Miscellaneous AFNI Utilities

- Reminder: almost all command line utilities have a `-help` option that provides a reminder about their usage; for most programs, the output of -help is the most up-to-date documentation
- `3dinfo` — print out information from a dataset .HEAD file
  - ◇ 3dinfo astrip+orig OR Define Datamode→Misc→Anat Info

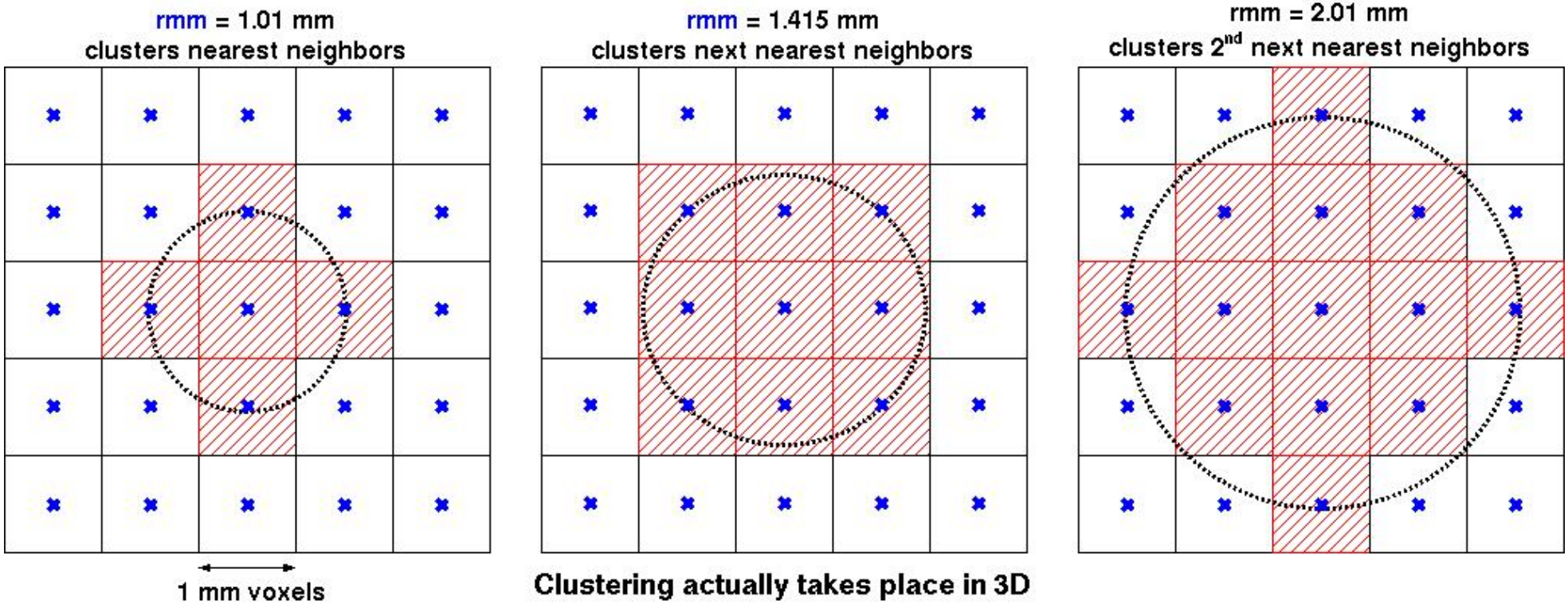
```
Dataset File:    astrip+orig
Identifier Code: MCW_SJIVYPTEAOH  Creation Date: Wed Sep 29 07:50:58 1999
Dataset Type:    Spoiled GRASS (-spgr)
Byte Order:      MSB_FIRST [this CPU native = LSB_FIRST]
Data Axes Orientation:
  first  (x) = Anterior-to-Posterior
  second (y) = Superior-to-Inferior
  third  (z) = Left-to-Right   [-orient ASL]
R-to-L extent:   -74.000 [R] -to-    73.600 [L] -step-     1.200 mm [124 voxels]
A-to-P extent:  -119.531 [A] -to-   119.531 [P] -step-     0.938 mm [256 voxels]
I-to-S extent:  -119.531 [I] -to-   119.531 [S] -step-     0.938 mm [256 voxels]
R-to-L center:    -0.200 [R]
A-to-P center:     0.000 [P]
I-to-S center:    -0.000 [I]
Number of values stored at each pixel = 1
  -- At sub-brick #0 '#0' datum type is short:            0 to           733

----- HISTORY -----
[cox@varda.biophysics.mcw.edu: Wed Sep 29 07:50:58 1999] 3dIntracranial -min_val 30
 -anat anat+orig -prefix astrip
```

