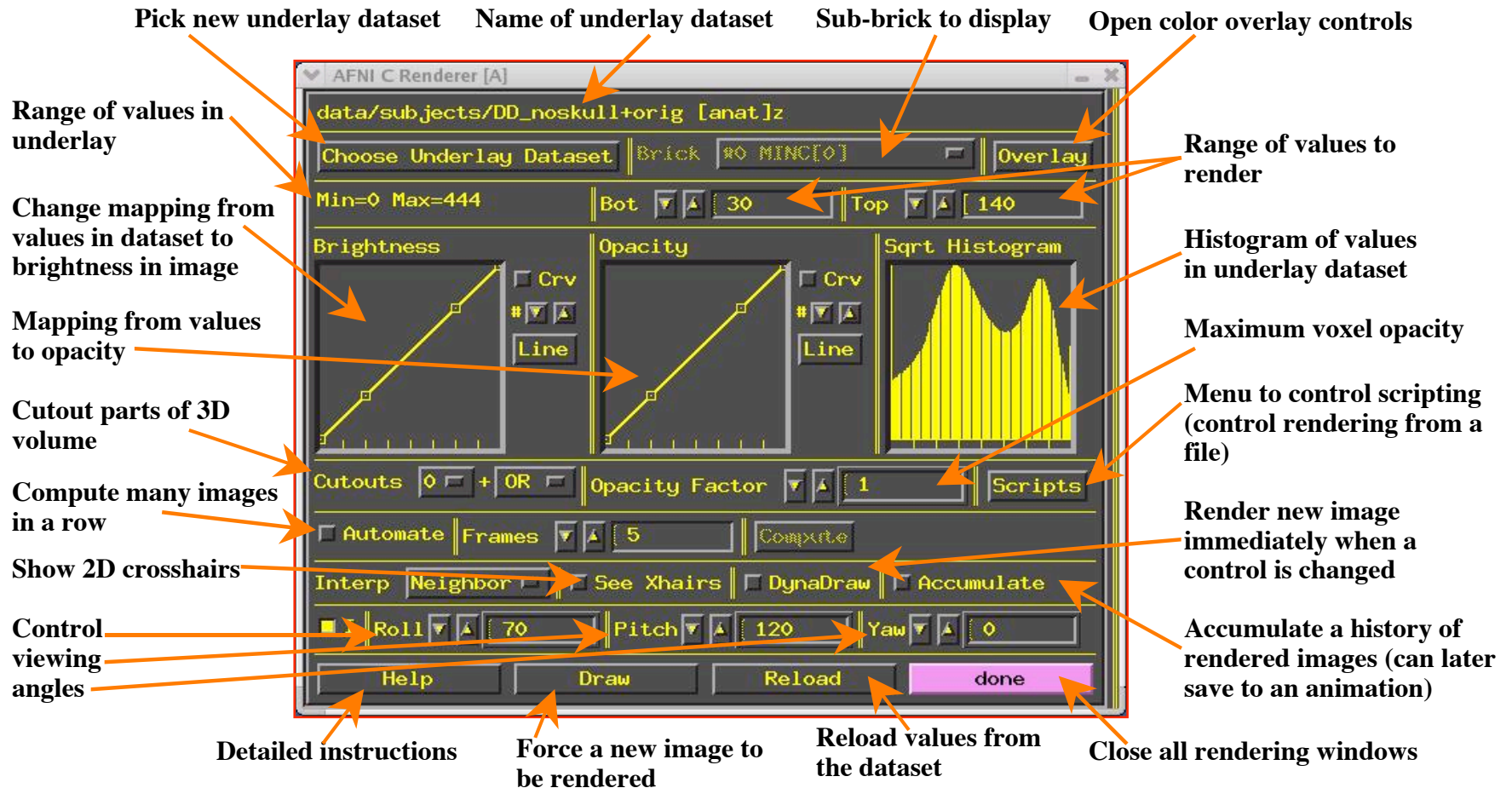
Data (black) and Reference waveforms (red)

