TEMPLATES AND ATLASES

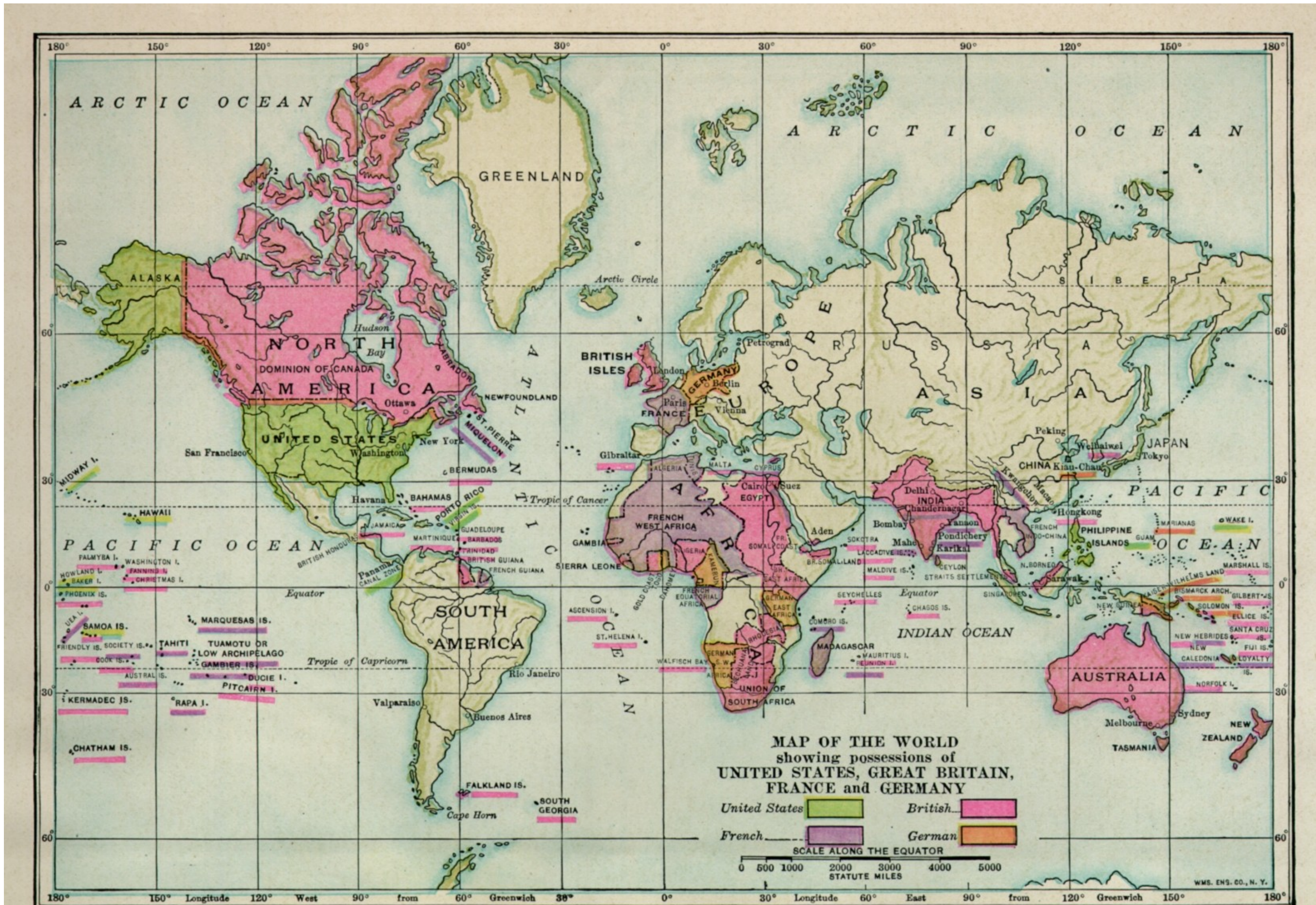


FIG. 1.

Abbrevs used here

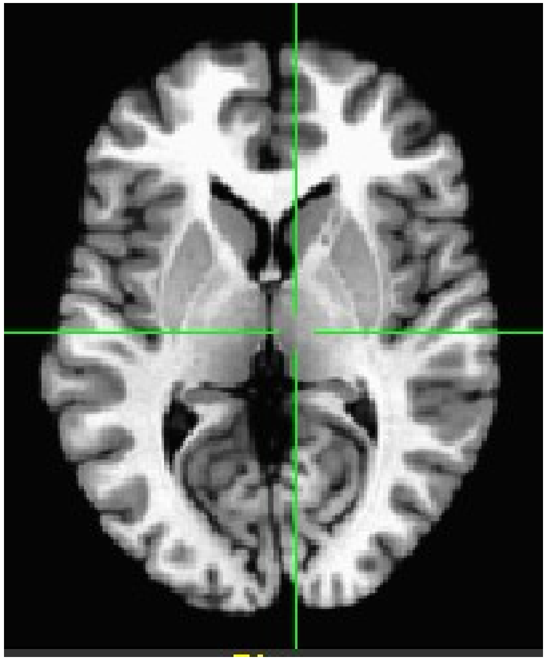
abbrev	= abbreviation
AKA	= also known as
anat	= anatomical
corr	= correlation
diff	= difference
dset	= dataset
e.g.	= exempli gratia (= "for example")
EPI	= echo planar image
Ex	= example
FOV	= field of view
i.e.	= id est (= "that is")
ijk	= coordinate indices (integer)
NB	= nota bene (= "note well")
phys	= physics or physical
ref	= reference
ROI	= region of interest
subj	= subject
vol	= volume
vox	= voxel(s)
xyz	= physical coordinates (units of mm)

Definitions

Template

A reference dataset (typically whole brain) used for matching shapes, reporting coordinates of results, etc.

Ex: TT_N27+tlrc, MNI_EPI+tlrc, TT_ICBM452+tlrc.



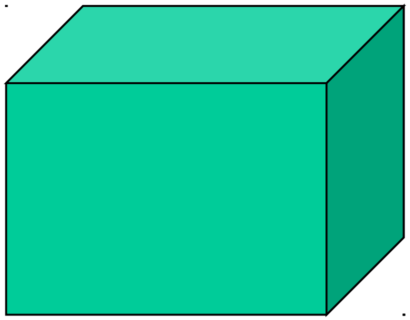
TT_N27+tlrc

Definitions

Template Space

An (x, y, z) coordinate system shared by many datasets in alignment with a template.

Ex: TLRC (Talairach-Tourneaux), MNI, MNI_ANAT, ORIG.



To see what "space" a dset is in, type:

`3dinfo -space DSET_NAME`

Definitions

A note on AFNI usage of "tlrc":

The "+tlrc" extension in a dataset's name is used to denote that the volume in question is in **a** standardized space; it does not always mean that the standard space in question is the Talairach-Tournoux one, specifically-- it could be MNI, pediatric template, macaque, ...

Hopefully the context makes things clear.

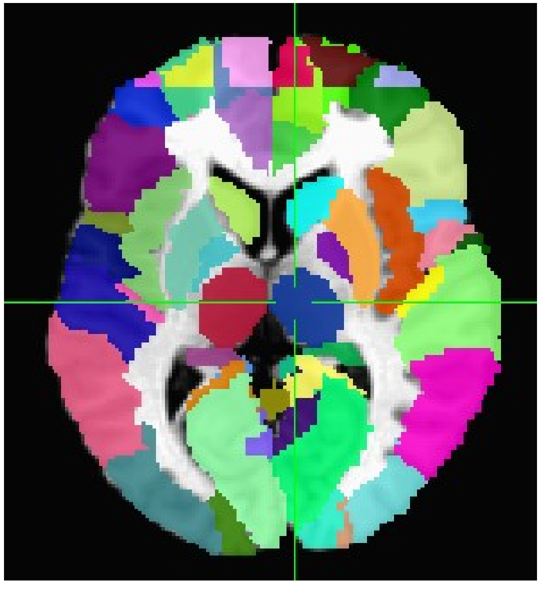
(Typically, there are so many templates for a given space now-- MNI, for example, has several templates-- that one really has to specify the full file name of a template to be able to refer to it unambiguously, anyways.)

Definitions

Atlas

A dset containing segmentation or parcellation information. It can be considered a "map" of ROIs: each ROI is defined as a set of voxels with a certain integer value (and a string label can be attached to each ROI).

Ex: TTatlas+tlrc, TT_N27_EZ_ML+tlrc, my_roidset+orig.

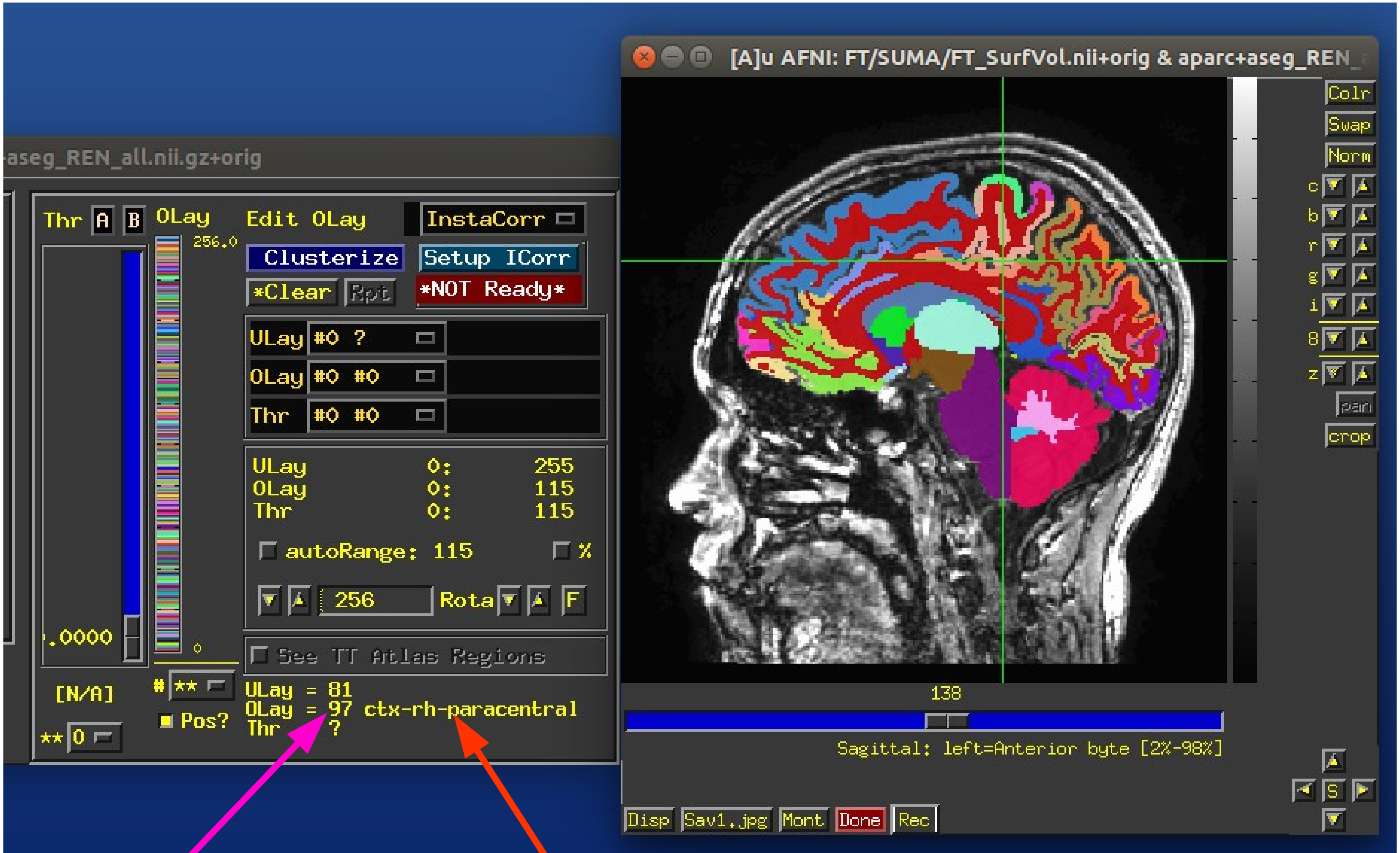


TT_N27_EZ_ML+tlrc

See more description about templates+atlases (including making your own) on the AFNI website:
https://afni.nimh.nih.gov/pub/dist/doc/htmldoc/template_atlas/framework.html

Definitions

Atlas (or general ROI) label in GUI

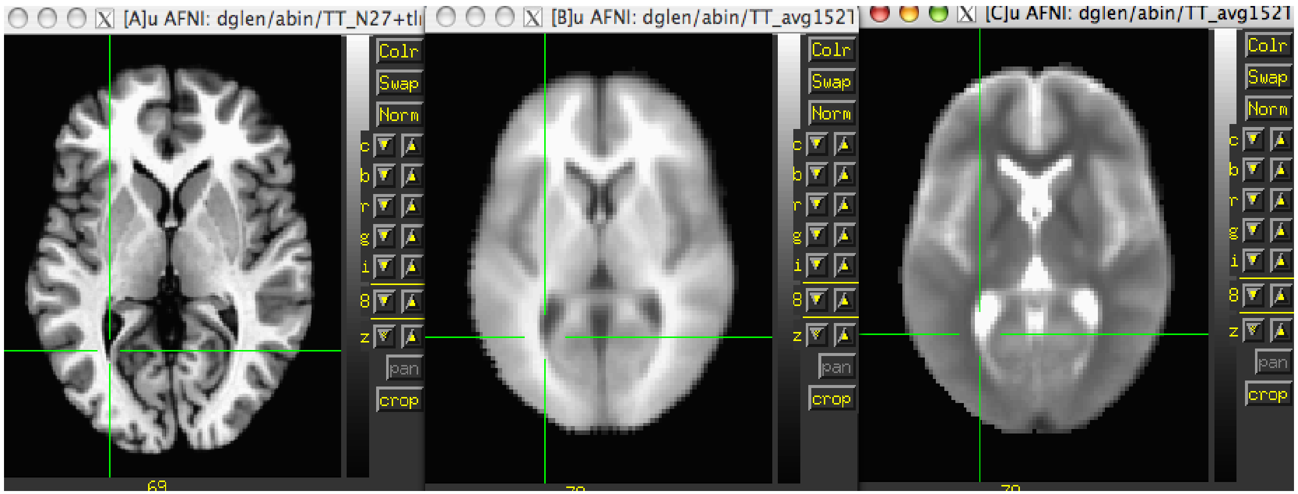


integer value of ROI

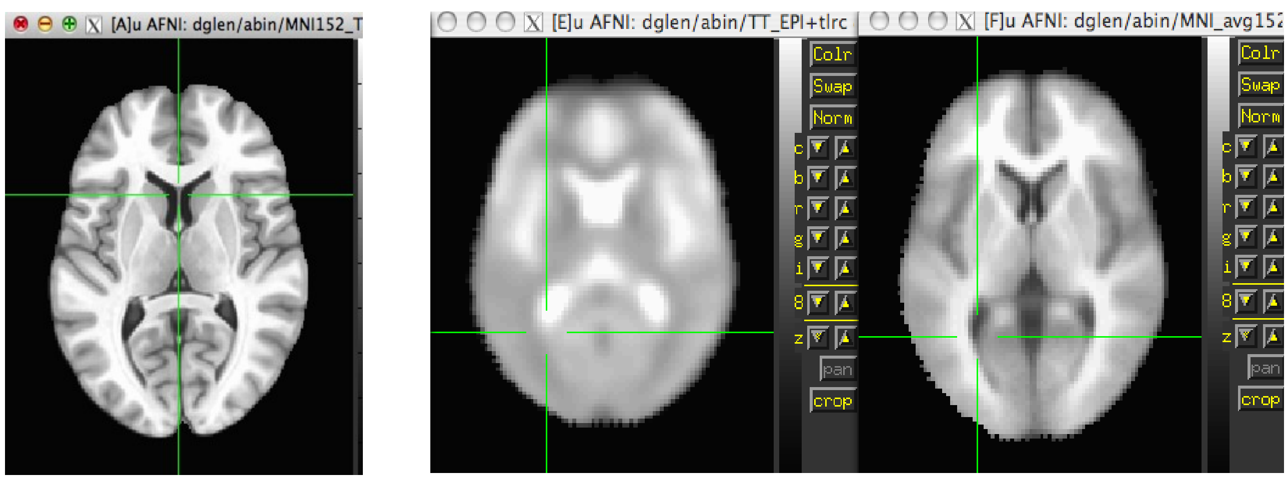
associated string label

Templates included with AFNI

After default AFNI installation, these templates (and others) would be in **~/abin/:**



TT_N27 | TT_avg152T1 | TT_avg152T2



MNI152_T1_2009c | TT_EPI | MNI_avg152T1

And a quick question: what important properties does each dset here have?

Templates included with AFNI

A helpful note on viewing templates (or any dsets) **each time** you open up the AFNI GUI, regardless of directory!

Set the **AFNI_GLOBAL_SESSION** variable in your ~/.afnirc file, e.g.,:

```
AFNI_GLOBAL_SESSION = /home/nmandela/abin
```

All dsets there will appear in your “Underlay” or “Overlay” menu in the AFNI GUI. (Use full path of directory, no “~” or “$HOME”.)