- `3dnewid` — Change the ID code in a dataset's .HEAD file
  - ◇ ID codes used internally to identify datasets (e.g., in parent-child relationships)
  - ◇ `3dnewid -fun` shows one ID code (supposed to be globally unique)
- `3dcopy` — make a copy of a dataset (.HEAD and .BRIK files)
  - ◇ Is equivalent to using Unix `cp` on the .HEAD and .BRIK files, then using `3dnewid` on the copy
- `3drename` — rename a dataset (.HEAD and .BRIK files)
  - ◇ Is equivalent to using Unix `mv` on the .HEAD and .BRIK files
- `3dNotes` — attach notes to a dataset .HEAD file that will be printed by `3dinfo`
  - ◇ `Dataset NOTES` plugin provides an interactive way to do the same thing
- `3dbucket` — assemble various sub-bricks into a single "bucket" dataset
  - ◇ Lets you put diverse results into one place for easy viewing
- `3ddup` — make a warp-on-demand (.HEAD file only) copy of a dataset
  - ◇ Is a way to make a copy of a dataset at a new resolution
  - ◇ Then use `Define Datamode→Resam` and `→Write` to write to disk
- `3drefit` — modify parameters in a dataset's .HEAD file
  - ◇ Lets you "patch" mistakes made in `to3d` (not by you, but by someone else)

Spatial Utilities

- 3dclust — find clusters of "active" voxels and print out a report about them
  - ◇ "Active" means nonzero (survives thresholding operation)
  - ◇ Clusters are defined by a connectivity radius parameter rmm:



  - ◇ Clustering starts by finding some nonzero voxel
  - ◇ All nonzero voxels closer than rmm millimeters (center-to-center distance) to the given voxel are included in the cluster
  - ◇ Cluster then grows outwards from all newly included voxels, using rmm again

◇ Clustering actually takes place in 3D:

↪ Assume cubical voxels with grid size L mm

↪ $L < rmm < \sqrt{2}L \Rightarrow$ connect voxels that share a common face

↪ $\sqrt{2}L < rmm < \sqrt{3}L \Rightarrow$ connect voxels that share a common edge

↪ $\sqrt{3}L < rmm < 2L \Rightarrow$ connect voxels that share a corner

↪ Larger values of rmm will jump over zero voxels

◇ You can override actual voxel size (which may not be cubical) by using the -dxyz=1 command line switch, which then pretends that voxel size L=1

◇ Sample report: 3dclust -1thresh 0.47 7 600 r1:time@1+orig

```
Cluster report for file r1:time@1+orig
[Connectivity radius = 7.00 mm  Volume threshold = 600.00 ]
[Single voxel volume = 98.4 (microliters) ]
[Voxel datum type    = short ]
[Voxel dimensions    = 3.750 mm X 3.750 mm X 7.000 mm ]
Mean and SEM based on Absolute Value of voxel intensities:
```