Menus for controlling graph displays

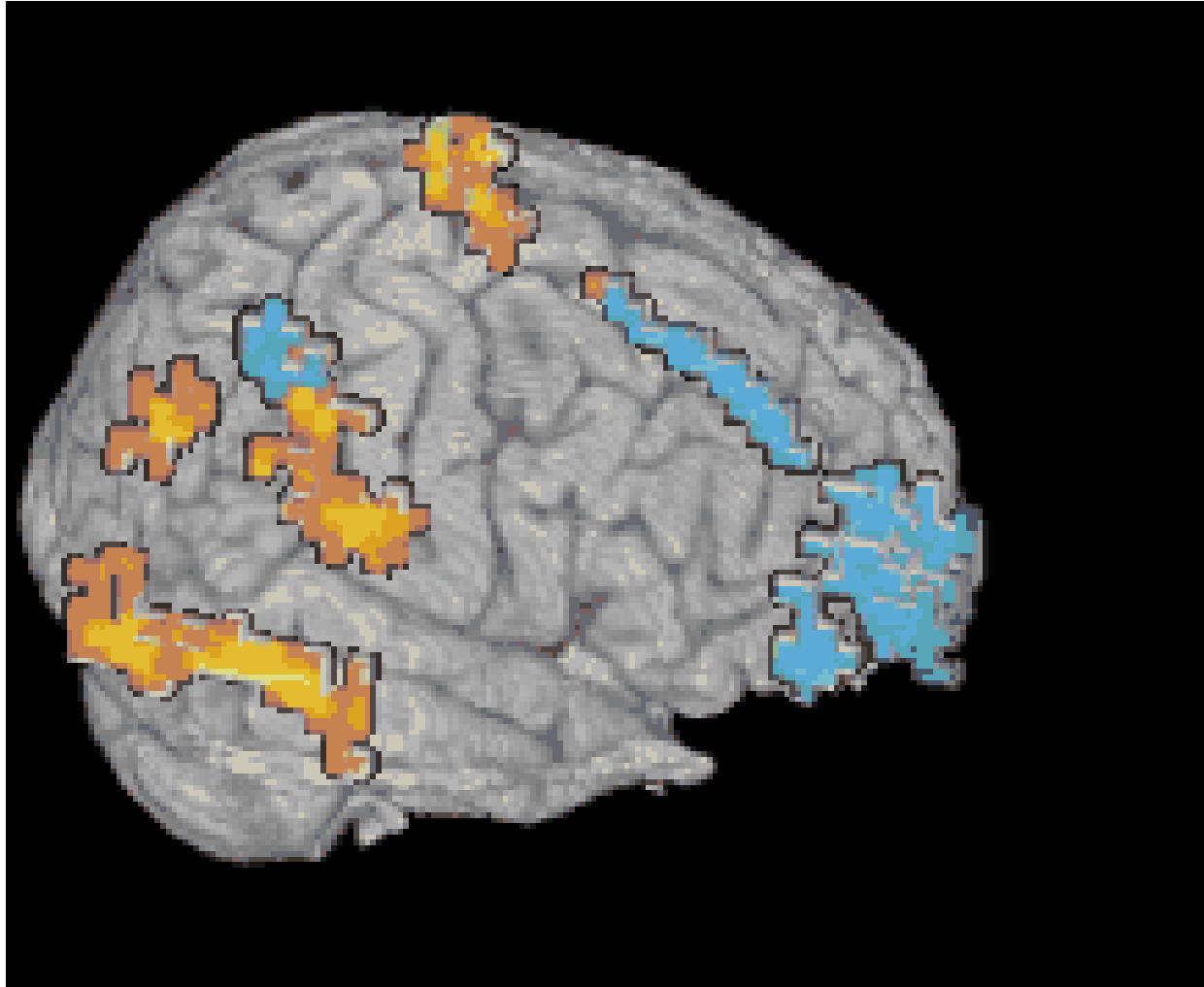
Define Function: Color Overlay Panel



Volume Rendering: an AFNI plugin



Staying Close to Your Data!