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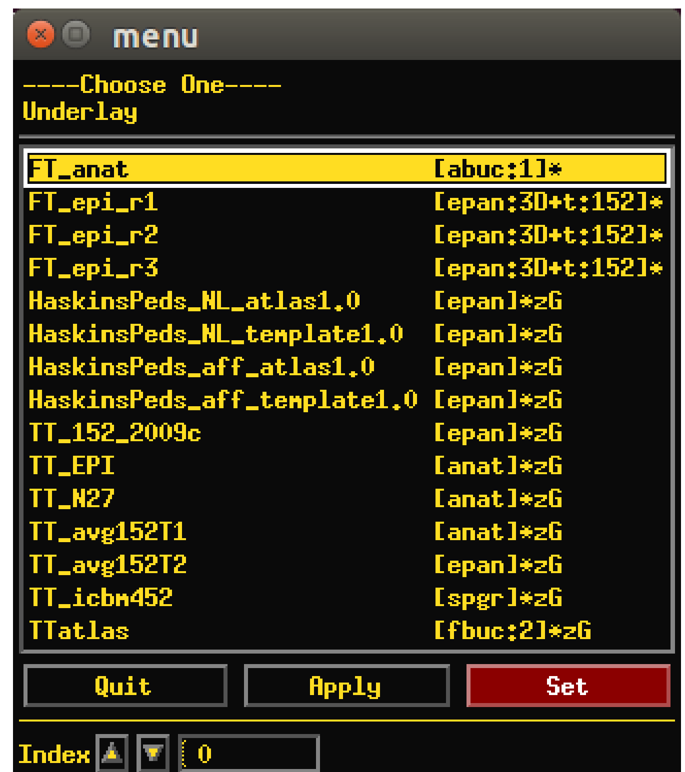
```

All dsets there will appear in your "Underlay" or "Overlay" menu in the AFNI GUI. (Use full path of directory, no "~" or "$HOME".)

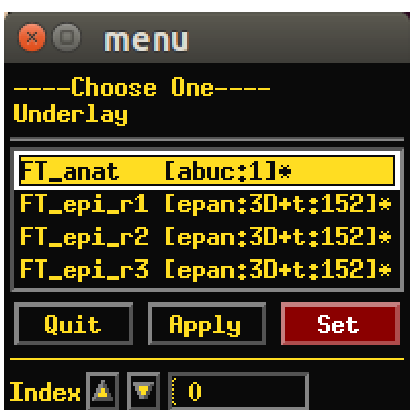
Ex: then open AFNI GUI in some directory, say:

```
~/AFNI_data6/FT_analysis/FT/
```

after



before



Standard spaces

Reasons to use a standard template space:

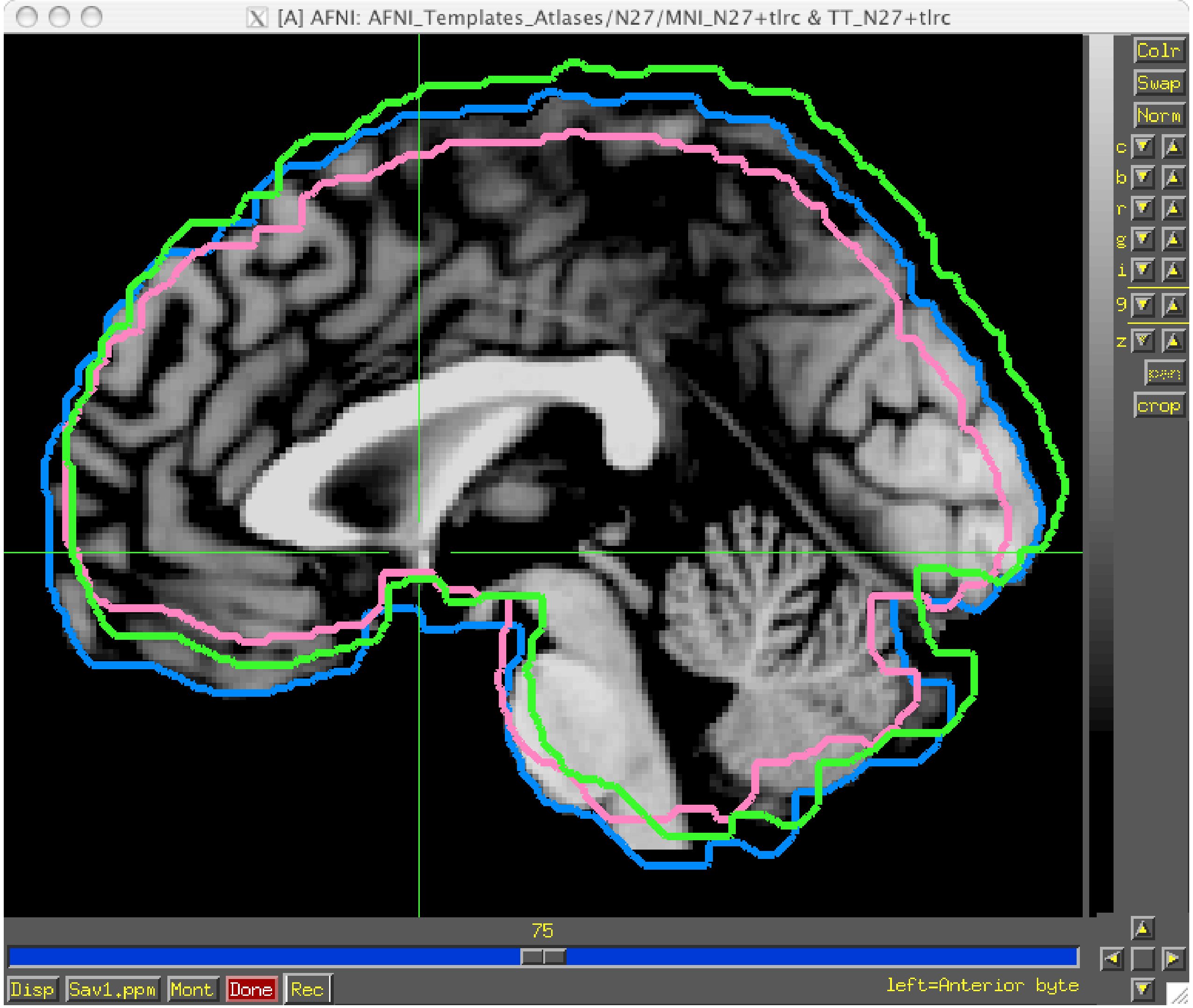
- Compare across subjects and groups easily for every voxel in the brain
- Standardize coordinates with others
- Know where a voxel is automatically from an atlas
- Mostly automated and no specific ROI drawing required

Reasons <u>not</u> to use a standard template space:

- Inconsistency among subjects
- Inconsistency among groups – elderly versus younger
- Use consistent anatomical ROIs with good anatomical knowledge
- Lower threshold for multiple comparison adjustments

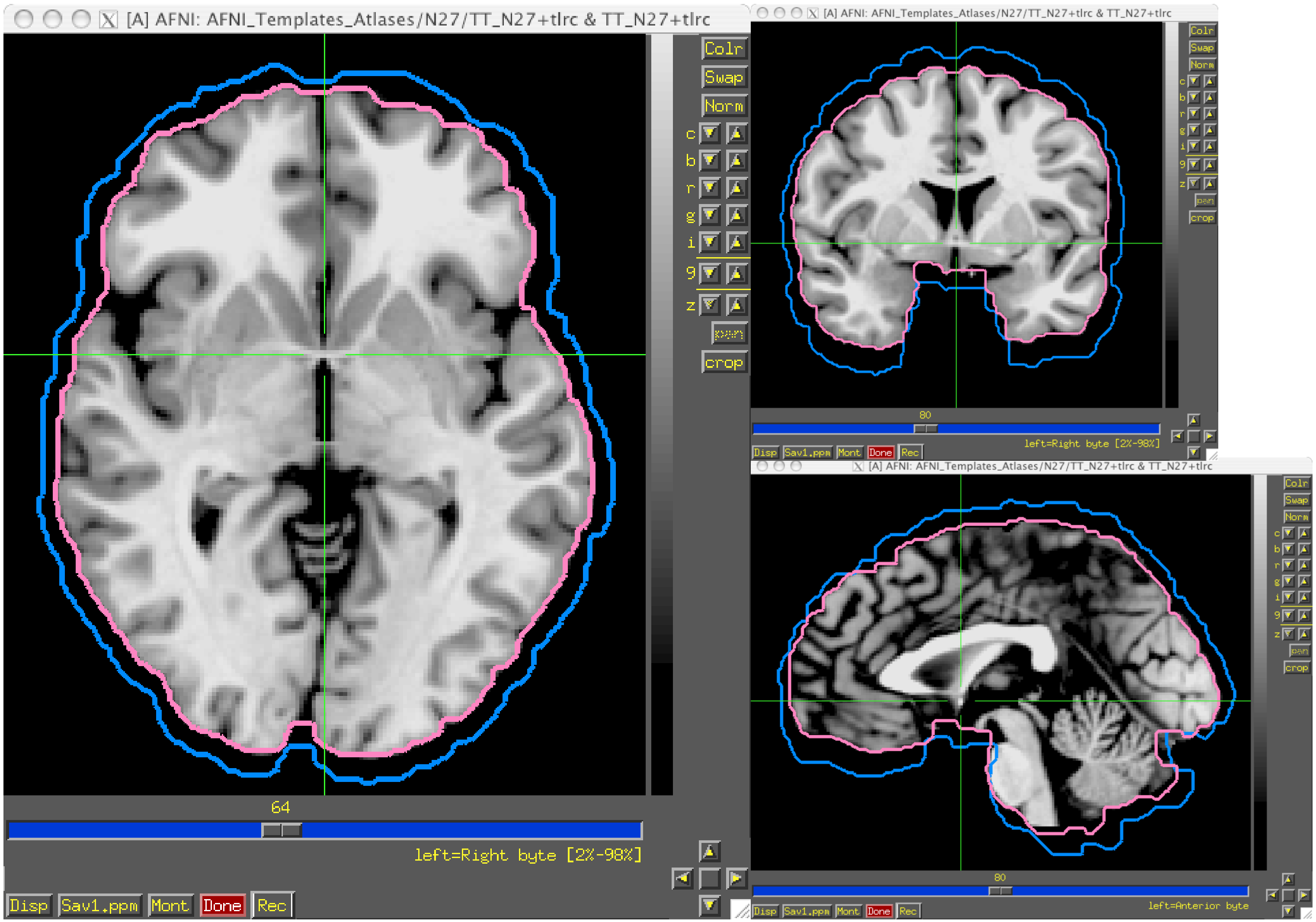
Template spaces differ in origin

TLRC, MNI, and MNI-Anat



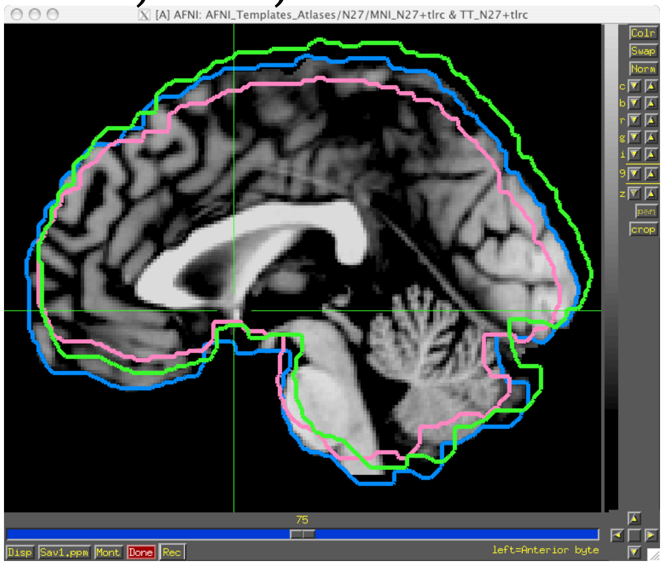
Template spaces differ in size

The **MNI** brain is larger than the **TLRC** brain.



From space to space

TLRC, MNI, and MNI-Anat



For going between TLRC and MNI:

Approximate equation
→ used by **whereami** and **3dWarp**

A manual TLRC transformation of MNI template to TLRC space
→ used by **whereami** (as precursor to MNI Anat.), based on N27 template

Multiple space coordinates reported in **whereami** output (**AFNI_ATLAS_TEMPLATE_SPACE_LIST**)

For going between MNI and MNI Anat (Eickhoff et al., 2005):

MNI + (0, 4, 5) = MNI Anat. (in RAI coordinate system)

Going between TLRC and MNI Anat (as practiced in whereami):

Go from TLRC (TT_N27) to MNI via manual transform of N27 template

Add (0, 4, 5)

Choosing a template

Try to pick a template that...

- is similar to the subject group: neonates, pediatric, young adults, elderly, macaque, rabbit...
- is of the same modality and coverage as your data sets
- has a relevant atlas segmentation.

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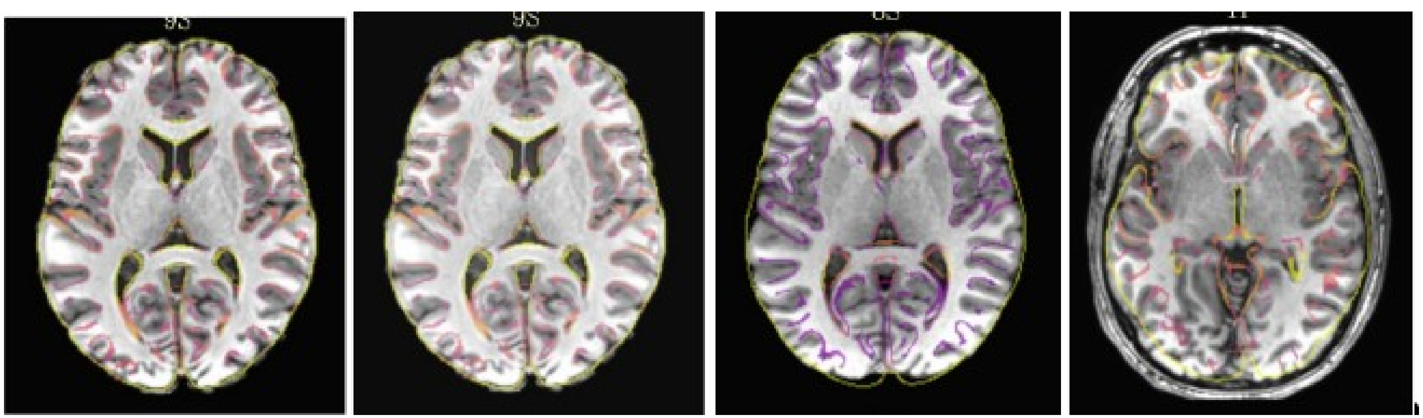
You can also make your own template (and maybe an atlas too):

- Individual or group template
  - Group: average or iterative (discussed more later)
- Scripts/commands exist in AFNI
  - *Ex*. Haskins pediatric atlas
    - ➡ several methods tested
    - best approach: *iterative nonlinear alignment*
      - ➪ **@toMNI_Awarp, @toMNI_Qwarpar**
      - **And now/soon make_template_dask.py**

Trading Spaces

How to transform data to a standard template space

- **@SSwarper** – skullstrip and align data to some select standard spaces
- **@animal_warper -** skullstrip, align data to animal template and bring atlas into native space
- **auto_warp.py** -combination affine and nonlinear alignment to a template
- **@auto_tlrc** – affine alignment to a template
- Manual talairach



@SSW AW @at manual

Trading Spaces

afni_proc.py options

tlrc block before volreg!

```
-volreg_tlrc_warp
-tlrc_base $tpath/$btemplate        (runs @auto_tlrc)
-tlrc_NL_warp  (runs auto_warp.py)
```

For @SSwarper output, add these:

```
-copy_anat anatSS.${subj}.nii          \
-anat_has_skull no                     \
-tlrc_NL_warp                          \
-tlrc_NL_warped_dsets                  \
          anatQQ.${subj}.nii           \
          anatQQ.${subj}.aff12.1D      \
          anatQQ.${subj}_WARP.nii
```

Registration To Standard Spaces

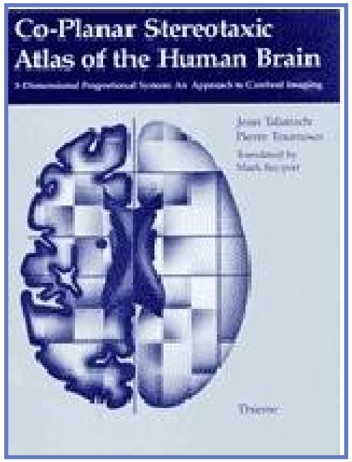
Transforming Datasets to Talairach-Tournoux Coordinates

- The original purpose of AFNI (*circa* 1994 A.D.) was to perform the transformation of datasets to Talairach-Tournoux (stereotaxic) coordinates
- The transformation can be manual, or automatic
- In manual mode, you must mark various anatomical locations, defined in

  Jean Talairach and Pierre Tournoux

  "Co-Planar Stereotaxic Atlas of the Human Brain"

  Thieme Medical Publishers, New York, 1988



  - Marking is best done on a high-resolution T1-weighted structural MRI volume
- In automatic mode, you need to choose a template to which your data are aligned. Different templates are made available with AFNI's distribution. You can also use your own templates.
- Transformation carries over to all other (follower) datasets in the same directory
  - This is where the importance of getting the relative spatial placement of datasets done correctly in **`to3d`** really matters
  - You can then write follower datasets, typically functional or EPI timeseries, to disk in Talairach coordinates
    - Purpose: voxel-wise comparison with other subjects
    - May want to blur volumes a little before comparisons, to allow for residual anatomic variability: AFNI programs **`3dmerge`** **`or`** **`3dBlurToFWHM`**

Automatic Talairach transform (affine) with @auto_tlrc

- In the olden days, people would spend a lot of time transforming data to standard space by hand (see Supplement slides for how to perform the Manual TLRC transform using the AFNI GUI by setting AC-PC landmarks).
- Here, we describe how to perform a TLRC transform ***automatically*** using AFNI's **@auto_tlrc** (used by *afni_proc.py* for linear affine alignment to standard space).
  - Differences from Manual Transformation:
    - Instead of setting AC-PC landmarks and volume boundaries by hand, the anatomical volume is warped (using 12-parameter affine transform) to a template volume in TLRC space.
    - The Anterior Commisure (AC) center is no longer at xyz = (0,0,0), and the size of brain box is that of the template you use.
      - For various reasons, some good and some bad, templates adopted by the neuroimaging community are not all of the same size. Be mindful when using various atlases or comparing standard-space coordinates.
    - You, the user, can choose from various templates for reference (just be consistent in your group analysis).
    - It is easy + automatic. Just check final results to make sure nothing went seriously awry.

@auto_tlrc example

- To run in AFNI_data6/afni/
  Transform the subj anat to a template space (output: **anat_TT+tlrc**):