Volume	CM RL	CM AP	CM IS	minRL	maxRL	minAP	maxAP	minIS	maxIS	Mean	SEM	Max Int	MI RL	MI AP	MI IS
3839	2.3	-15.3	4.4	-11.0	10.0	-28.1	-5.6	-9.4	20.6	0.0069	4.8e-04	0.0176	3.0	-13.1	5.6
2067	16.0	56.8	9.4	3.0	24.0	39.4	65.6	1.9	16.9	0.0059	4.3e-04	0.0107	17.0	61.9	13.1
1772	38.4	-5.3	0.2	24.0	52.0	-13.1	-1.9	-9.4	5.6	0.006	5.1e-04	0.0111	31.0	-1.9	-1.9
1575	-18.4	-36.7	4.5	-25.0	-18.0	-43.1	-28.1	-9.4	13.1	0.0072	0.001	-0.0181	-18.0	-43.1	5.6
1477	-1.4	-65.8	-31.7	-4.0	10.0	-69.4	-58.1	-39.4	-28.1	0.0109	0.001	-0.0201	-4.0	-65.6	-31.9
1280	24.5	-30.0	1.4	24.0	31.0	-35.6	-24.4	-9.4	9.4	0.0053	4.9e-04	-0.0089	24.0	-35.6	5.6
1181	0.7	-50.9	0.6	-4.0	10.0	-54.4	-46.9	-13.1	5.6	0.0071	0.0011	-0.0154	-4.0	-50.6	5.6
886	42.9	-28.8	-10.9	38.0	52.0	-31.9	-20.6	-13.1	-5.6	0.0059	7.7e-04	0.0096	38.0	-31.9	-9.4
689	33.2	-4.7	17.8	31.0	38.0	-9.4	-1.9	13.1	24.4	0.0074	0.0011	0.0133	31.0	-1.9	20.6
14766	9.8	-20.1	-1.8							0.0069	2.7e-04				

◇ -1thresh 0.47=threshold to apply to dataset ; 7=rmm ; 600=volume of smallest cluster to report (in mm^3=microliters)

- 3dmerge — spatially edit and/or combine datasets (the very first "3d" program!)
  - ◇ "Editing" options (applied to each input dataset) include:
    - ↪ Clipping (setting small values to zero)
    - ↪ Thresholding (setting voxels to zero based on some other sub-brick)
    - ↪ Spatial filtering (e.g., Gaussian blur)
    - ↪ Spatial clustering
  - ◇ "Combining" options include (all are voxel-wise across multiple input datasets, after the editing operations are carried out):
    - ↪ Mean; Mean of nonzero inputs
    - ↪ Maximum; Maximum absolute value
    - ↪ Count of nonzero input voxels
- 3dZeropad — add planes of zeros around a dataset
  - ◇ Can also cut planes off edges of dataset
- 3dZcutup and 3dZcat — cut slices out of dataset; glue datasets together
  - ◇ In the slice (z) direction
  - ◇ Used when processing a big 3D+time dataset is too much

- 3dZregrid — resample dataset in the slice (z) direction
  - ◇ Used when you want to compare datasets acquired with different slice thickness
  - ◇ But you should really be more careful when acquiring your datasets!
- 3dcalc — voxel-by-voxel general purpose calculator
  - ◇ Useful for combining ROI masks in various ways
  - ◇ Useful for forming 'conjunction tests', and many other voxel-wise operations

```
examples:

   3dcalc  -prefix mask_17.2    -a stats+orig'[2]'                -expr 'ispositive(a-17.2)'
   3dcalc  -prefix stat_mask    -a stats+orig'[2]'  -b mask+orig  -expr 'a*ispositive(b)'
   3dcalc  -prefix stats_9      -a stats+orig'[2]'  -b mask+orig  -expr 'a*equals(b,9)'

   3dcalc  -prefix data_9_to_4  -a stats+orig  -expr '9*iszero(a-4)+a*notzero(a-4)'
```

- 3dMean — voxel-by-voxel mean of input datasets
  - ◇ Like 3dmerge -gmean, but simpler to use, and much faster than 3dcalc
- 3dClipLevel — estimate the voxel value at which to threshold an EPI dataset so as to remove most non-brain tissue
  - ◇ Same algorithm is used as starting point in 3dAutomask