“ShowThru” rendering of functional activation:
animation created with [Automate](#) and [Save:aGif](#) controls

Other Parts of AFNI

- Batch mode programs
 - ★ Are run by typing commands directly to computer, or by putting commands into a text file ([script](#)) and later executing them
- Good points about batch mode
 - ★ Can process new datasets exactly the same as old ones
 - ★ Can link together a sequence of programs to make a customized analysis (a personalized [pipeline](#))
 - ★ Some analyses take a long time
- Bad points about batch mode
 - ★ Learning curve is “all at once” rather than gradual
 - ★ If you are, like, under age 35, you may not know how to type commands into a computer
 - At least we don’t make you use punched cards (yet)

AFNI Batch Programs

- Many important capabilities in AFNI are **only** available in batch programs
 - ★ A few examples (of more than 100, from trivial to complex)
- 3dDeconvolve = multiple linear regression on 3D+time datasets, to fit each voxel's time series to an activation model and then test these fits for significance
- 3dvolreg = 3D+time dataset registration, to correct for small subject head movements
- 3dANOVA = 1-, 2-, 3-, and 4- way ANOVA layouts, for combining & contrasting datasets in Talairach space
- 3dcalc = general purpose voxel-wise calculator
- 3dclust = find clusters of activated voxels
- 3dresample = resample a dataset to a new grid orientation and/or voxel size