```
@auto_tlrc                    \
    -base TT_N27+tlrc         \
    -suffix _TT               \
    -input anat+orig
```

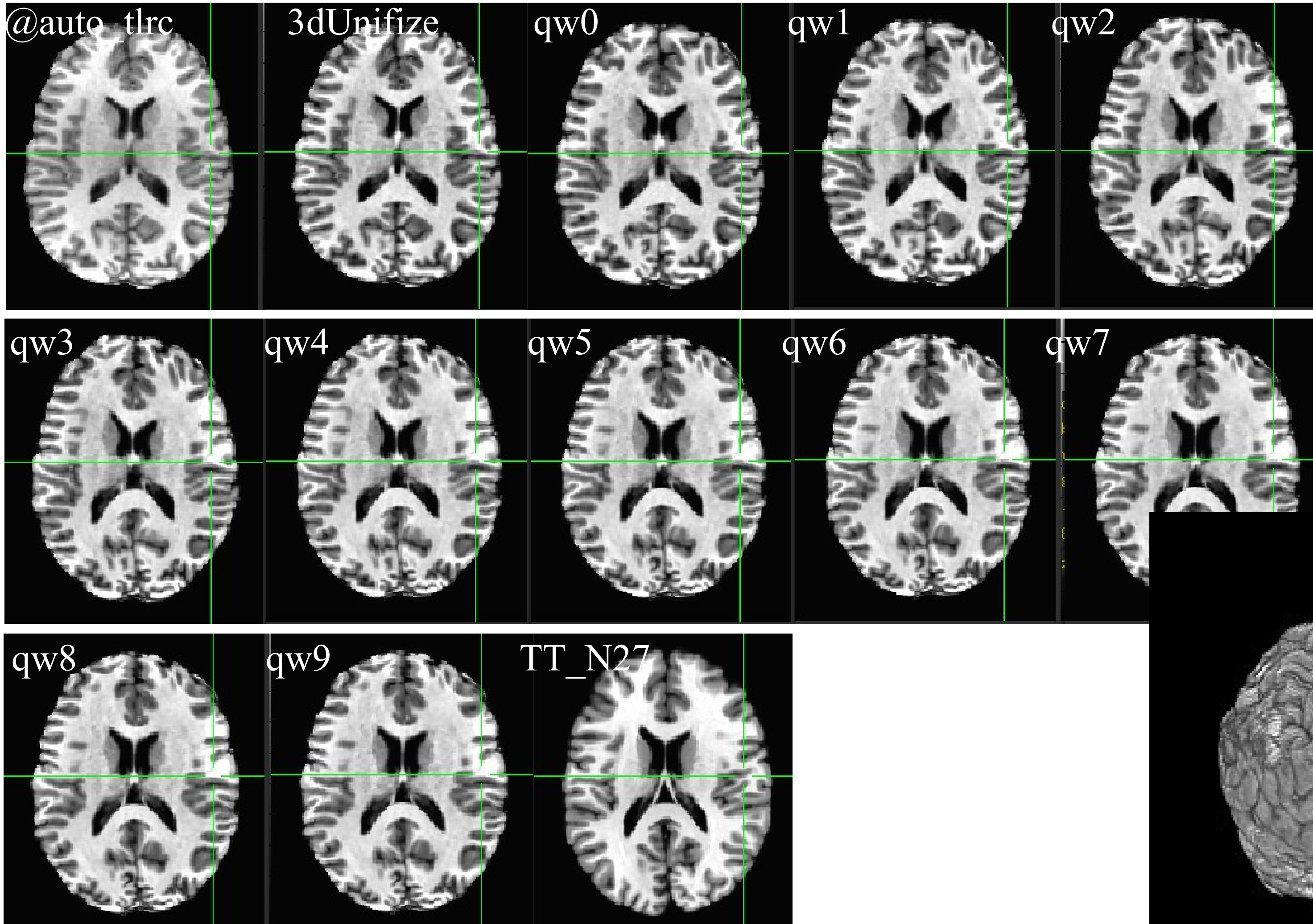
- Then apply the transform stored in **anat_TT+tlrc**'s header to a "follower dset" (here, func data), specifying output resolution at 3 mm (output: **func_slim_TT+tlrc**):

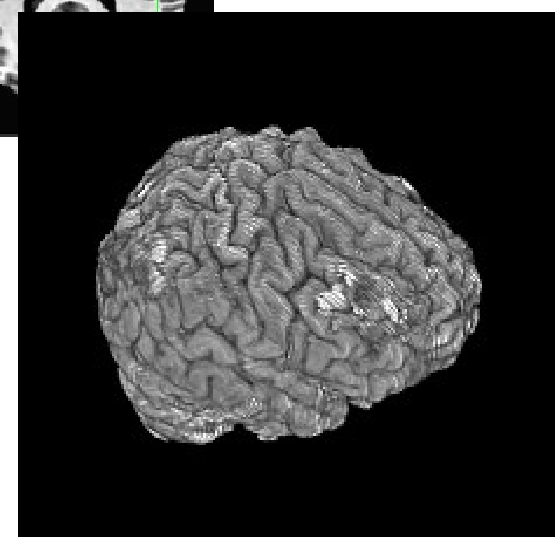
```
@auto_tlrc                    \
    -apar anat_TT+tlrc        \
    -input func_slim+orig     \
    -suffix _TT               \
    -dxyz  3
```

- Instead of **TT_N27**, you could also use the **icbm452,** or the mni's **avg152T1** template, or any other template you like
  (see **@auto_tlrc -help** for a few good words on templates)

Nonlinear alignment to template

3dQwarp, through multiple levels of refinement →





Nonlinear alignment to template

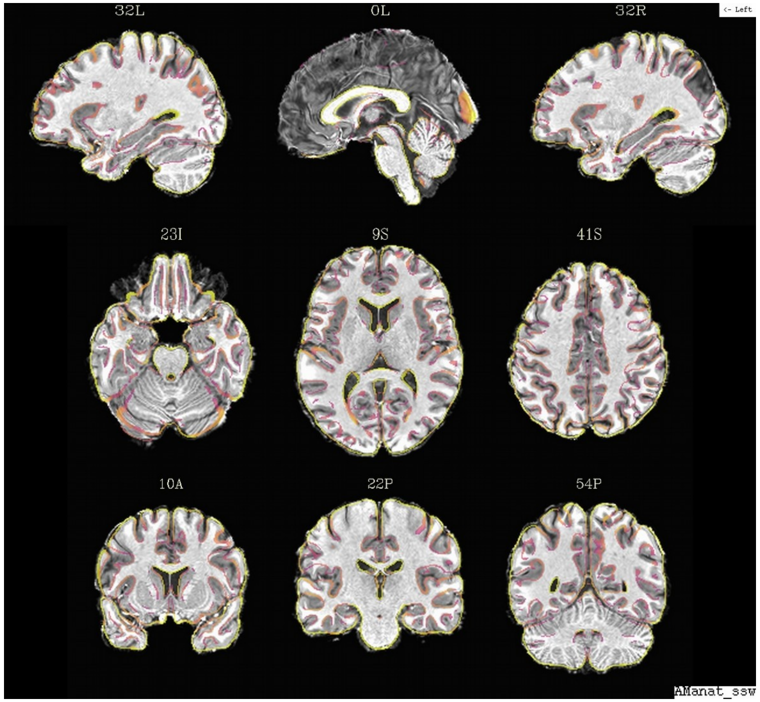
Multiple nonlinear alignment tools in AFNI

3dQwarp: the standard nonlinear workhorse

auto_warp.py: wrapper for alignment functionality, ~simpler syntax
(@auto_tlrc + 3dQwarp together)

Ex:
```
auto_warp.py -base MNI152_T1_2009c+tlrc. \
      -suffix _awarp -input strip+orig.
```

@SSwarper: skull stripping and alignment in one-- and bonus automatic QC images



+ @SSwarper uses a multi-volume base; several exist for standard templates already, and more can be made-- see full description for these online:

https://afni.nimh.nih.gov/pub/dist/doc/htmldoc/template_atlas/sswarper_base.html

Measuring quality of alignment

Can compare: nonlinear alignment vs affine alignment

+ Estimate warp from subject anat to template for a group of subjects
+ Apply warp when processing FMRI data (here, resting state)
+ Check changes in seed-based correlation maps between results
  - better method would have higher corr in GM networks and lower corr in WM.

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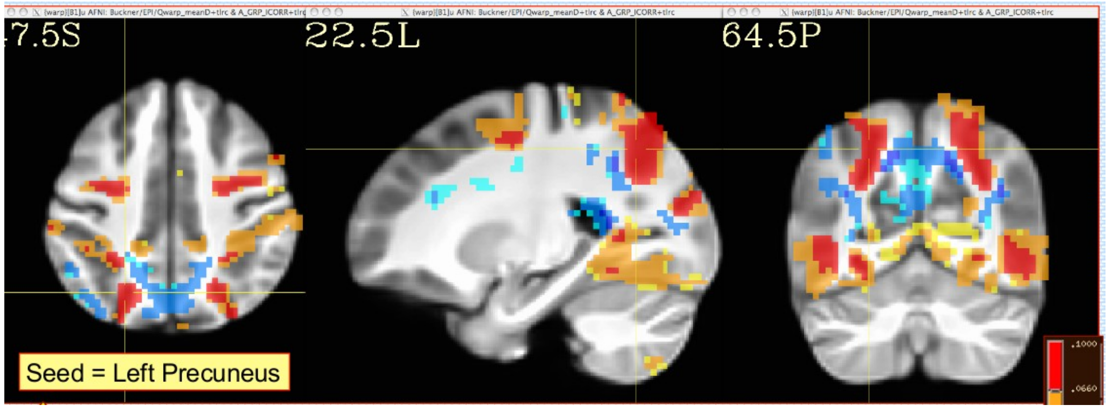
red: [0.066, 0.100] corr
increase for 3dQwarp results

blue: [0.066, 0.100] corr
decrease for 3dQwarp results

188 FCON1000 Cambridge
datasets



(Cox & Glen, 2013, OHBM)

Measuring quality of alignment

<u>Can compare: using detailed vs non-detailed template for nonlinear alignment</u>

+ Estimate warp from subject anat to template for a group of subjects
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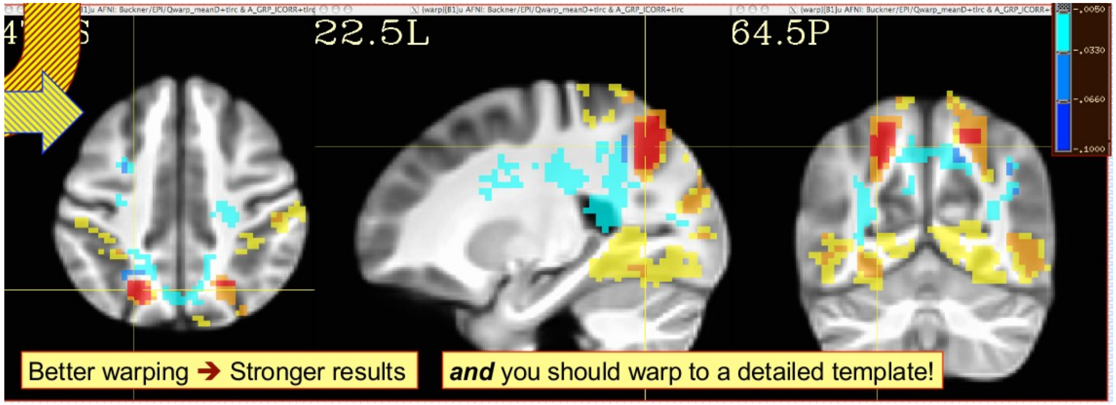


(Cox & Glen, 2013, OHBM)

Measuring quality of alignment

<u>Can compare 3dQwarp with other available nonlinear alignment tools</u>

+ For a group of subjects, estimate warp from anat to template
+ Apply warp to labeled ROIs, and measure % overlap in results.

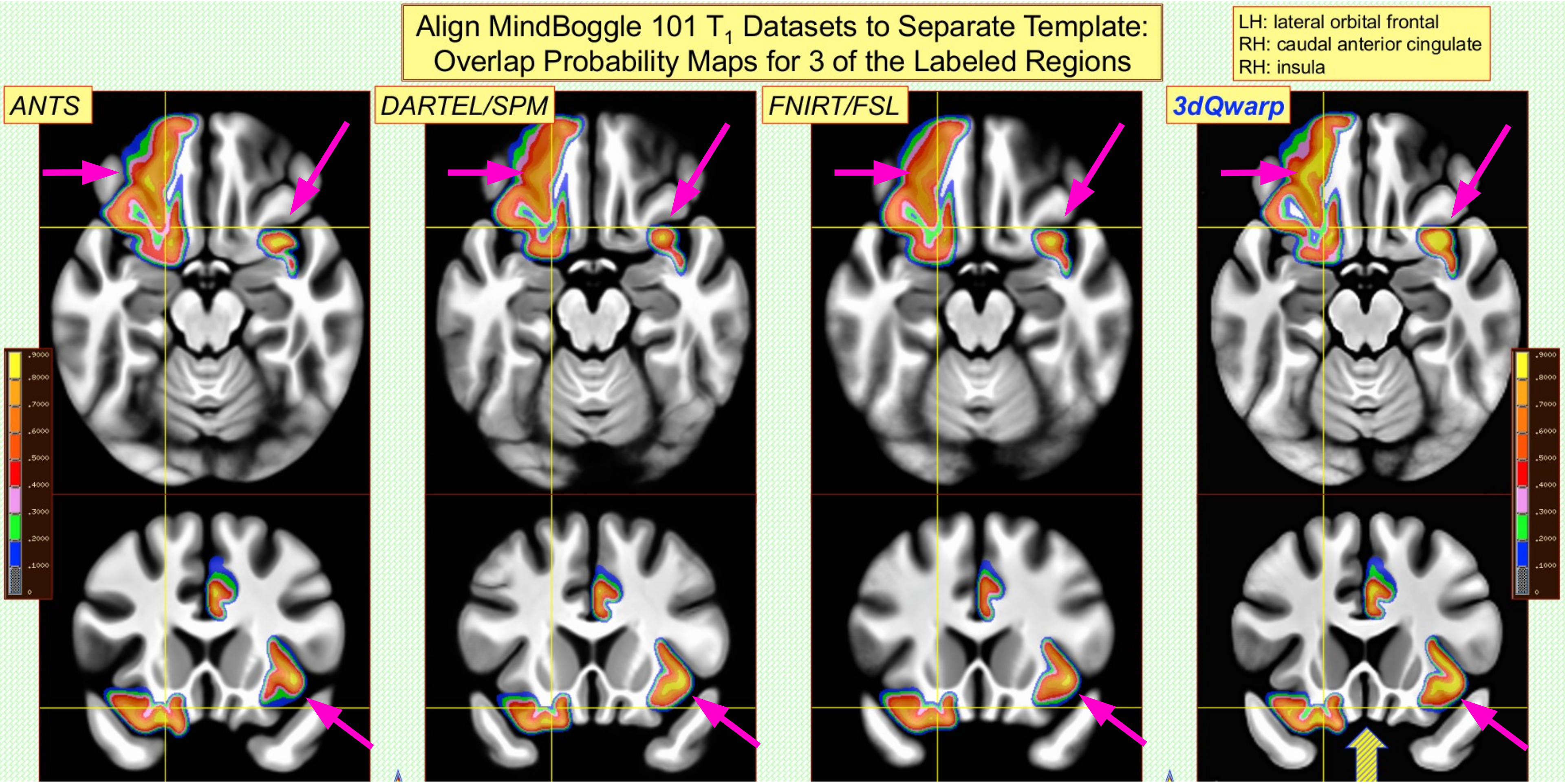
ANTS, DARTEL and FNIRT run with default settings

(Cox & Glen, 2013, OHBM)

Measuring quality of alignment

<u>Can compare 3dQwarp with other available nonlinear alignment tools</u>

+ For a group of subjects, estimate warp from anat to template
+ Apply warp to labeled ROIs, and measure % overlap in results. (Yellow: >90% overlap)



ANTS, DARTEL and FNIRT run with default settings

(Cox & Glen, 2013, OHBM)

Nonlinear alignment to standard space

Advantages

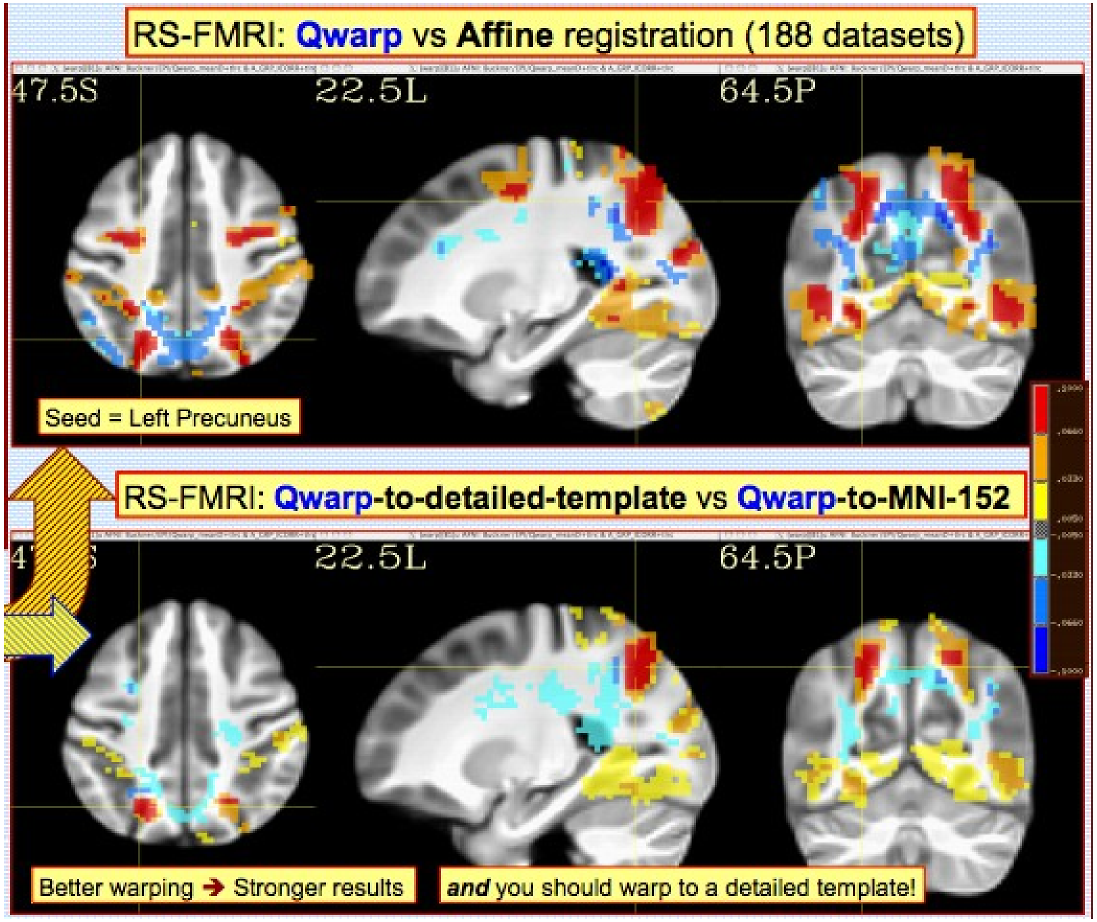
- Better spatial correspondence across data