- 3dIntracranial — strip the scalp and other non-brain tissue from a high-resolution T1-weighted anatomical dataset
  - ◇ Useful for volume rendering fun
  - ◇ Combined with 3dfractionize, is another way to make a brain-only mask
- 3daxialize — rewrite a dataset in a new slice orientation
- 3dresample — rewrite a dataset in a new orientation and interpolated to a new voxel size
- 3drotate — rigid body 3D rotation of a dataset
- 3dWarp — nonrigid 3D transformation of a dataset
- 3dAnatNudge — automatically try to align EPI and structural datasets
  - ◇ Dataset Nudge plugin lets you do the same manually
- 3dTagalign — align 2 datasets based on manually set tags
  - ◇ Tags are set with the Edit Tagset plugin
  - ◇ Alignment can be rigid body (6 parameters) or affine (12 parameters)
  - ◇ This can be very useful when 3dAnatNudge doesn't work well

Masking and ROI Utilities

- 3dAutomask — create a brain-only mask from an EPI dataset
- 3dfractionize — resample a high-resolution dataset to lower resolution
  - ◇ Used to take high-resolution mask (ROI) datasets to EPI resolution
  - ◇ Can compute fraction of each output voxel that is occupied by nonzero input voxels (default operation)
  - ◇ Can let input voxels "vote" on the value of output voxels (since multiple input voxels can overlay a larger output voxel, must have a scheme to decide which input value "wins")
- 3dmaskdump — print out all the voxel values indicated by a mask dataset
- 3dUndump — take a text file and put its values into a dataset
  - ◇ The inverse of 3dmaskdump
- 3dmaskave — print out the average of voxels over an ROI
  - ◇ Can compute a 1D time series averaged from a 3D+time dataset over an ROI
  - ◇ Can also use ROI Average plugin
- 3dROIstats — print out statistics of voxels from multiple ROIs
- 3dOverlap — count number of voxels that are nonzero in all input sub-bricks