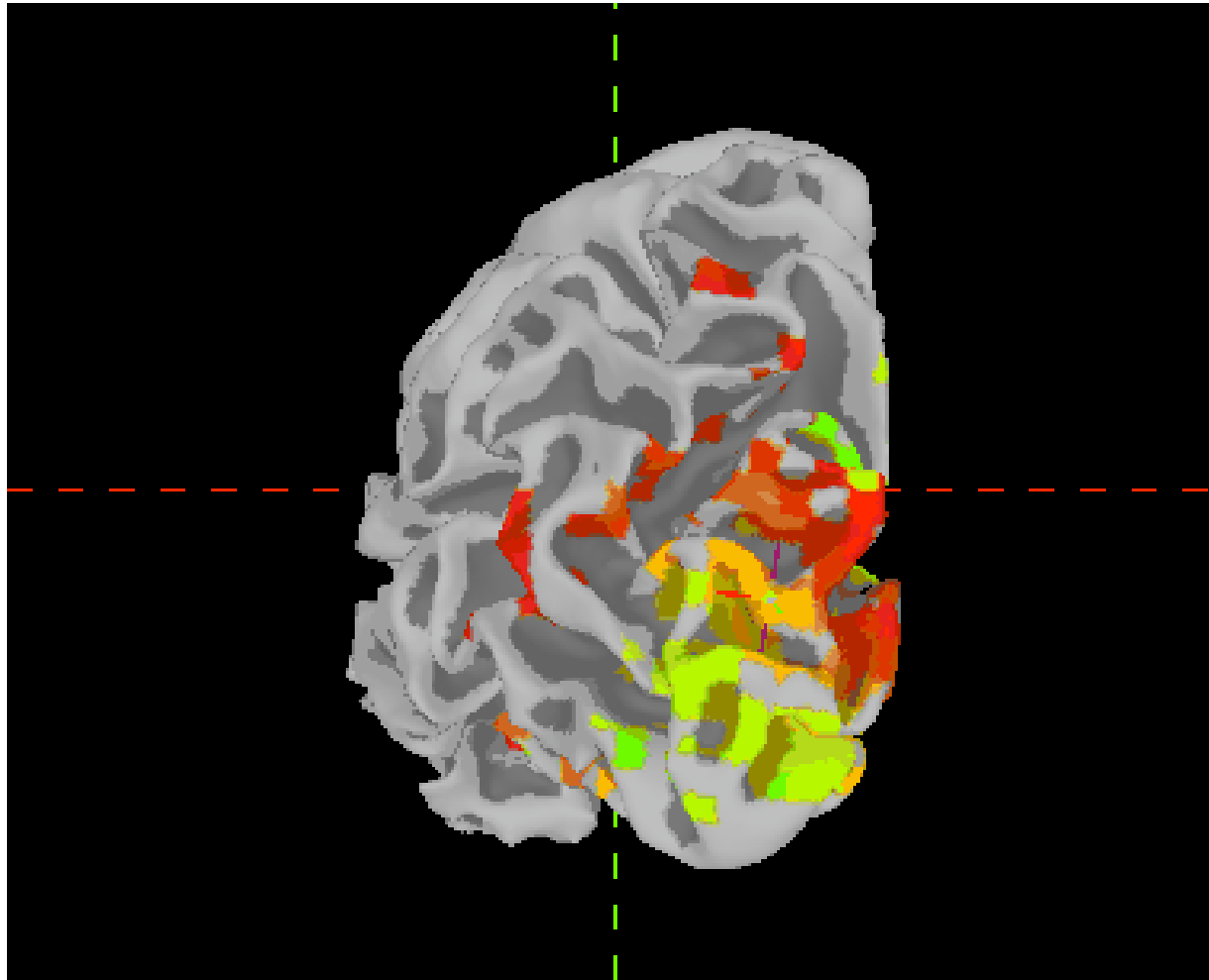
AFNI Plugins

- A [plugin](#) is an extension to AFNI that attaches itself to the interactive AFNI GUI
 - ★ **Not** the same as a batch program
 - ★ Offers a relatively easy way to add certain types of interactive functionality to AFNI
 - ★ A few examples:
- [Draw Dataset](#) = ROI drawing
- [Render \[new\]](#) = Volume renderer
- [Dataset#N](#) = Lets you plot multiple 3D+time datasets as overlays in an AFNI graph viewer
- [Histogram](#) = Plots a histogram of a dataset or piece of one
- [Edit Tagset](#) = Lets you attach labeled “tag points” to a dataset (e.g., as anatomical reference markers)

SUMA, et alii

- SUMA is the AFNI surface mapper
 - ★ For displaying surface models of the cortex
 - Surface models come from FreeSurfer (MGH) or SureFit (Wash U) or BrainVoyager
 - ★ Can display functional activations mapped from 3D volumes to the surface
 - ★ Can draw ROIs on the cortical surface
- SUMA is a separate program from AFNI, but can “talk” to AFNI so that volume and surface viewing are linked
 - ★ Click in AFNI or SUMA to change focus point, and the other program jumps to that location at the same time
 - ★ Functional overlay in AFNI can be sent to SUMA for simultaneous display
- And much more — stayed tuned for the SUMA talks to come!

SUMA Teaser Movie



Color from AFNI, Images from SUMA
Images captured with the 'R' recorder function,
then saved as animation with [Save:aGif](#) control

Other Educational Presentations

- How to get images into AFNI (program **to3d**)
- Detailed hands-on with using AFNI for data viewing
- Signal modeling & analysis: theory & hands-on (**3dDeconvolve**)
- Image registration (**3dvolreg**)
- Volume rendering hands-on (this is pretty fun)
- ROI drawing hands-on (this is the most fun part)
- Transformation to Talairach hands-on
- Group analysis: theory and hands-on (**3dANOVAX**)
- SUMA hands-on
- Surface-based analysis
- Miscellaneous AFNI utility programs and plugins
- A tour of the AFNI Website

Ongoing AFNI+SUMA Projects

- Complex ANOVA models for group analyses
 - ★ Unbalanced designs, missing data, continuous covariates, multi-nested designs,
- Diffusion ‘tensor’ analyses
 - ★ Computation of **D** tensor, FA, tracts,
- Modeling of Gd-DTPA leakage rates into damaged tissue
- Modifying AFNI to write out NIfTI-1 (.nii) datasets
 - ★ And to more fully support the features of NIfTI-1 files
- Finishing the changes to 3dDeconvolve to simplify deconvolution analysis on paradigms with irregular timing
- Real-time image acquisition on the GE Excite platform
- More surface-based analysis tools
- Automatic Talairach-ization + skull stripping
- Better ways to organize collections of datasets