  → consistent data reinforces across group
- Final data matches template (reporting coordinates, etc.)

Disadvantages

- Individual data is distorted
- Aligned data matches template. Choose template carefully
- Skullstripping must be done much more carefully

  → note that **@SSwarper** actually *combines* nonlinear warping with skullstripping, so benefit now!
- Processing time much slower (but... such is life)



(Cox & Glen, 2013, OHBM)

Going where the atlases live

AFNI binary directory for datasets and configuration

AFNI_atlas_spaces.niml describe the distributed atlases

CustomAtlases.niml and SessionAtlases.niml allow for more atlases and templates

Saving the Environment

AFNI_ATLAS_LIST "CA_ML_18_MNI,DKD_Desai_MPM" "ALL"

AFNI_TEMPLATE_SPACE_LIST “MNI,TLRC”

AFNI_ATLAS_COLORS CA_ML_18_MNI

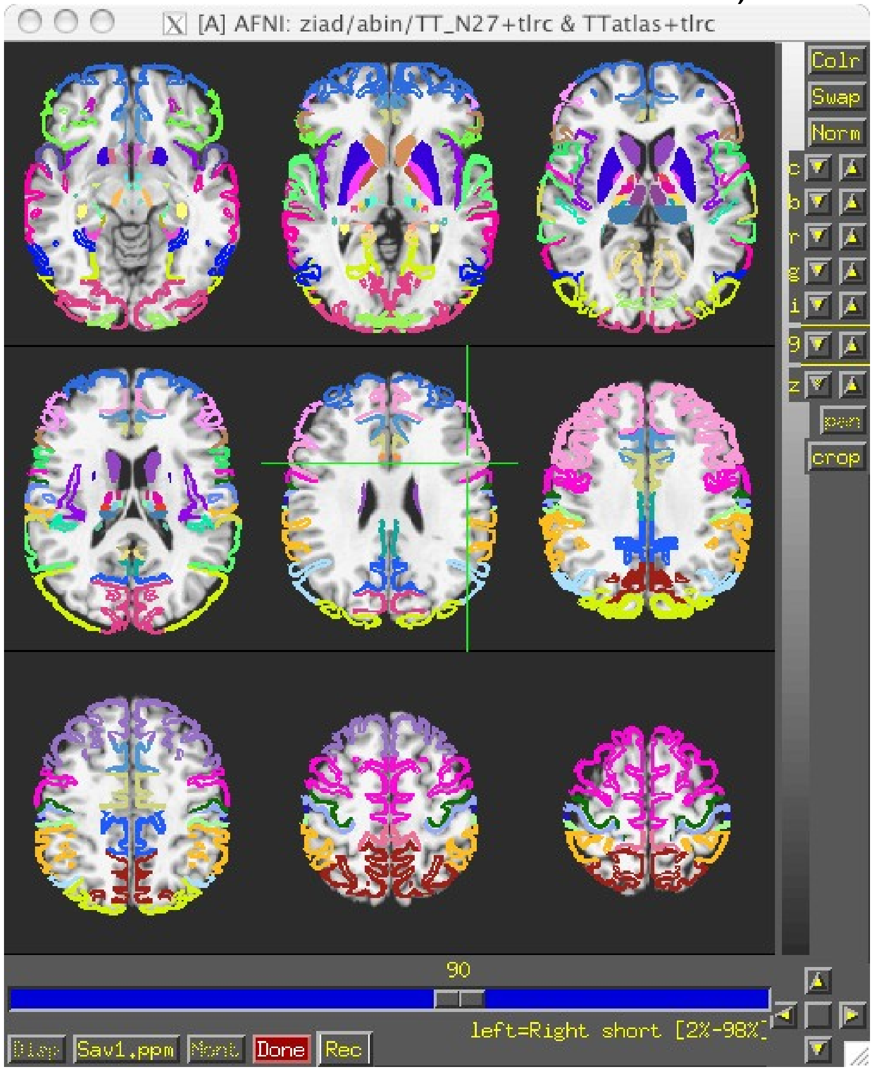
AFNI_SUPP_ATLAS_DIR ~/MyAtlases

AFNI_WHEREAMI_DEC_PLACES 2

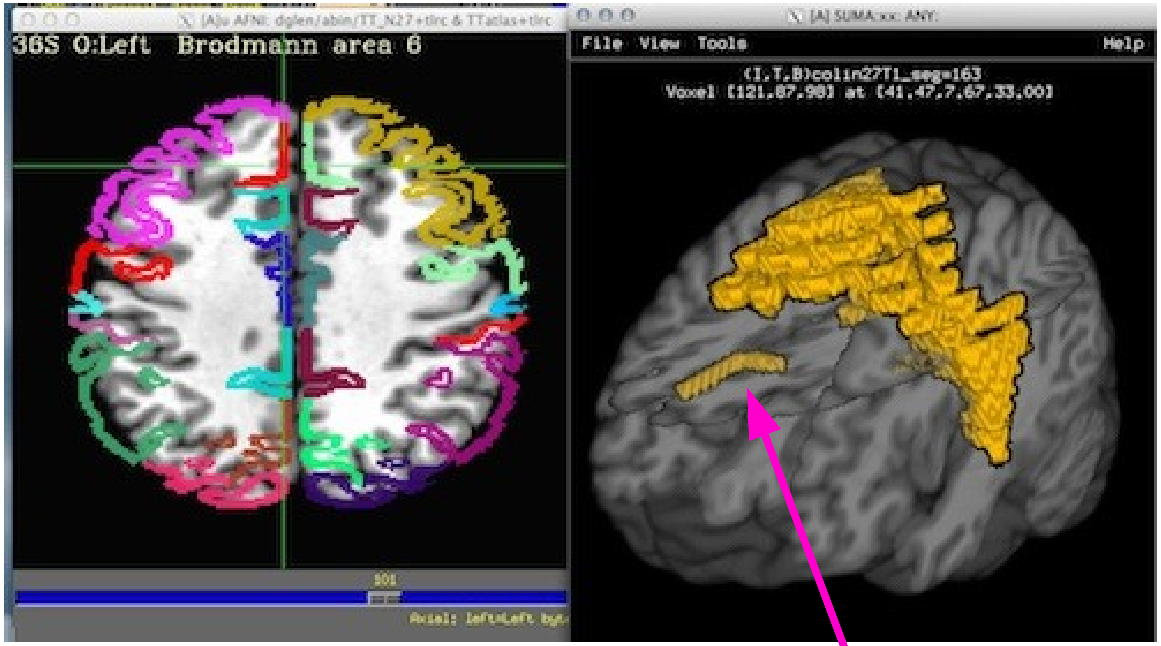
AFNI_WHEREAMI_MAX_SEARCH_RAD 3

Atlases distributed with AFNI: TT_Daemon

- TT_Daemon : Created by tracing Talairach and Tournoux brain illustrations.
  - Generously contributed by Jack Lancaster and Peter Fox of RIC UTHSCSA)



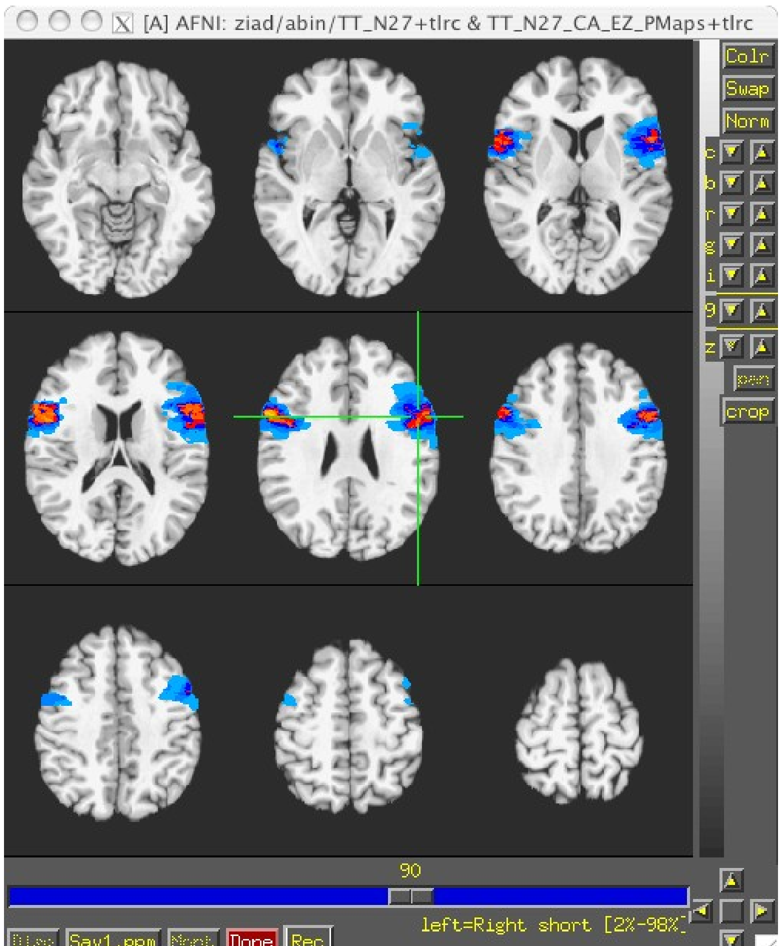
Caution: Talairach Daemon (TT_Daemon) problems

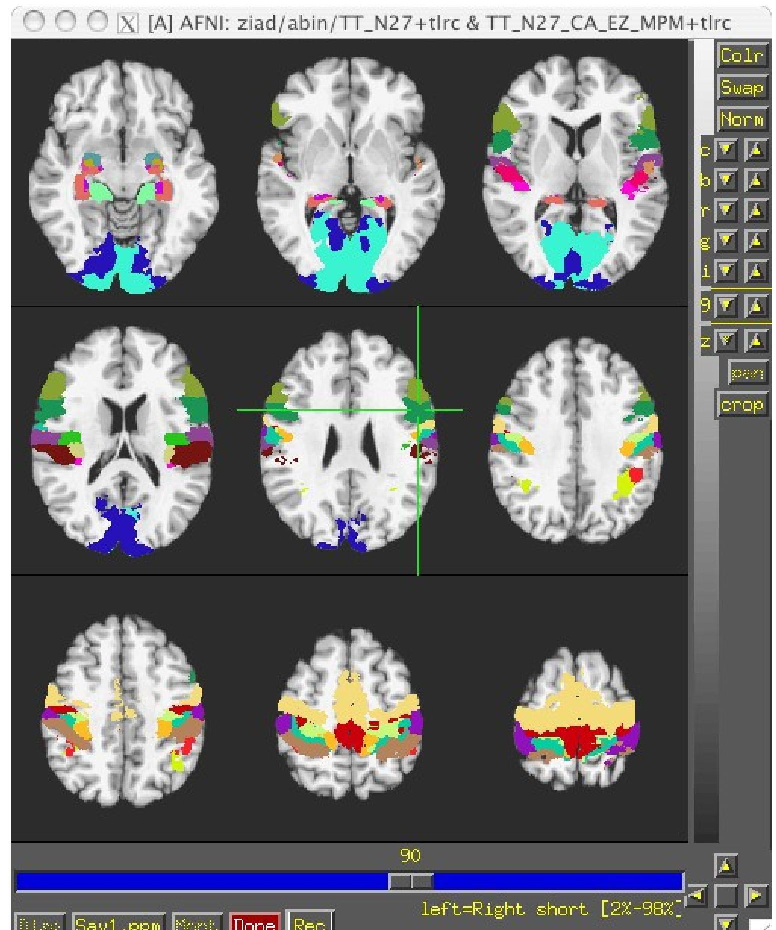


This piece is labeled as BA 6,
but is really another part.

Atlases distributed with AFNI: "Anatomy Toolbox"

- CA_N27_MPM, CA_N27_ML, CA_N27_PM: Anatomy Toolbox's atlases with some created from cytoarchitectonic studies of 10 human post-mortem brains
  - ◇ Probabilistic maps and max. probability maps generously contributed by K. Amunts, S. Eickhoff, and K. Zilles of IME, Julich, Germany





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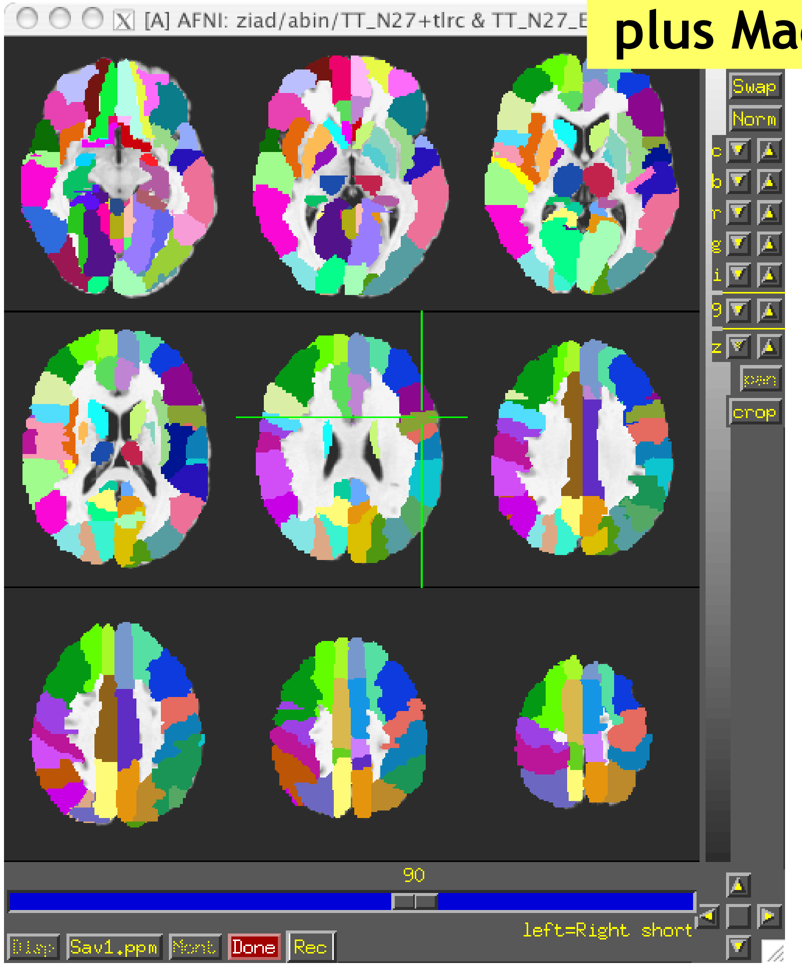
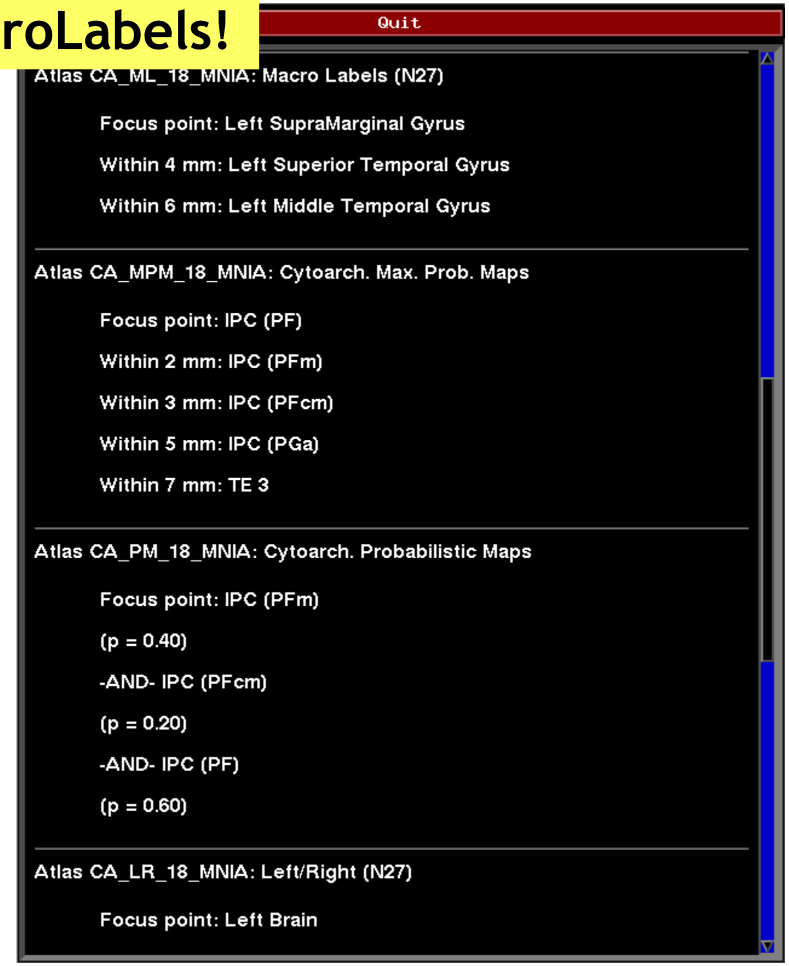
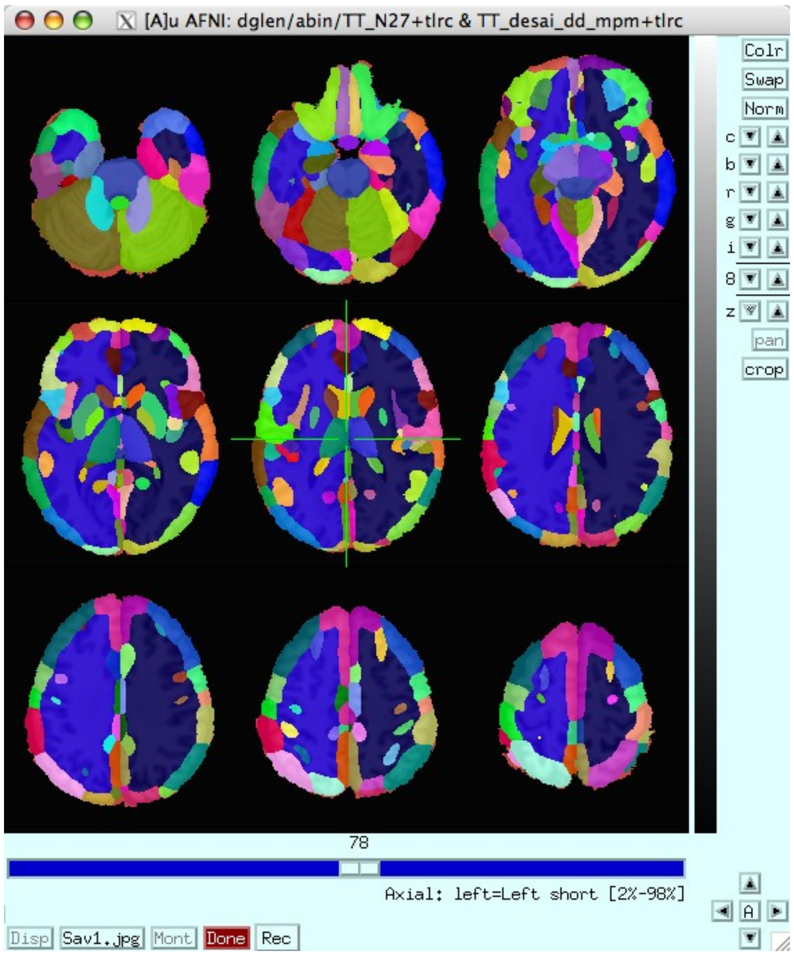


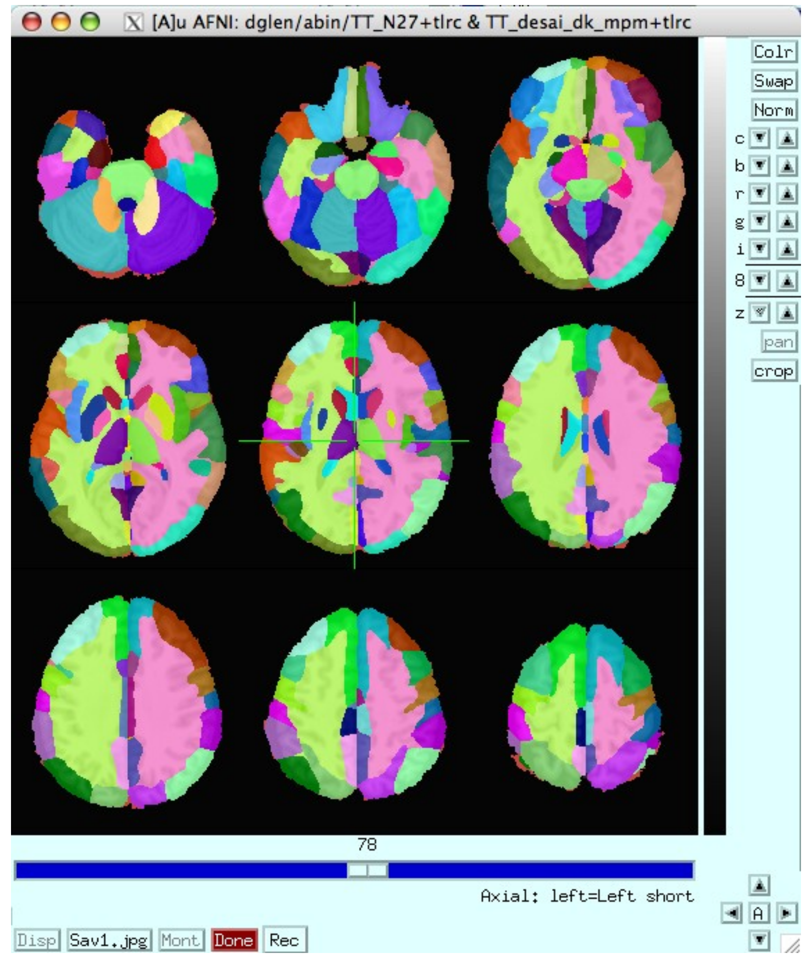
plus MacroLabels!



Atlases distributed with AFNI: Desai PMaps and MPMs

- Atlases generated with typical AFNI pipeline using *@auto_tlrc* and FreeSurfer segmentation across multiple subjects





Using atlases in AFNI GUI

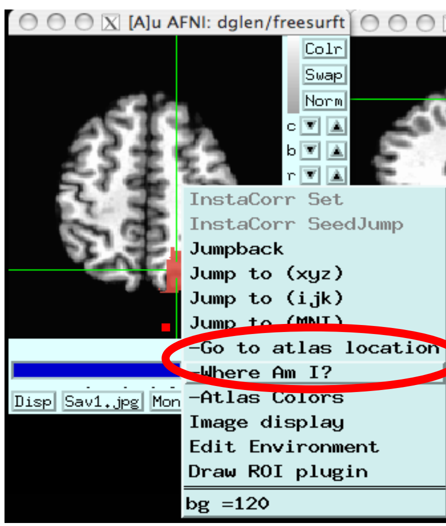
- Some fun and useful things to do with `+tlrc` datasets are on the 2D slice viewer.

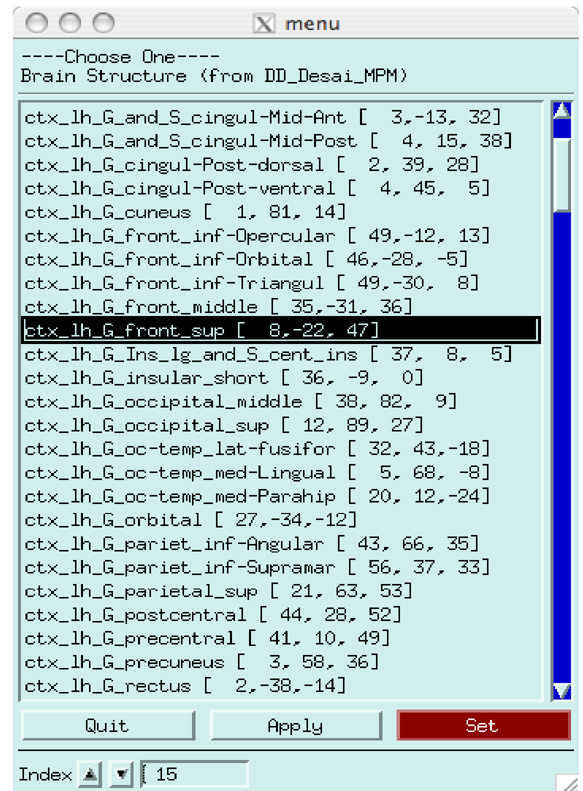
  ***Ex:* can be run in ~/AFNI_data6/afni/**

  1) Right click to get menu:

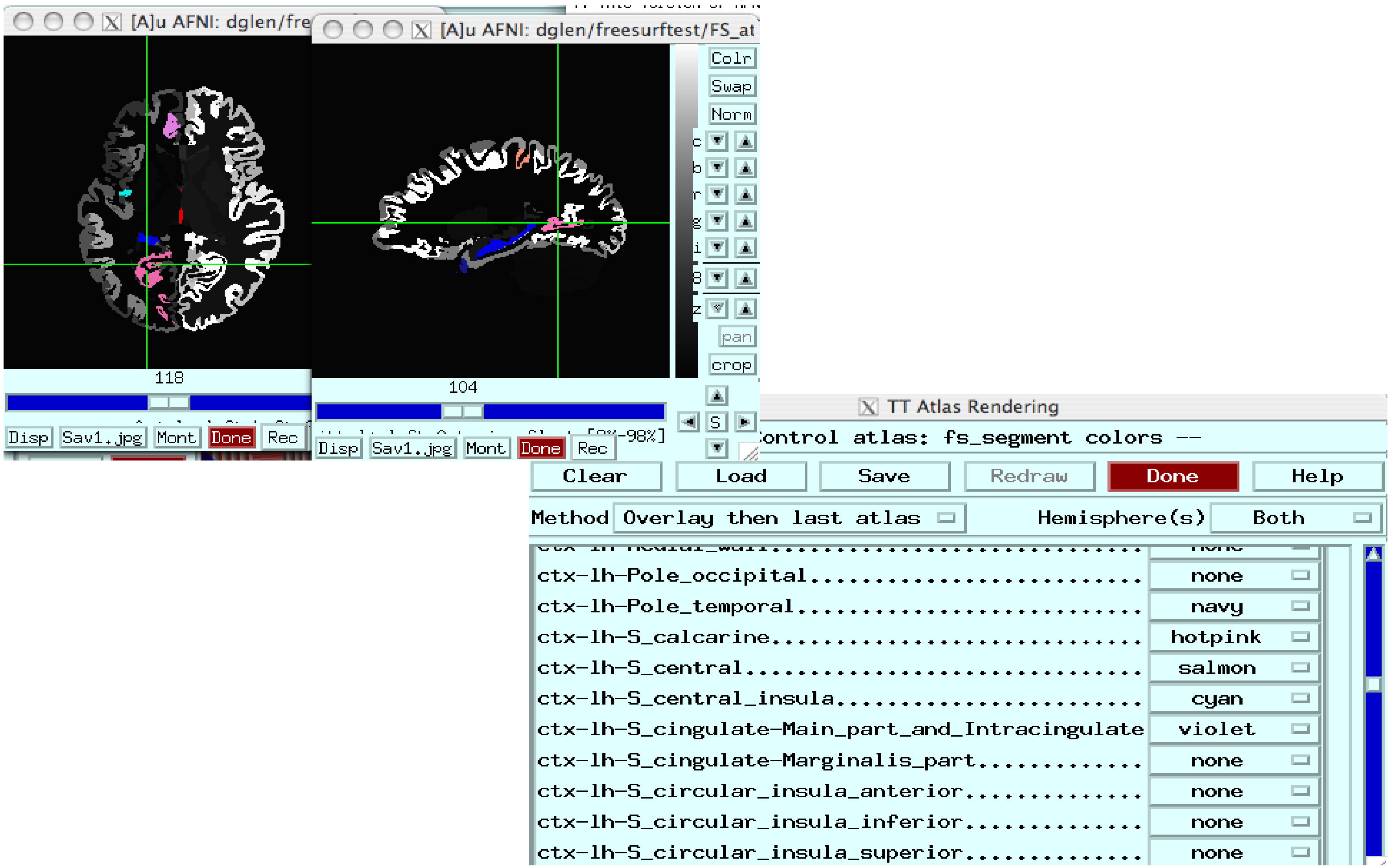
  - **[Go to Atlas Location]**

    Lets you jump to centroid of regions to current default atlas (set by AFNI_ATLAS_COLORS) Works in `+orig`, too.





◇ [Atlas colors]



Lets you show atlas regions over your own data (works only in `+tlrc`).

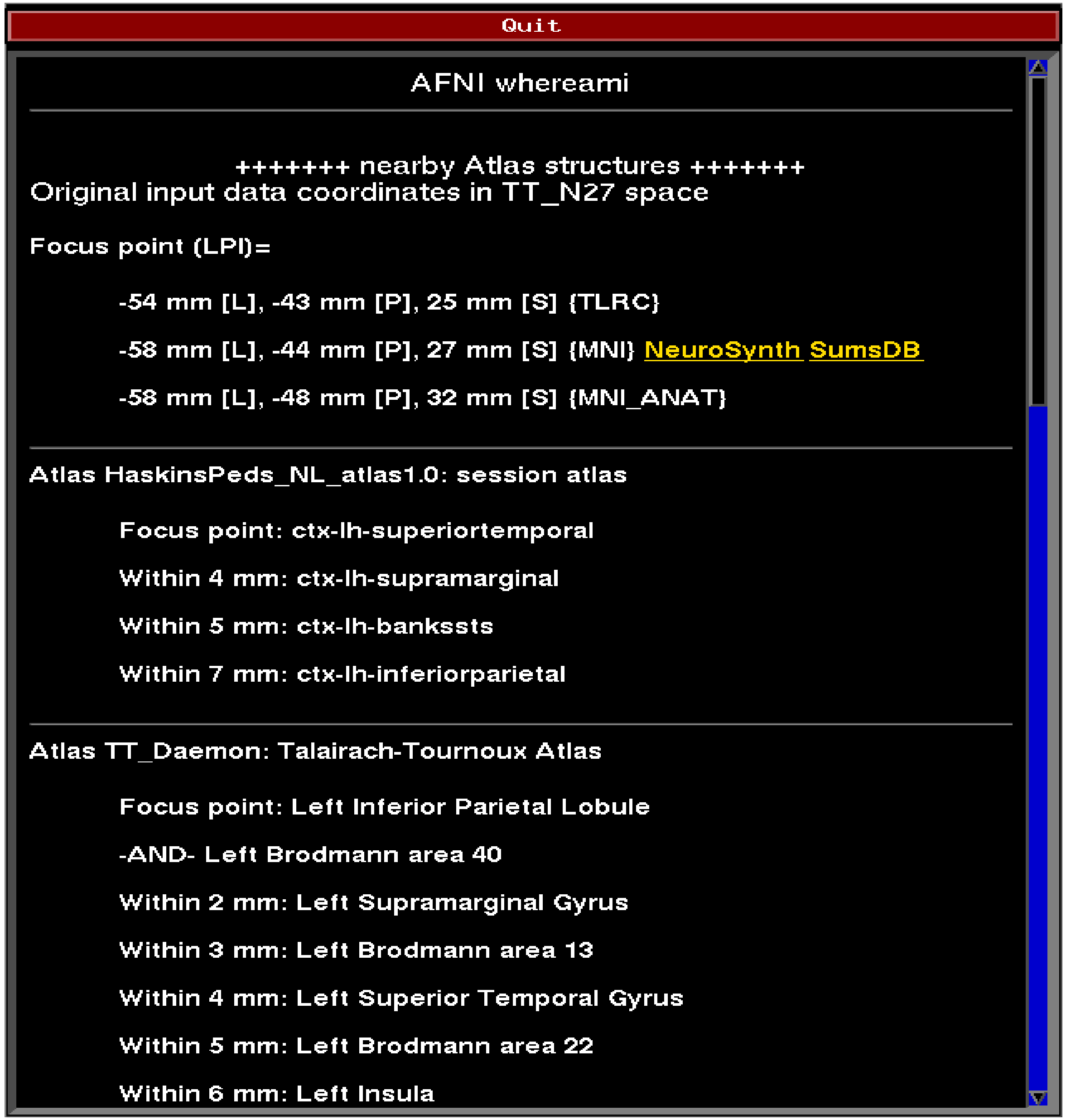
◇ [Where am I?]

Shows you where you are in various atlases and spaces

(works in `+orig` too, if you have a transformed parent)

For atlas installation, and much, much more, see help in command line version:

`whereami -help`



whereami on the command line

whereami can combine usefully with **3dClusterize**:

1) **3dClusterize** finds cluster volumes, and
2) **whereami** provides detailed info like overlap with atlas regions

***Ex*: can be run in ~/AFNI_data6/afni/**