3D+time Dataset Utilities

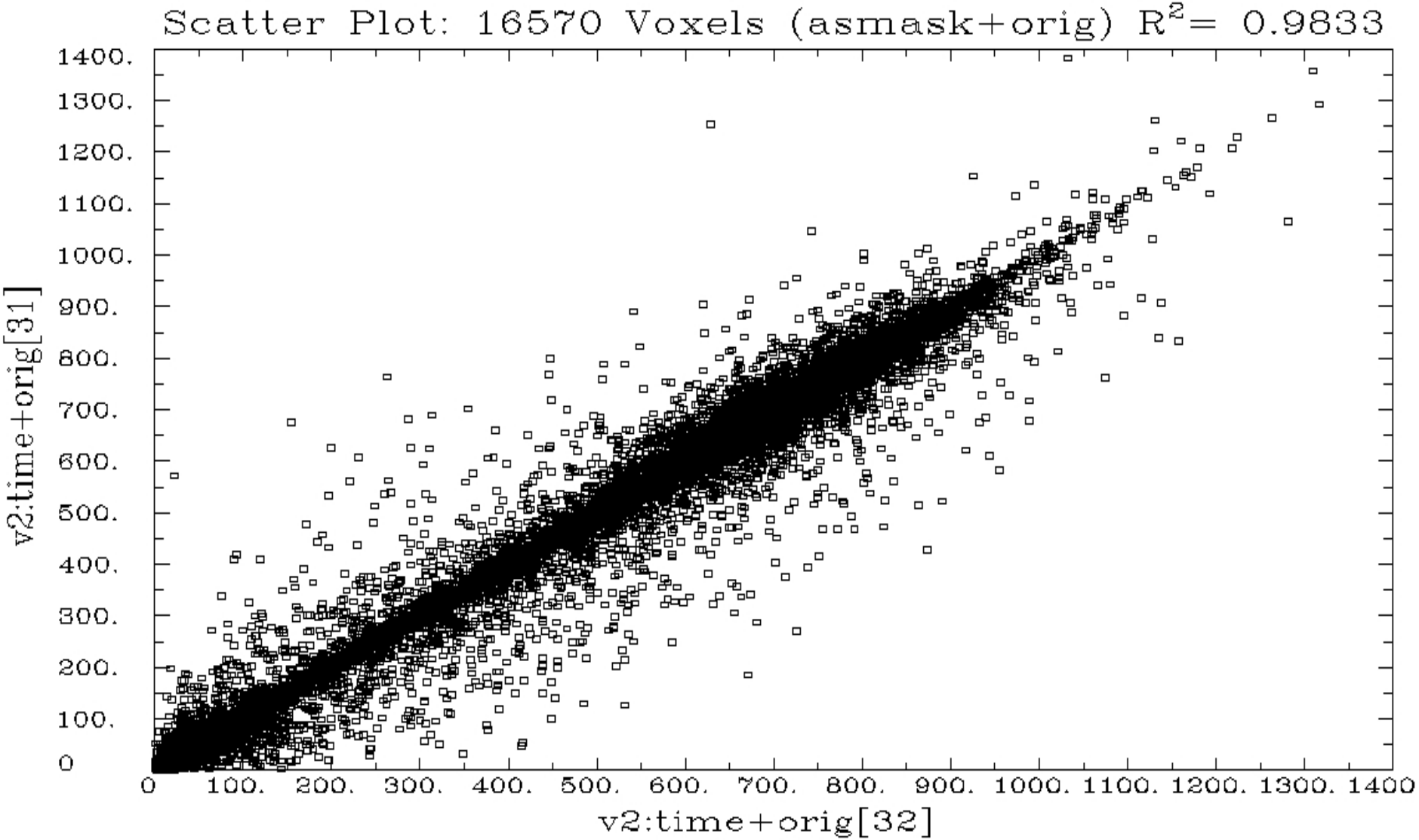
- 3dTsmooth — smooth a 3D+time dataset along the time axis
- 3dFourier — filter time series in the Fourier domain
  - ◇ Allows more general filtering than 3dTsmooth
- 3dTcat — catenate 3D+time datasets together
  - ◇ For use in 3dDeconvolve, for example
- 3dTstat — basic statistics on 3D+time datasets
  - ◇ Voxel-wise mean, standard deviation, median, etc.
- 3dTqual and 3dToutcount — check 3D+time datasets for 'outliers'
  - ◇ Now also included automatically in to3d
  - ◇ 3dDespike — remove outliers (spikes) from voxel time series
- 3dDetrend — subtract least squares fits of 'trends' from voxel time series
  - ◇ Usually better to do this at the same time as activation analysis
- 3dTshift — align dataset slices to the same time origin
  - ◇ Can also be done in 3dvolreg, before registration

Miscellaneous Useful Plugins

Define Datamode→Plugins→

- Coord Order — set the order in which coordinates are displayed
  - ◇ AFNI default order is RAI: -x = Right +x = Left
    -y = Anterior +y = Posterior
    -z = Inferior +z = Superior
  - ◇ Can choose another order with this plugin: most common is LPI or "flipped"
- Histogram — graph a histogram of a sub-brick
  - ◇ Or of an ROI, or a spherical region about the AFNI focus point

- Dataset#N — allows you to graph extra dataset time series in an AFNI graph viewer (overlaid in color on the current underlay dataset time series)
  - ◇ In conjunction with the Double Plot graphing function
- ScatterPlot — plot values from 1 sub-brick vs. values from another



1D Time Series Utilities

- waver — generates 1D time series which are convolution of input stimulus timing with model hemodynamic response functions
- 1dplot — graphs 1D time series files
  - ◇ Not very fancy graphs: mostly useful for quick look at data, not for publications
- 1dcat — catenate columns of 1D time series files
- 1deval — like 3dcalc for 1D time series
- 1dtranspose — transpose a 1D file (exchange rows and columns)
  - ◇ If you want to input a 1D file as an AFNI dataset, then the columns correspond to sub-bricks