```
# Threshold the index-0 vol (an F-stat) at >9.5 and
# find clusters with >=1000 voxels
3dClusterize -1sided RIGHT 9.5                 \
    -clust_nvox 1000 -NN 1                     \
    -inset func_slim+orig -ithr 0 -idat 0      \
    > clusts.1D
```

```
# Use the center of mass coords in
# cols [1,2,3] to show location according
# to several atlases (TT, MNI, etc.); also
# shows nearby structures
whereami                 \
    -coord_file          \
    clusts.1D'[1,2,3]'   \
    -tab | more
```

```
++ Input coordinates orientation set by default rules to RAI
+++++++ nearby Atlas structures +++++++

Original input data coordinates in TLRC space

Focus point (LPI)                       Coord.Space
   0 mm [L],    0 mm [P],    0 mm [S]   {Unknown}
   2 mm [R],  -60 mm [P],    9 mm [S]   {TT_N27}
   2 mm [R],  -60 mm [P],    9 mm [S]   {TT_avg}
Atlas           Within  Label                                Prob.   Code
TT_Daemon       0.0     Right Posterior Cingulate             MPM    20
TT_Daemon       2.0     Right Cuneus                          MPM    40
TT_Daemon       3.0     Left  Posterior Cingulate             MPM    220
TT_Daemon       4.0     Left  Cuneus                          MPM    240
TT_Daemon       6.0     Right Lingual Gyrus                   MPM    32
CA_N27_ML       0.0     Right Calcarine Gyrus                 ---    44
CA_N27_ML       1.0     Left Calcarine Gyrus                  ---    43
CA_N27_ML       1.0     Left Lingual Gyrus                    ---    47
CA_N27_ML       2.0     Right Lingual Gyrus                   ---    48
CA_N27_ML       5.0     Cerebellar Vermis (4/5)               ---    111
CA_N27_MPM      0.0     Area 17                               ---    181
CA_N27_MPM      3.0     Area 18                               ---    240
CA_N27_PM       0.0     Area 17                              0.60    38
CA_N27_PM       0.0     Area 18                              0.30    67
```

whereami on the command line

whereami can also report the overlap of ROIs with atlases

***Ex*: can be run in ~/AFNI_data6/afni/**

```
# Quick way to make test ROI a sphere at a given location)
echo -14 66 23 > tmp.txt
3dUndump                  \
   -xyz                   \
   -prefix tmproi.nii.gz  \
   -master anat+tlrc      \
   -datum byte            \
   -srad 9.5              \
   tmp.txt
```

```
# report overlap
whereami \
    -omask tmproi.nii.gz
```

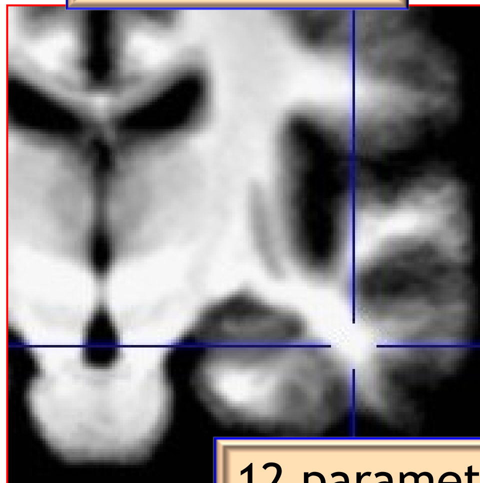
```
++ Input coordinates orientation set by default rules to RAI
++ In ordered mode ...
++ Have 2 unique values of:
   0   1
++ Skipping unique value of 0
++ ==========================================================
++ Processing unique value of 1
++    3695 voxels in ROI
++    3695 voxels in atlas-resampled mask
Intersection of ROI (valued 1) with atlas TT_Daemon (sb0):
   63.3 % overlap with Right Precuneus, code 45
   17.6 % overlap with Right Cuneus, code 40
   7.9  % overlap with Right Posterior Cingulate, code 20
   -----
   88.8 % of cluster accounted for.

Intersection of ROI (valued 1) with atlas TT_Daemon (sb1):
   29.7 % overlap with Right Brodmann area 31, code 107
   10.2 % overlap with Right Brodmann area 18, code 95
   3.2  % overlap with Right Brodmann area 7, code 87
```

Make your own template

MNI 152 template

Linear = Affine



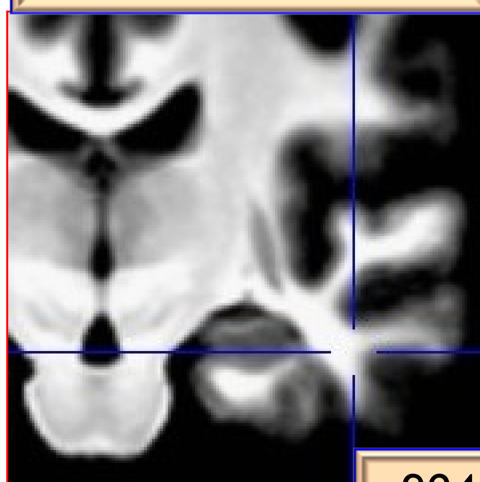
12 parameters

@toMNI_Awarp
@toMNI_Qwarpar
Averages of 21
3 Tesla brain volumes
with varied
levels of refinement in
the nonlinear warping
(smaller patch=more refinement)

Nonlinear: Patch=101

+1002

Nonlinear: Patch=49



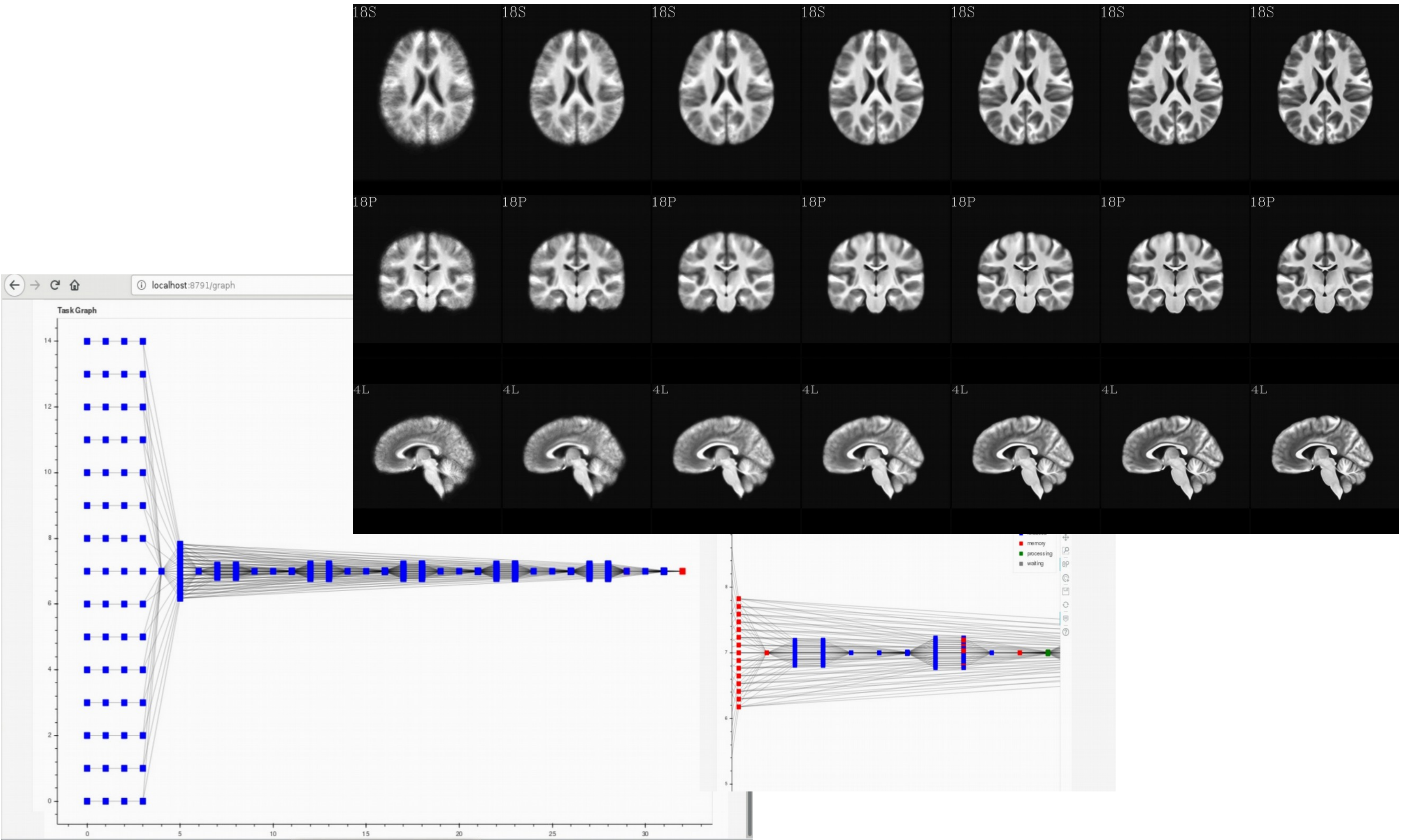
+9048

Nonlinear: Patch=23

+70008

Make your own template - faster, easier!

make_template_dask.py - Dask parallelization - 10, 100 or 1000 subjects on a cluster, server or PC



Make your own atlas!

- New atlases – easy and fun. Make your own!
  - make available in AFNI GUI and whereami and to other user

```
@AfniEnv -set AFNI_SUPP_ATLAS_DIR ~/MyCustomAtlases/
```

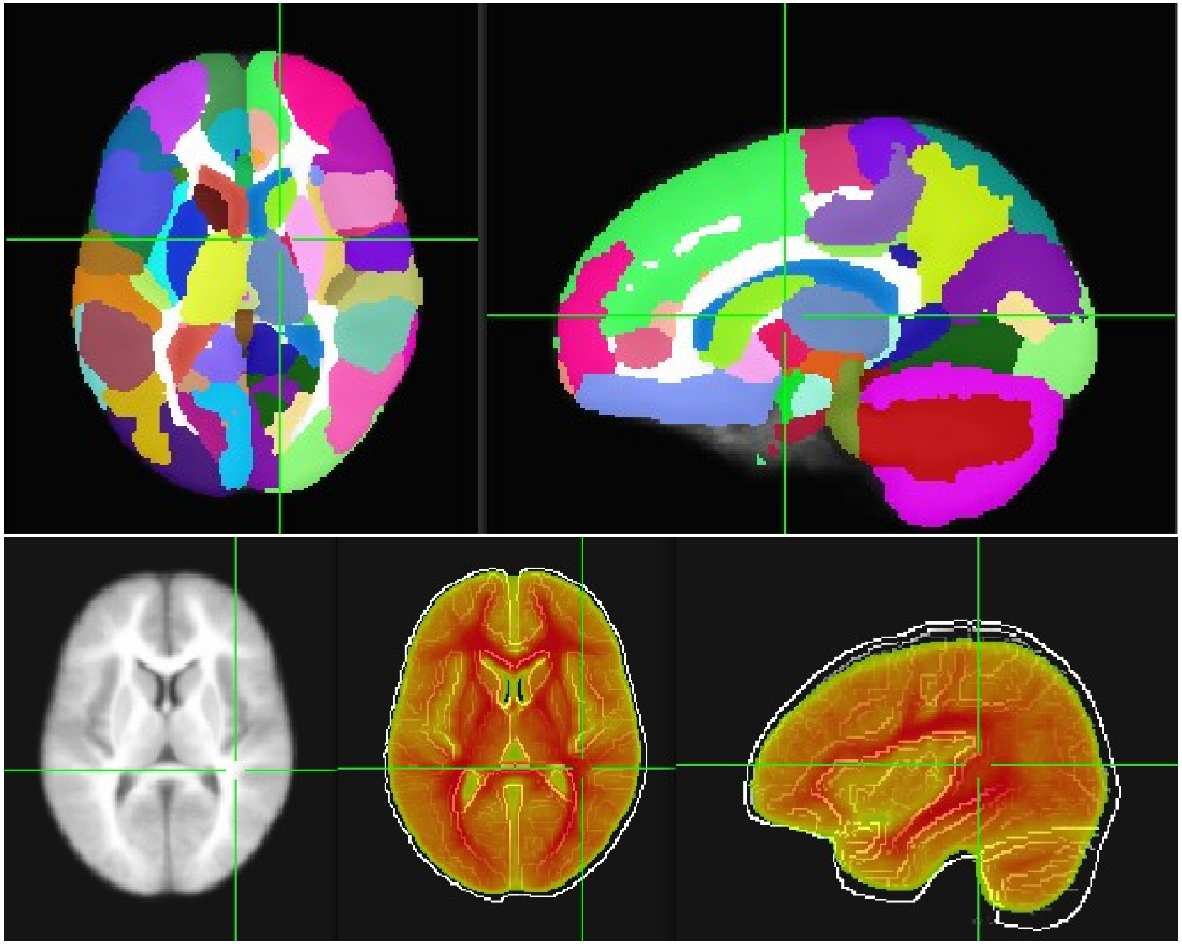
Then:

```
@Atlasize -space MNI -dset atlas_for_all.nii \
                  -lab_file keys.txt 1 0 -atlas_type G
```

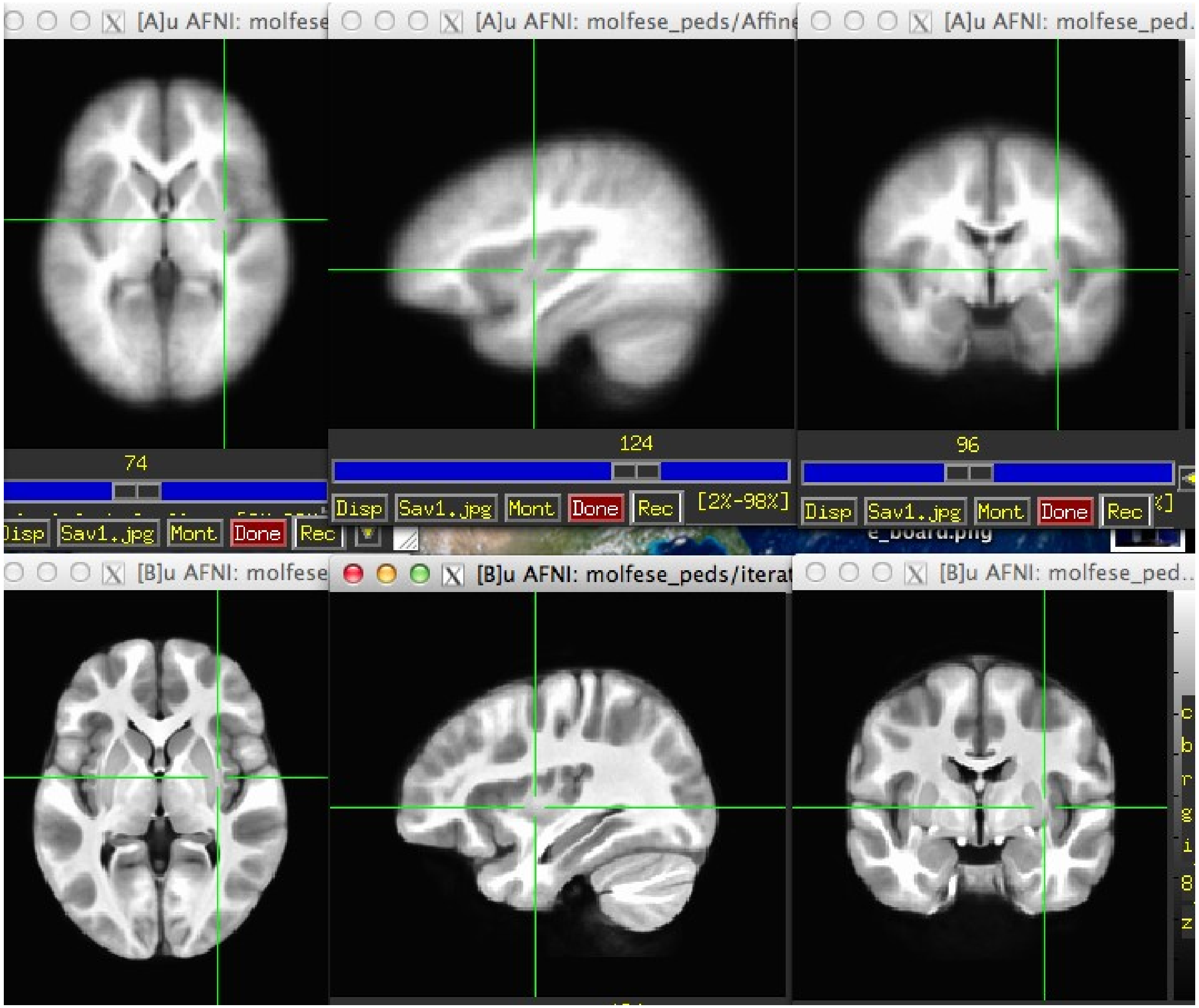
In ~/MyCustomAtlases/ you will now find atlas_for_all.nii along along with a modified CustomAtlases.niml file.

Haskins Pediatric Atlas

- Pediatric brain atlas and templates (7-12 years old) – Peter Molfese, (formerly Haskins Labs, now at NIH - woohoo!)
- Manually corrected segmentation from Freesurfer.
- Probabilistic, MPM and template
- ~75 subjects → 500 (ages 6-13)
- Affine, nonlinear averages, ideal/typical subjects, outliers



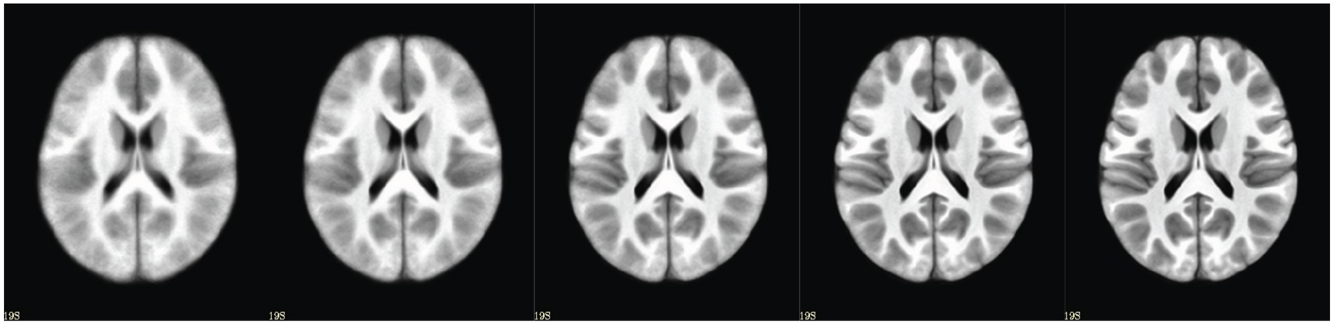
Haskins Pediatric Atlas: the templates



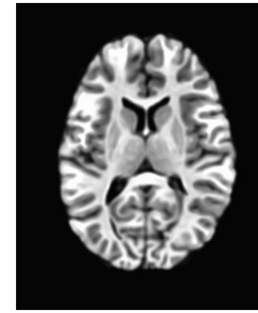
Affine Group

Nonlinear Group I – iterative

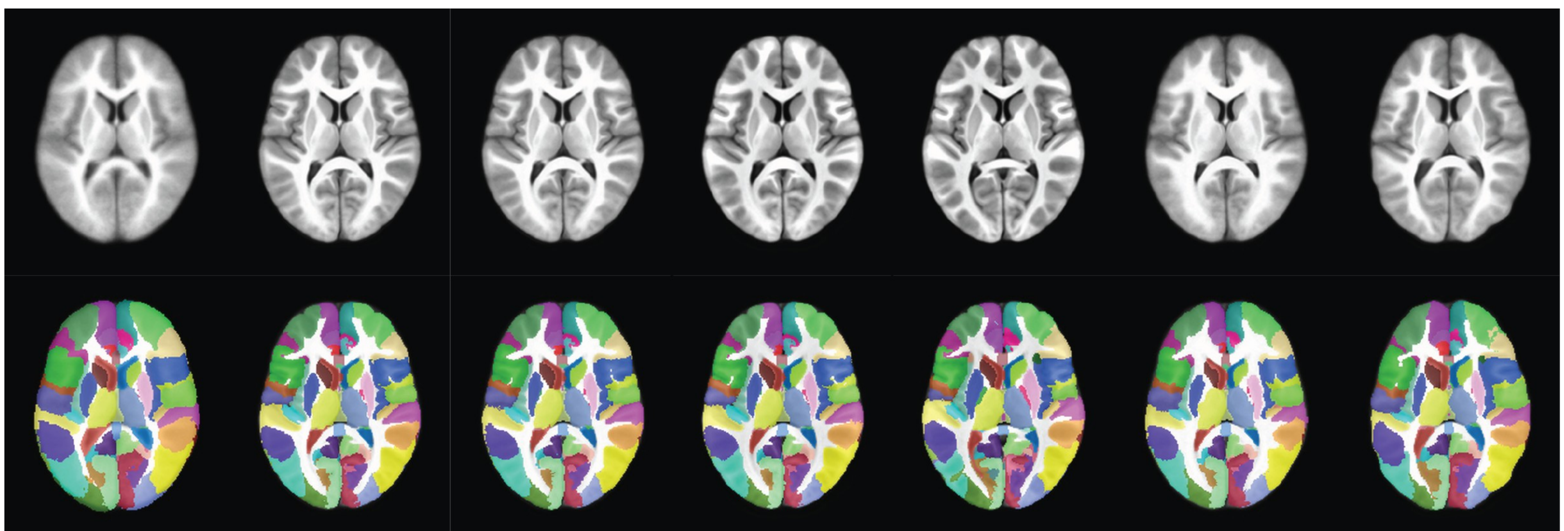
ALTERNATIVE ATLAS CREATION TECHNIQUES: ITERATIVE AND TYPICAL METHODS



Iterative nonlinear alignment to affine template with progressively smaller patch sizes

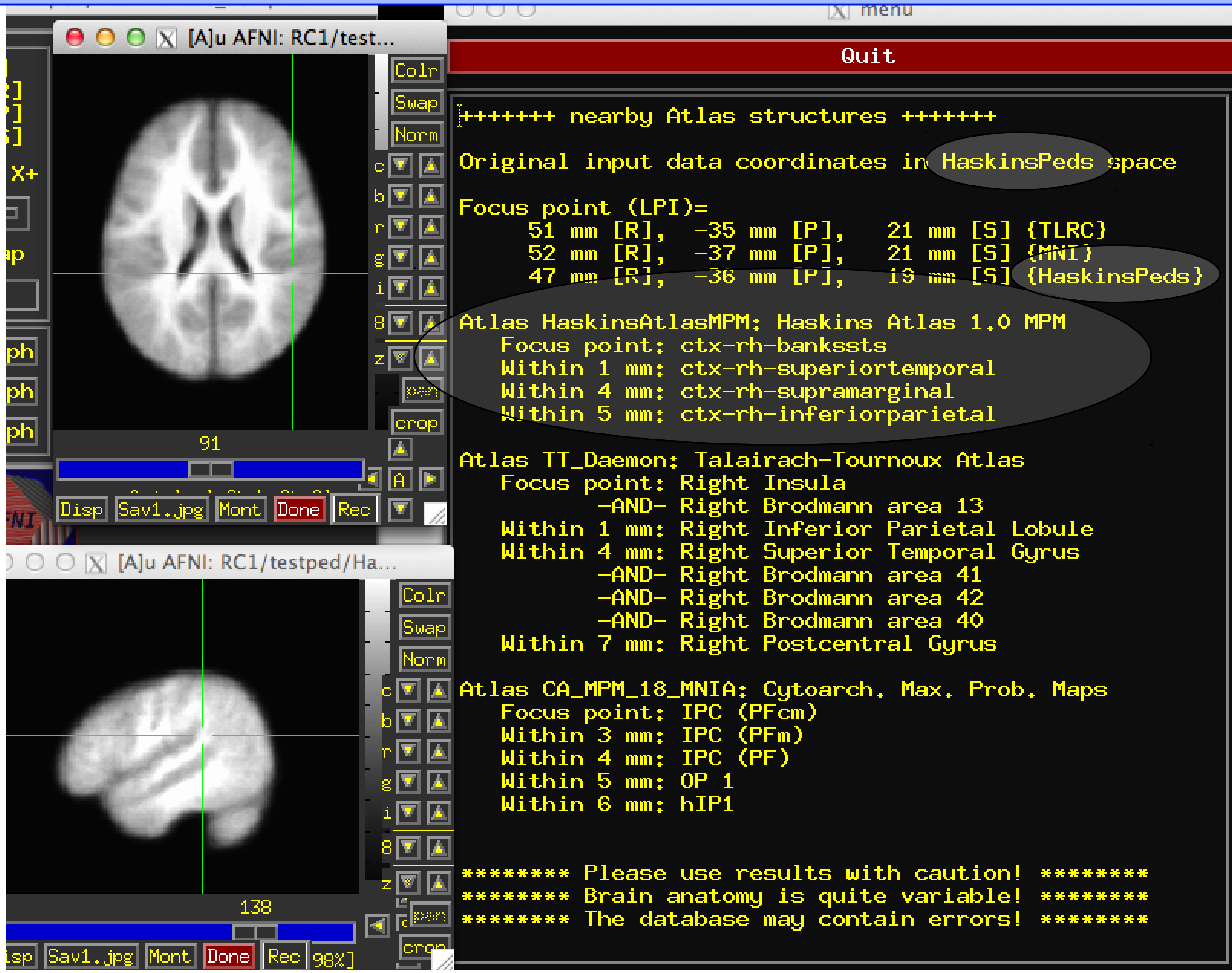


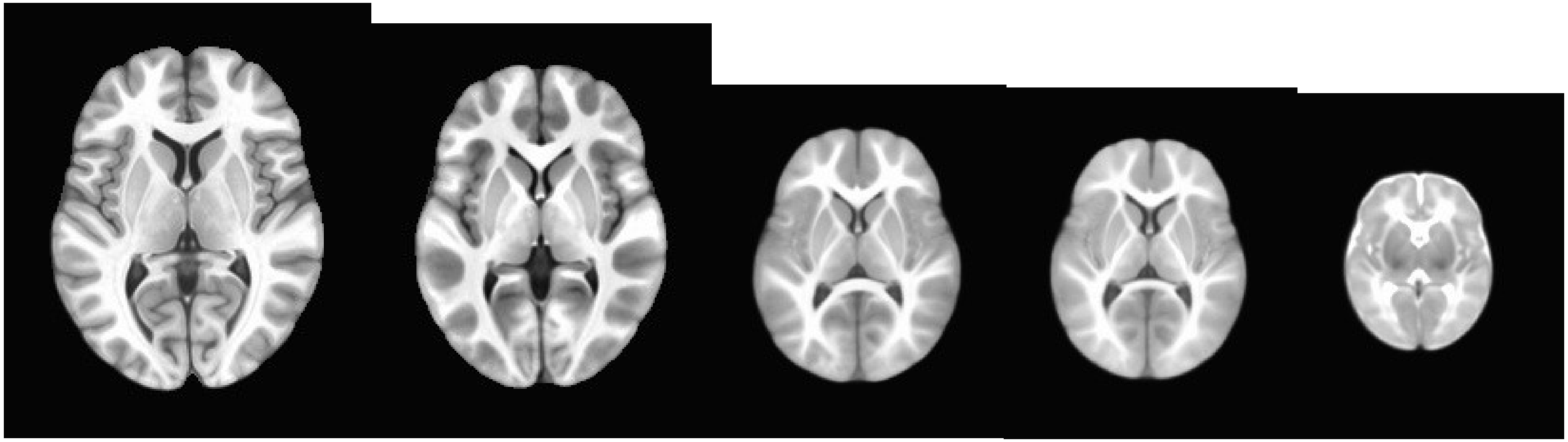
“Typical” Brain

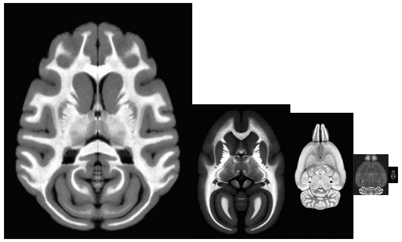


Affine | Affine Iterative | Typical Iterative | MNI Iterative | Nonlinear to MNI | Nonlinear to Affine | Nonlinear to Typical

Haskins Pediatric Atlas



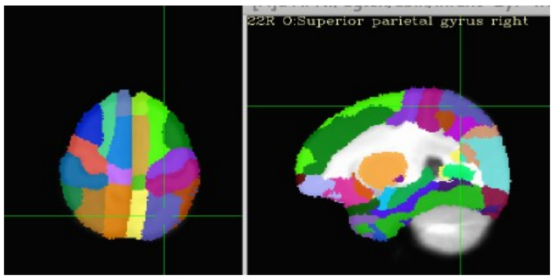


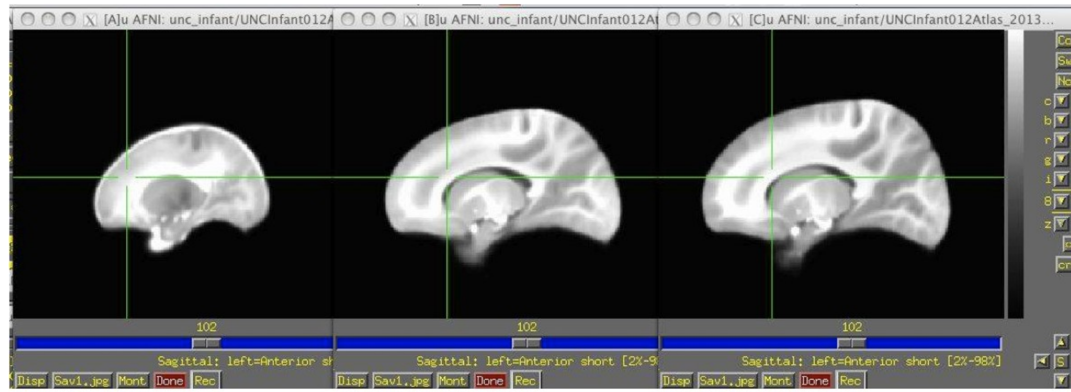


Templates and Atlases across Species in AFNI

Atlases and Templates Available!

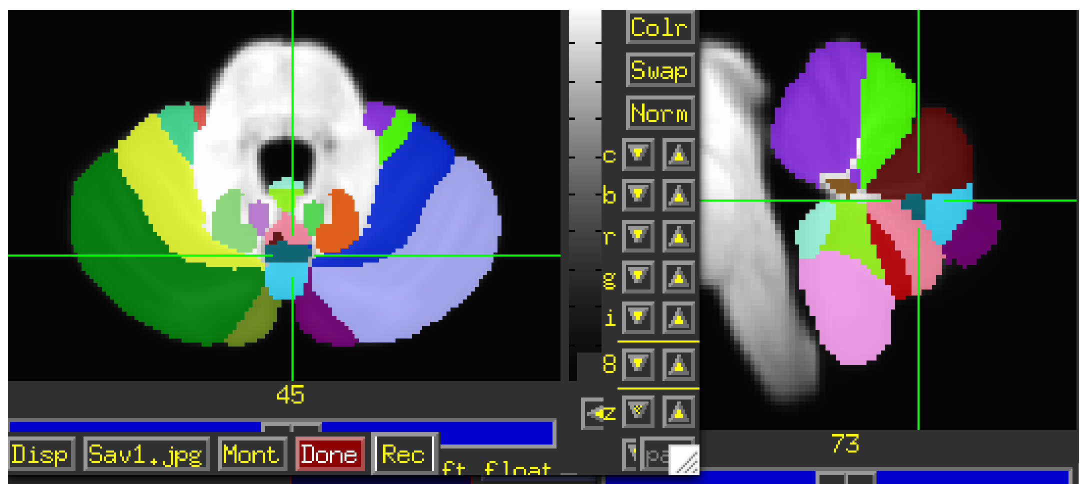
- Infant brain atlas and templates – neonate, 1-year, 2-year. Contributed by Feng Shi, UNC





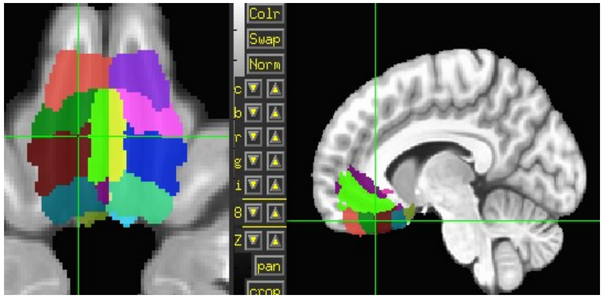
UNC infant templates and atlases – neonate, 1 yr, 2 yr old

- Cerebellum atlas and templates – Jorn Diedrichsen,UCL,UK contribution



More Atlases and Templates Available!

Ventromedial Prefrontral Cortex (vmPFC, Scott Mackey)



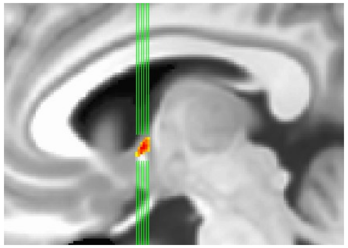
Waxholm Rat Atlas - Papp, et al.

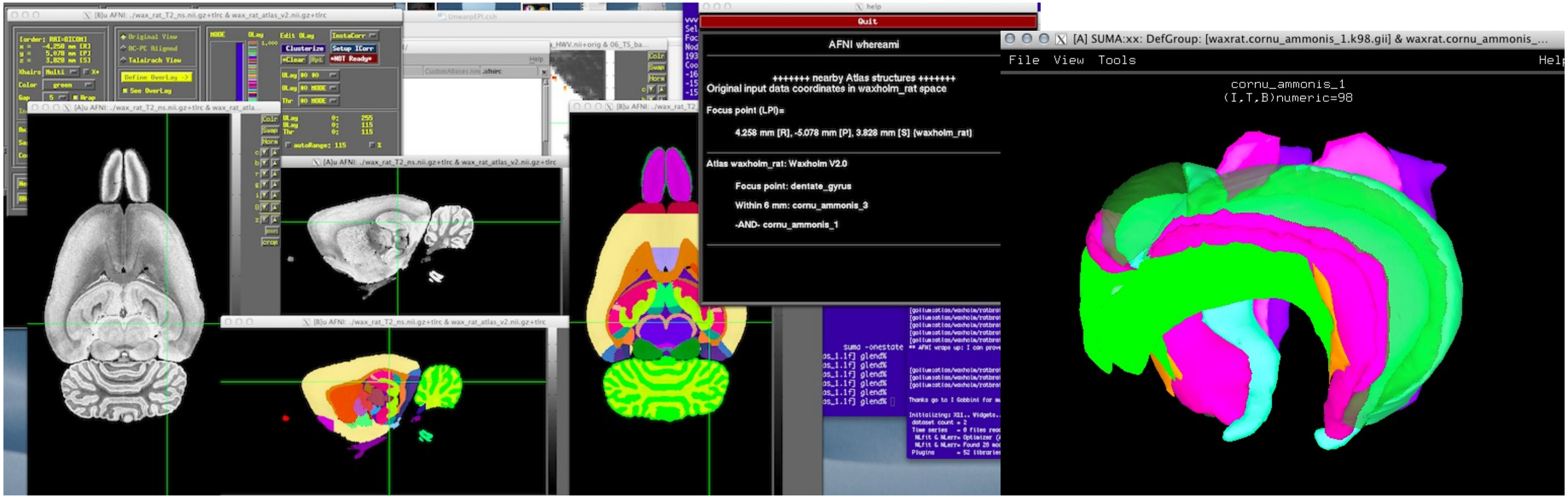
Rat brain templates in Paxinos space – Karolinska Institute, Woo Hyun Shim MGH contributions

All of these are user requests or contributions!

What do you need?