Dataset Simulators

- 3dTSgen — generates a dataset from a time series model and noise
- 3dConvolve — generates a dataset by convolution (the opposite of 3dDeconvolve
- 3dcalc — can be use to generate datasets with noise added (if you are clever)

Environment Variables and .afnirc

- Operation of AFNI is affected by many Unix environment variables
  - ◇ Full documentation is in file README.environment (in AFNI distributions)
  - ◇ Environment variables can be set in your shell startup file (e.g., .cshrc) or in AFNI's startup file (.afnirc), in your home directory
  - ◇ Some environment variables can be set from the pseudo-plugin `Define Datamode→Misc→Edit Environment`
- Some useful environment variables (there are many more)
  - ◇ `AFNI_PLUGINPATH` gives the directory where AFNI will look for plugins when it starts up
  - ◇ `AFNI_SESSTRAIL` gives the number of directory levels to show in the `Switch Session` chooser
  - ◇ `AFNI_HINTS` can be used to turn off the popup hints (tooltips)
  - ◇ `AFNI_COMPRESSOR` can be used to tell AFNI programs to compress .BRIK files when they are written out
  - ◇ `AFNI_AUTOGZIP` can be used to tell AFNI programs to gzip compress .BRIK files if they appear like "good" candidates for compression (e.g., ROI datasets)

- ◇ AFNI_LEFT_IS_LEFT can be used to have axial and coronal images displayed with the subject's left on the display left (default is subject's left on the display right: radiological order)
- ◇ AFNI_ALWAYS_LOCK can be used to turn on inter-controller Lock at startup
- ◇ AFNI_NOSPLASH can be used to hide the AFNI splash window (but why?)
- ◇ AFNI_ENFORCE_ASPECT can be used to make defective window managers (KDE, Gnome) keep the image window aspect ratios when resizing (I then also recommend setting the window manager so that it doesn't redraw the windows during resizing operations)

- Sample .afnirc file:

```
***ENVIRONMENT
AFNI_LEFT_IS_LEFT      = YES    // images show subject's left on screen left
AFNI_graph_width       = 512    // in pixels
AFNI_graph_height      = 384
AFNI_graph_ggap        = 6      // gap between sub-graphs
AFNI_graph_data_thick  = 1      // use thick lines for data graphs
AFNI_SPLASHTIME        = 1.0    // shorten the splash screen display
AFNI_ALWAYS_LOCK       = YES    // locking windows together
AFNI_ENFORCE_ASPECT    = YES
AFNI_AUTOGZIP          = YES    // 02 Mar 2001
```

- See README.environment and README.setup for details on all environment variables and other setup issues

AFNI Command Line Switches

- Command line switches to the interactive AFNI program itself are not often needed, but are sometimes useful:
  - ◇ `-R` = recursively search directories for datasets (may take a long time)
  - ◇ `-noqual` = skip the "quality" check for marker transformations
  - ◇ `-noplugins` = don't load plugins
  - ◇ `-skip_afnirc` = don't read the .afnirc file
  - ◇ `-ncolors nnn` = use 'nnn' gray levels for image display (default=80)
  - ◇ `-nomall` = disables use of AFNI's internal malloc() (if it causes problems)

Final AFNI Fun

- Try clicking each mouse button in the blank area to the right of the `Done` button
- Try clicking or typing into the splash screen
- Try using `BHelp` in a blank area of the AFNI controller
- To exit AFNI quickly, press the Shift key down, then click on `Done`

Roundup of Useful AFNI Programs and Plugins

- Dataset Creation and Conversion

`to3d`	Reads image files, writes AFNI format datasets
`3dAFNIto3D`	Convert AFNI format dataset to .3D format (ASCII lists)
`3dAFNItoANALYZE`	Convert AFNI format dataset to ANALYZE format
`3dAFNItoMINC`	Convert AFNI format dataset to MINC format
`3dANALYZEtoAFNI`	Convert ANALYZE format dataset to AFNI format
`3dMINCtoAFNI`	Convert MINC format dataset to AFNI format
`3dThreetoRGB`	Convert 3 scalar datasets to 1 RGB AFNI format dataset

- Auxiliary Programs for Dataset Creation from Images

`Ifile`	Reads GE realtime EPI files and runs to3d
`Imon`	Reads GE realtime EPI files as they are created
`rtfeedme`	Dissects one dataset, sends images to AFNI realtime plugin
plugin: `RT Options`	Control options for AFNI realtime image input
`from3d`	Writes dataset slices into image files
`abut`	Creates zero-filled slices to put into dataset gaps

- Quality Checks for 3D+time Datasets

`3dToutcount`	Check voxel time series for quality (temporal outliers)
`3dTqual`	Check dataset sub-bricks for quality (spatial outliers)

- 3D+time Pre-processing Programs

`3dTshift`	Shift slices to a common time origin (temporal interpolation)
`3dDespike`	Remove spikes from voxel time series
`3dDetrend`	Remove trends from voxel time series
`3dFourier`	FFT-based lowpass and highpass filtering
`3dTsmooth`	Smooth time series in the time domain

- 3D+time Analysis Programs

`3dDeconvolve`	Multiple linear regression and deconvolution
plugin: `Deconvolution`	Interactive deconvolution
`3dfim`	Single regressor linear analysis
`3dfim+`	Extended version of `3dfim`
`3ddelay`	Single regressor linear analysis with time shifting
`3dNLfim`	Nonlinear regression
plugin: `NLfit & NLerr`	Interactive nonlinear regression
`3dTcorrelate`	Correlate two input datasets, voxel-by-voxel
`3dAutoTcorrelate`	Correlate each voxel with every other voxel
`3dpc`	Principal component analysis

- Model 1D Time Series Generators

`sqwave`	Generate a square wave (a very old program)
`waver`	Generate hemodynamic responses to stimulus time series

- Dataset Histogram Programs

`3dAnhist`	Create and plot histogram of dataset, print peaks
`3dhistog`	Create histogram of dataset to a file
plugin: `Histogram`	Interactively graph histogram of a dataset (or ROI)
plugin: `ScatterPlot`	Interactively graph 1 sub-brick vs. another (or ROI)
`3dClipLevel`	Find value to threshold off outside-the-brain voxels
`3dUniformize`	Correct T1-weighted dataset for non-uniform histogram
`3dIntracranial`	Strip off outside-the-brain voxels

- Group Dataset Statistical Analysis Programs

`3dttest`	paired and unpaired t-tests
`3dANOVA`	1-way ANOVA (fixed effects)
`3dANOVA2`	2-way ANOVA (fixed, random, mixed effects)
`3dANOVA3`	3-way ANOVA (fixed, random, mixed effects)
`3dFriedman`	nonparametric Friedman test
`3dKruskalWallis`	nonparametric Kruskal-Wallis test
`3dWilcoxon`	nonparametric Wilcoxon test
`3dMannWhitney`	nonparametric 3dMannWhitney test
`3dRegAna`	voxel-wise linear regression analyses
`3dFDR`	False Discovery Rate analysis

- Programs for Manipulating Information in the Dataset Header

`3dinfo`	Prints out information from the header
`3dAttribute`	Prints out a single header attribute
`3dnewid`	Assigns a new ID code to a dataset
`3drefit`	Lets you change attributes in a dataset header
`3dNotes`	Lets you put text notes into a dataset header
plugin: `Dataset NOTES`	Interactive header notes editor

- Programs for Changing Dataset Spatial Structure

`3daxialize`	Rewrite dataset with slices in different direction
`3dresample`	Rewrite dataset in new orientation, with new voxel size
`3dLRflip`	Flip dataset Left↔Right

- Programs for Assembling Sub-Bricks into 4D Datasets

`3dTcat`	Assemble a 3D+time dataset from multiple input sub-bricks
`3dbucket`	Assemble a bucket dataset from multiple input sub-bricks

- Programs for Changing Slice Structure

`3dZcat`	Glue multiple sub-bricks together along the z-axis
`3dZcutup`	Cut slices out of a dataset to make a 'thinner' dataset
`3dZeropad`	Add zero slices around the edges of a dataset
`3dZregrid`	Interpolate a dataset to a different slice thickness

- Image Registration Programs

`3dvolreg`	Volumetric registration (rigid body in 3D)
`2dImReg`	Slice-by-slice registration (rigid body in 2D, each slice separately)

- Spatial Transformations of Dataset Geometry

`3drotate`	Rigid body rotation of dataset in 3D
`3dWarp`	Non-rigid transformation of 3D coordinates
`3dAnatNudge`	Try to align EPI and structural volumes automatically
plugin: `Nudge Dataset`	Align EPI and structural volumes manually
`3dTagalign`	Align datasets by matching manually placed 'tags'
plugin: `Edit Tagset`	Place 'tags' in a dataset interactively
`adwarp`	Transform dataset using warp from dataset header
`Vecwarp`	Transform 3-vectors using warp from dataset header

- Dataset File Manipulation

`3dcopy`	Copy a dataset to make new files
`3drename`	Rename dataset files
`3ddup`	Make an 'empty' duplicate (warp-on-demand) of a dataset

- ROI Generation and Usage Programs

plugin: `Draw Dataset`	Manually draw ROI mask datasets
`3dAutomask`	Generate a brain-only mask from an EPI dataset
`3dmaskave`	Calculate dataset values averaged over a ROI
`3dmaskdump`	Output all dataset values in a ROI
`3dROIstats`	Calculate dataset values from multiple ROIs
`3dUndump`	Input text values into a dataset (inverse of `3dmaskdump`)
`3dOverlap`	Create mask that is overlap of nonzero voxels from multiple datasets
`3dfractionize`	Resample a mask dataset to a different resolution

- Simple Calculations on Datasets, Producing New Datasets

`3dcalc`	Voxel-by-voxel general purpose calculator
`3dmerge`	Various spatial filters, thresholds, and averaging
`3dTstat`	Various statistics of multi-brick datasets, voxel-by-voxel
`3dMean`	Average datasets together, voxel-by-voxel, for each time point
`3dWinsor`	Nonlinear order statistics filter for spatial smoothing

- Computation of Various Numbers from Datasets

`3ddot`	Dot product (correlation coefficient) of 2 sub-bricks
`3dclust`	Find connected clusters of nonzero voxels
`3dExtrema`	Find local maxima (or minima) of datasets
`3dFWHM`	Estimate Full Width Half Maximum of dataset spatial correlation

- Simulated Dataset Generators

`3dTSgen`	Generate 3D+time dataset from 1D model and noise
`AlphaSim`	Simulate datasets and estimate statistical power
`3dConvolve`	Simulate datasets via convolution

- Programs for Dealing with 1D Time Series

`1dcat`	Catenate them horizontally
`1deval`	1D calculator (like 3dcalc for 1D files)
`1dplot`	Graph them
`1dtranspose`	Transpose them (interchane rows and columns)

- Miscellaneous File Manipulations

`2swap`	Byte pair swap: `ab` ↔ `ba`
`4swap`	Byte quad swap: `abcd` ↔ `dcba`
`24swap`	Mixed 2 and 4 byte swaps in same file
`strblast`	Find a string in a file and replace it with junk

- Miscellaneous Utilities

`byteorder`	Report the byteorder of the current CPU
`ccalc`	A command line calculator (like 3dcalc)
`cdf`	Compute probabilities, thresholds for standard distributions
`count`	Generate numbered strings for command line scripts

- Image File Header Printouts

`dicom_hdr`	Print information from a DICOM file
`ge_header`	Print information from a GE I. file
`mayo_analyze`	Print information from a ANALYZE .hdr file
`siemens_vision`	Print information from a Siemens Vision .ima file

- Miscellaneous Visualization Tools

`aiv`	AFNI Image Viewer program
plugin: `Render [new]`	Interactive volume rendering
plugin: `Dataset#N`	Graph extra dataset time series in AFNI graph viewer