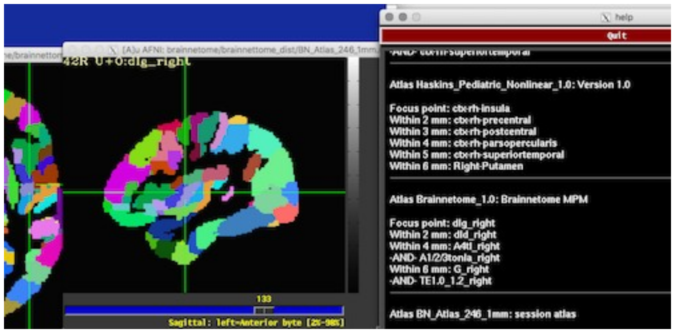
BNST – Torrisi, NIMH

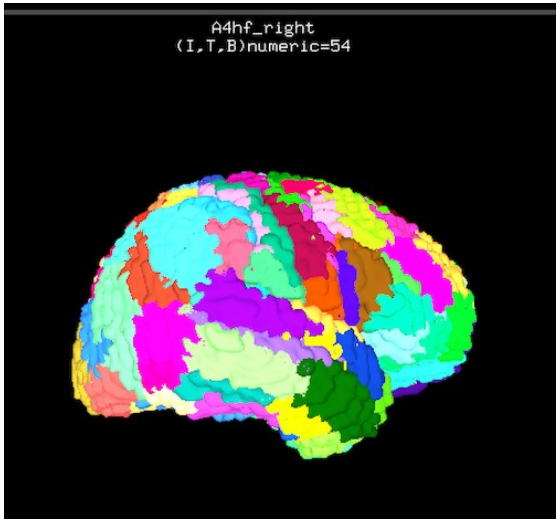




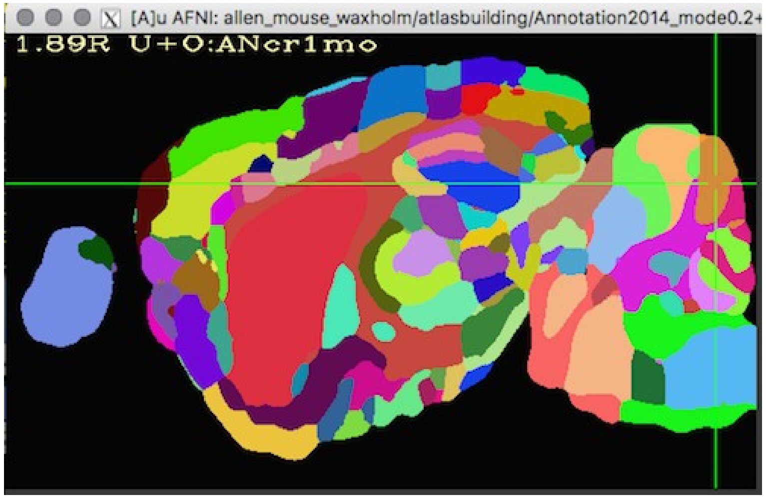
Even More Atlases and Templates Available!

Brainnetome





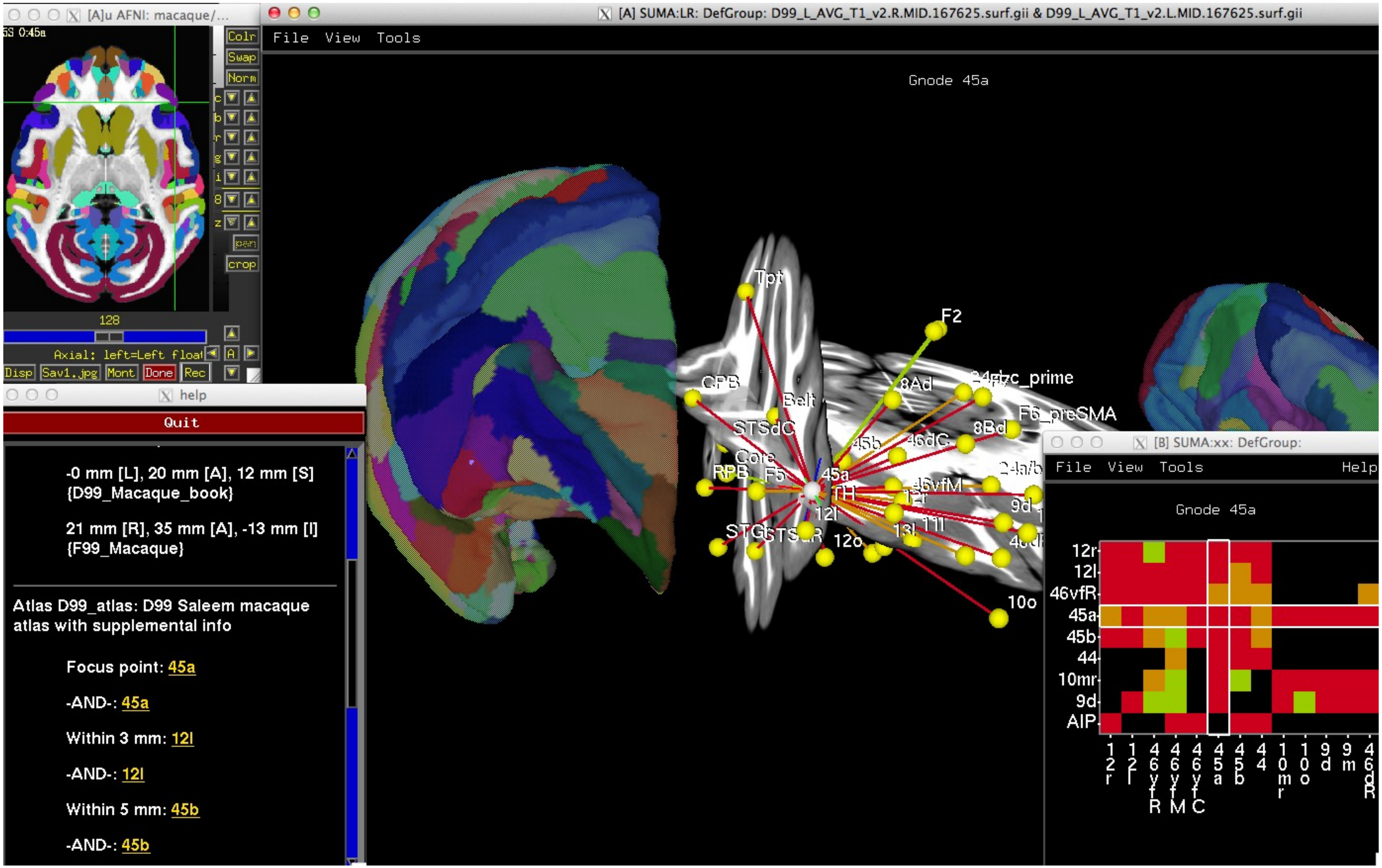
Allen Mouse Brain



All of these are user requests or contributions!

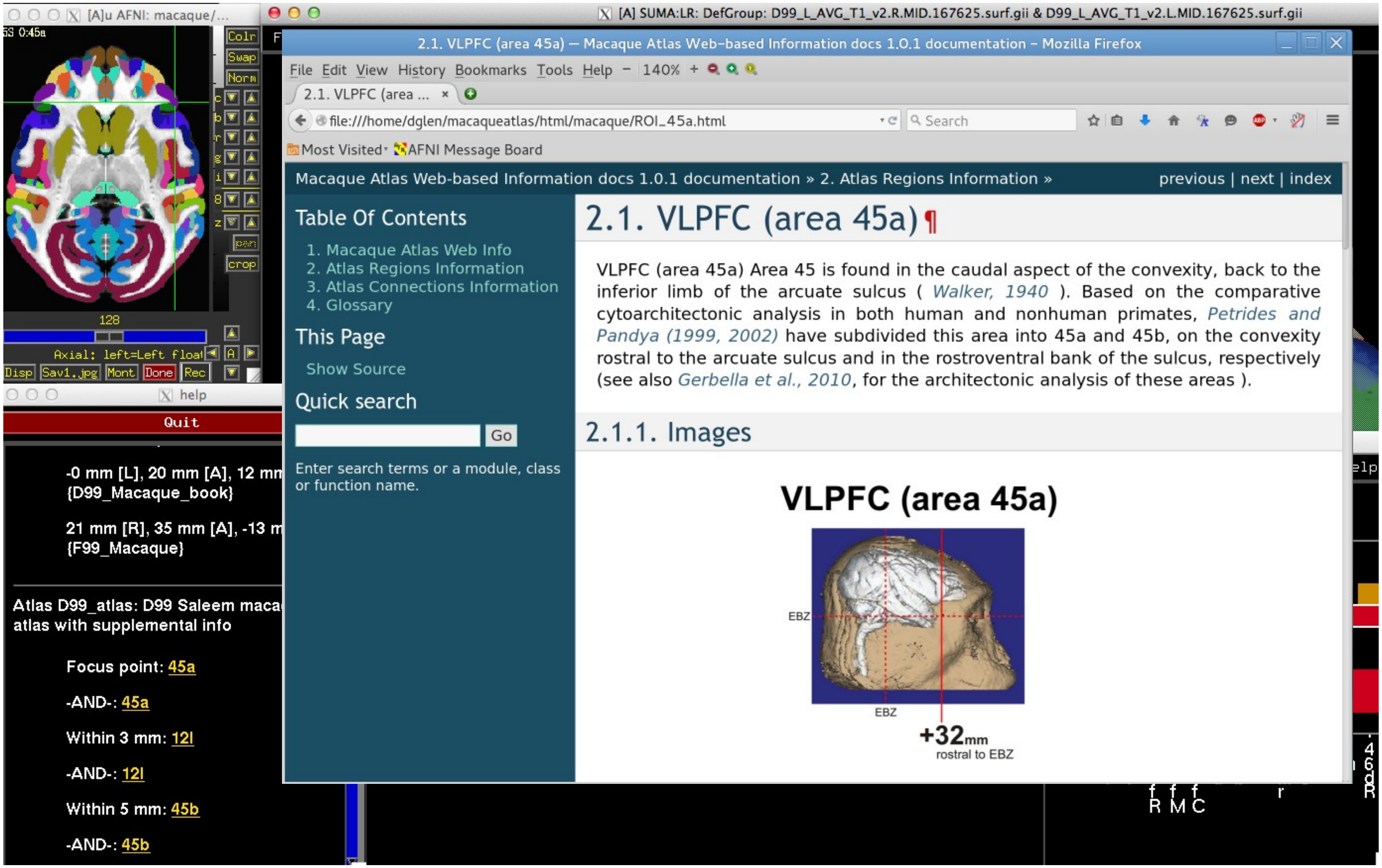
What do you need?

Saleem macaque atlas – MRI, surfaces, connections, supplemental webpages

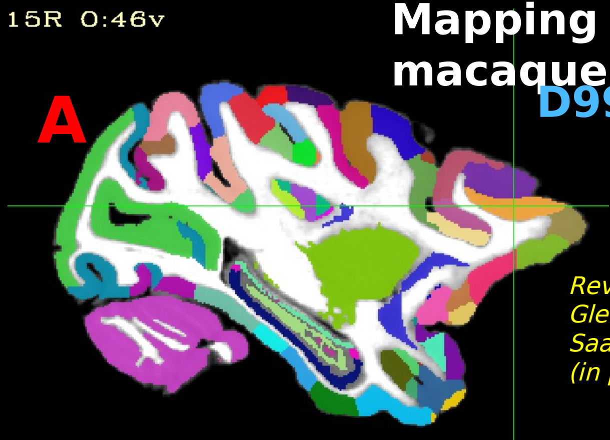


@Install_D99_macaque - install templates, atlas and set AFNI variables

Saleem macaque atlas – MRI, surfaces, connections, supplemental webpages (in development)

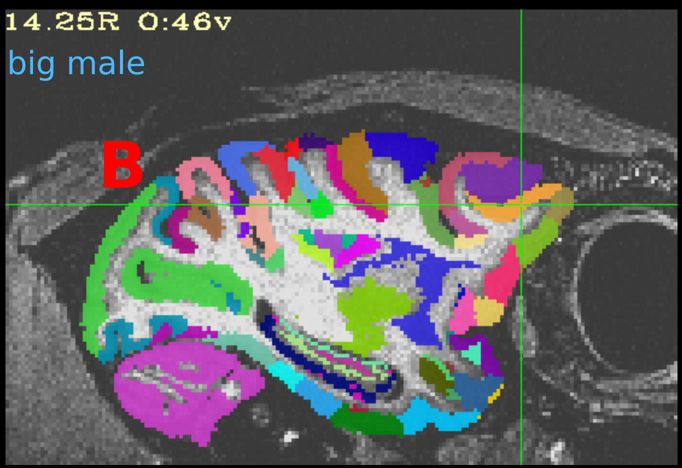


Mapping the digital atlas onto different macaques MRI

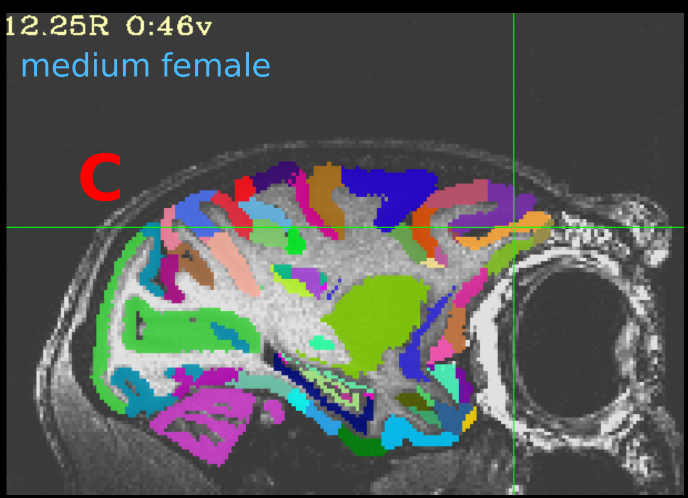


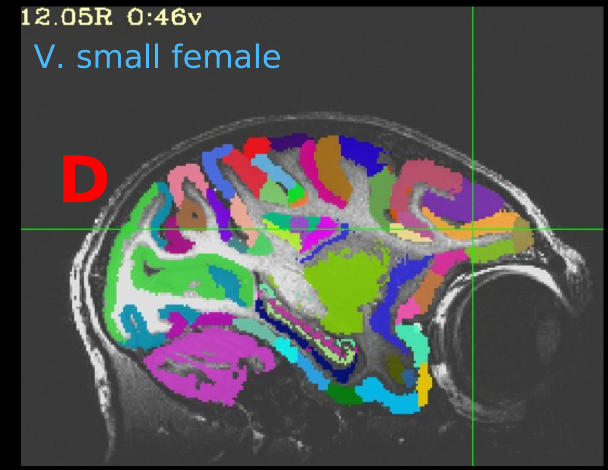
D99 – Digital atlas

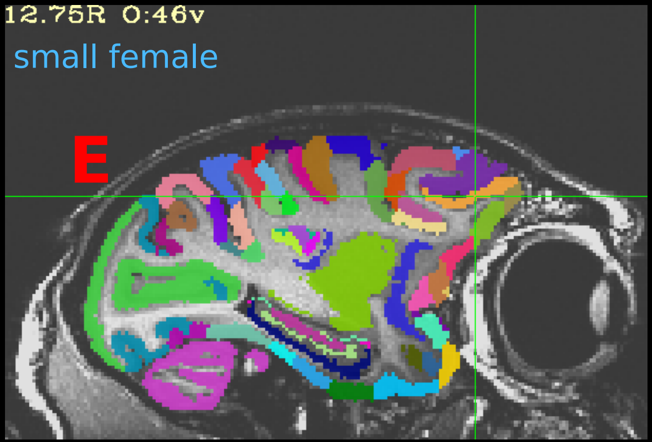
Reveley, Gruslys, Ye, Samaha, Glen,
Saad, Seth, Leopold, and Saleem
(in preparation)

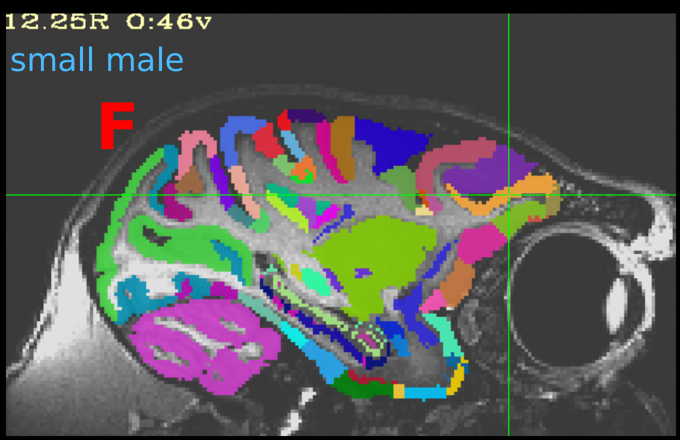


Spatial transformation of the atlas segmentation to each macaque's native space



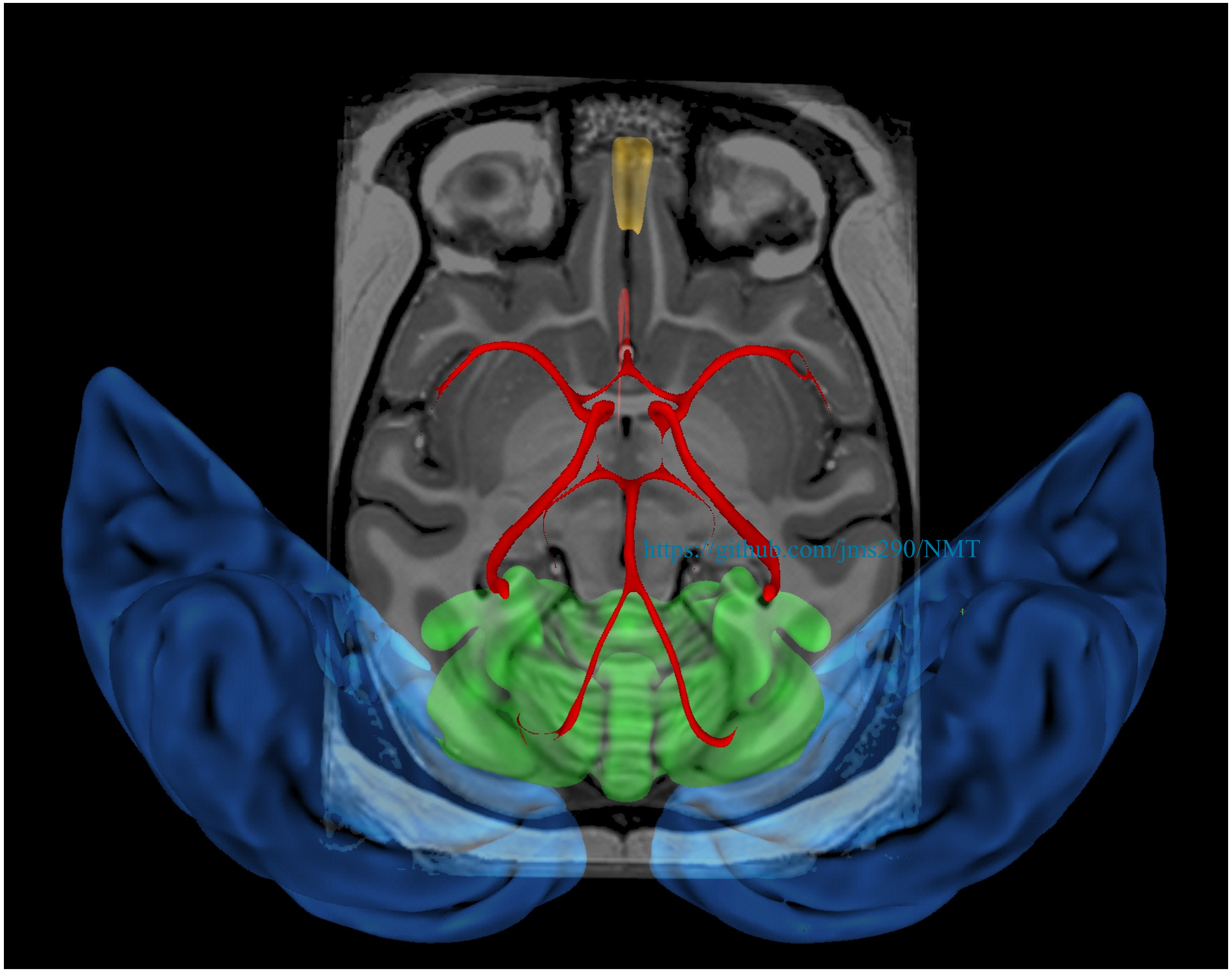






NMT (NIH Macaque Template)

Group template from 31 macaques (+ surfaces, GM/WM/CSF segmentation)



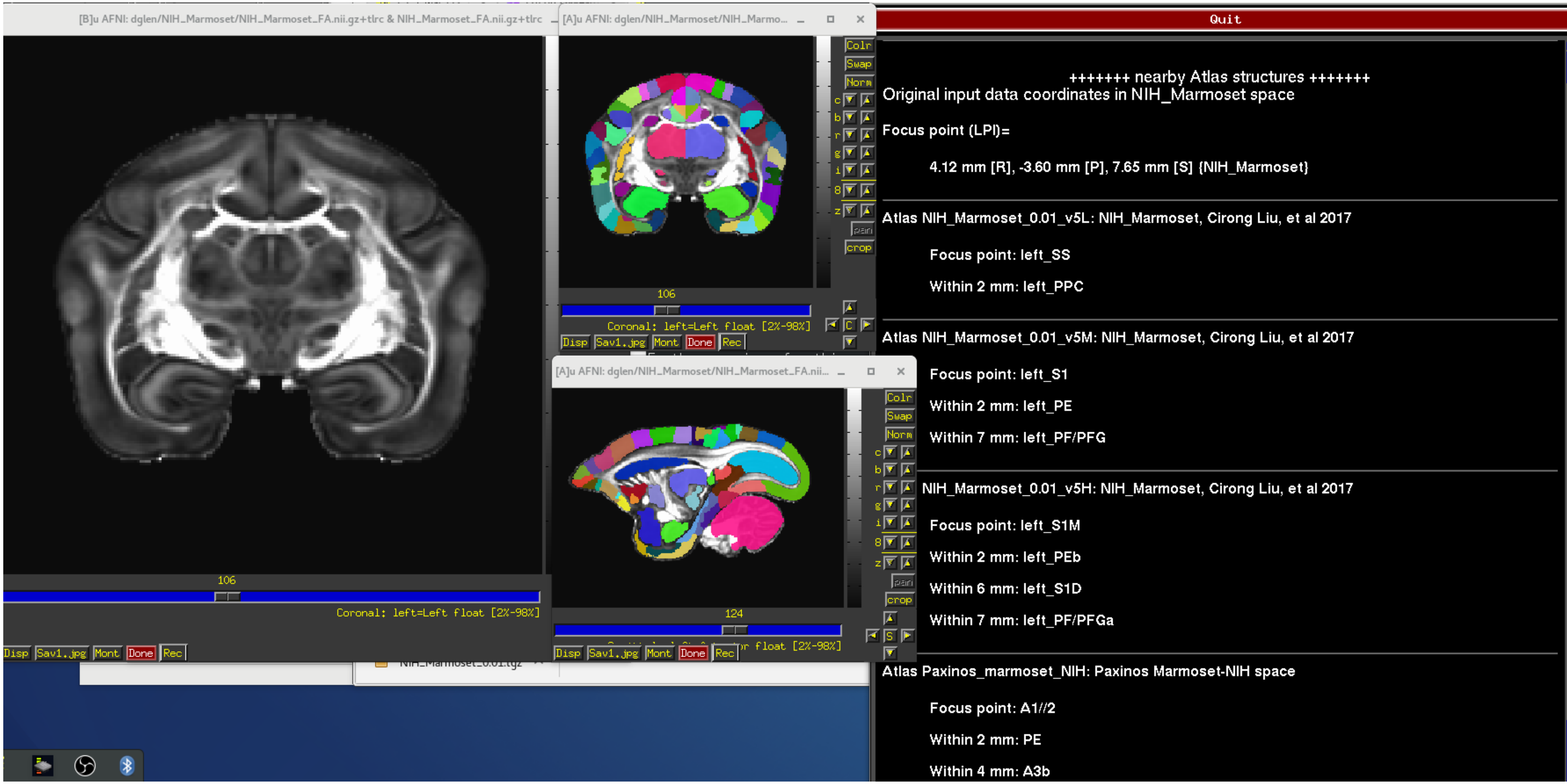
https://afni.nimh.nih.gov/pub/dist/atlases/macaque/nmt/

https://github.com/jms290/NMT

(Seidlitz, et al., 2017)

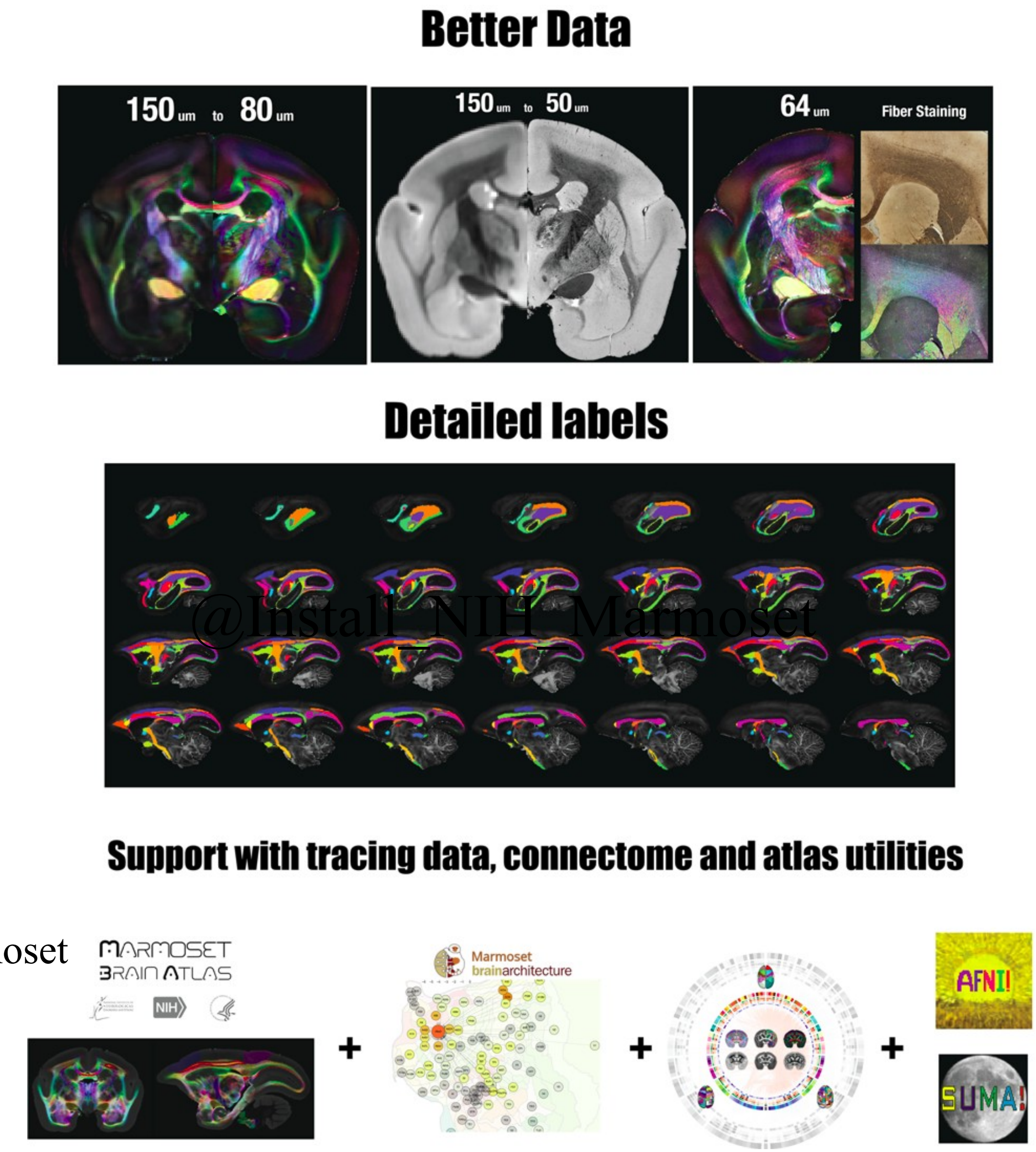
NIH Marmoset Template

Individual marmoset template - **150um** resolution



(Liu, Ye, Yen, Newman, Glen, Leopold, Silva, 2018)

2018: *improved* NIH Marmoset Template

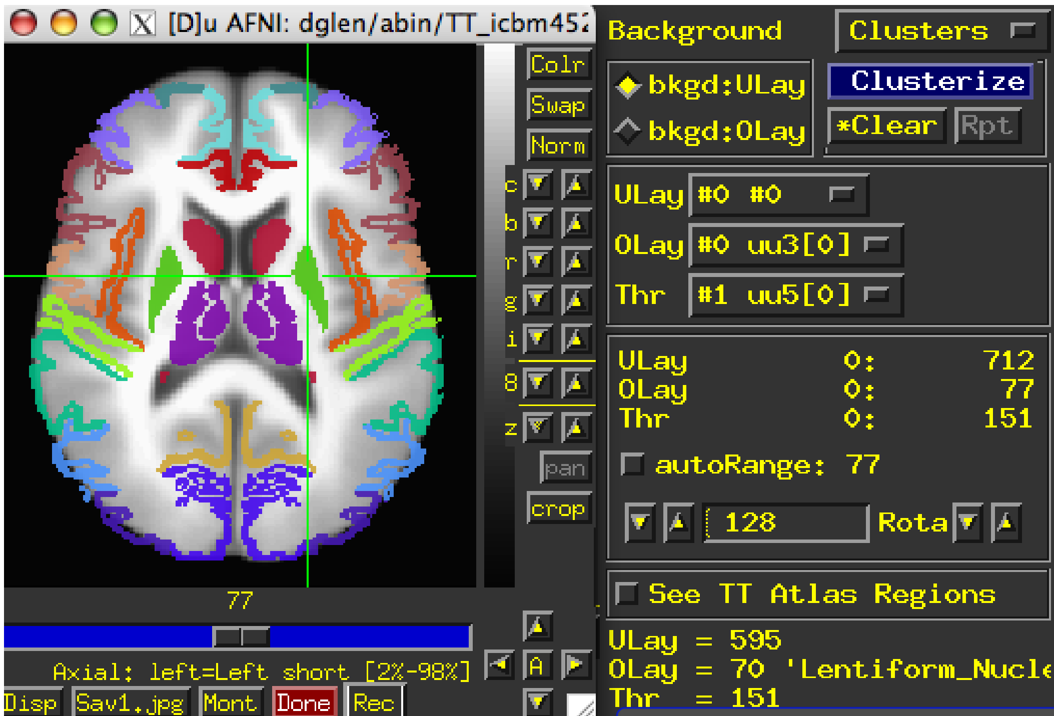


@Install_NIH_Marmoset

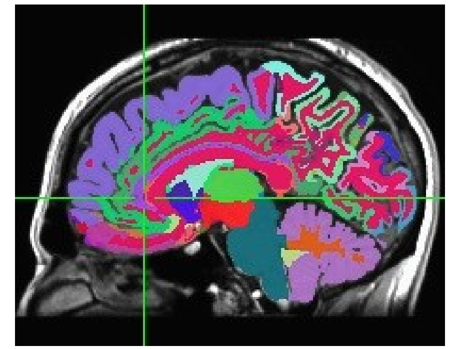
(Liu et al., 2018, SfN)

Individual Subjects

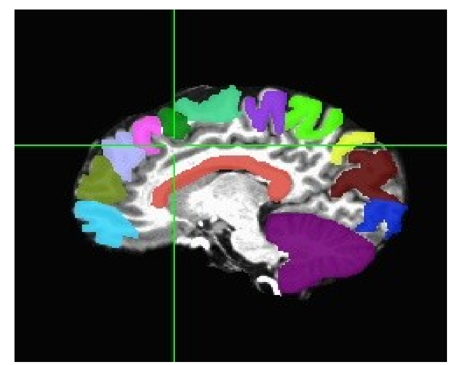
@SUMA_MakeSpecFS – atlasizes too!



Overlay panel shows structure name. Now FreeSurfer segmentation can also be used in **whereami.**



FreeSurfer segmentation



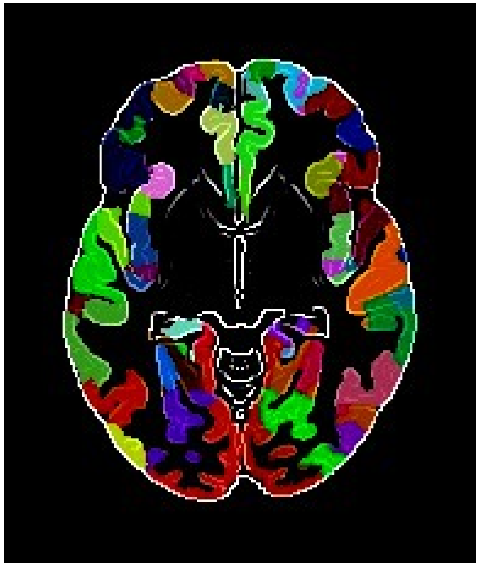
Manual segmentation

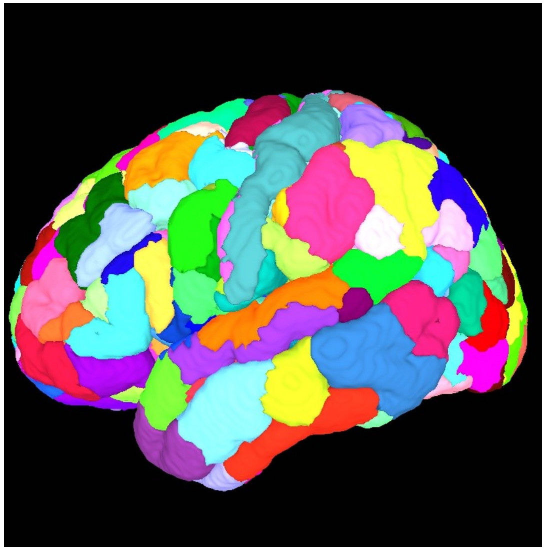
In Development

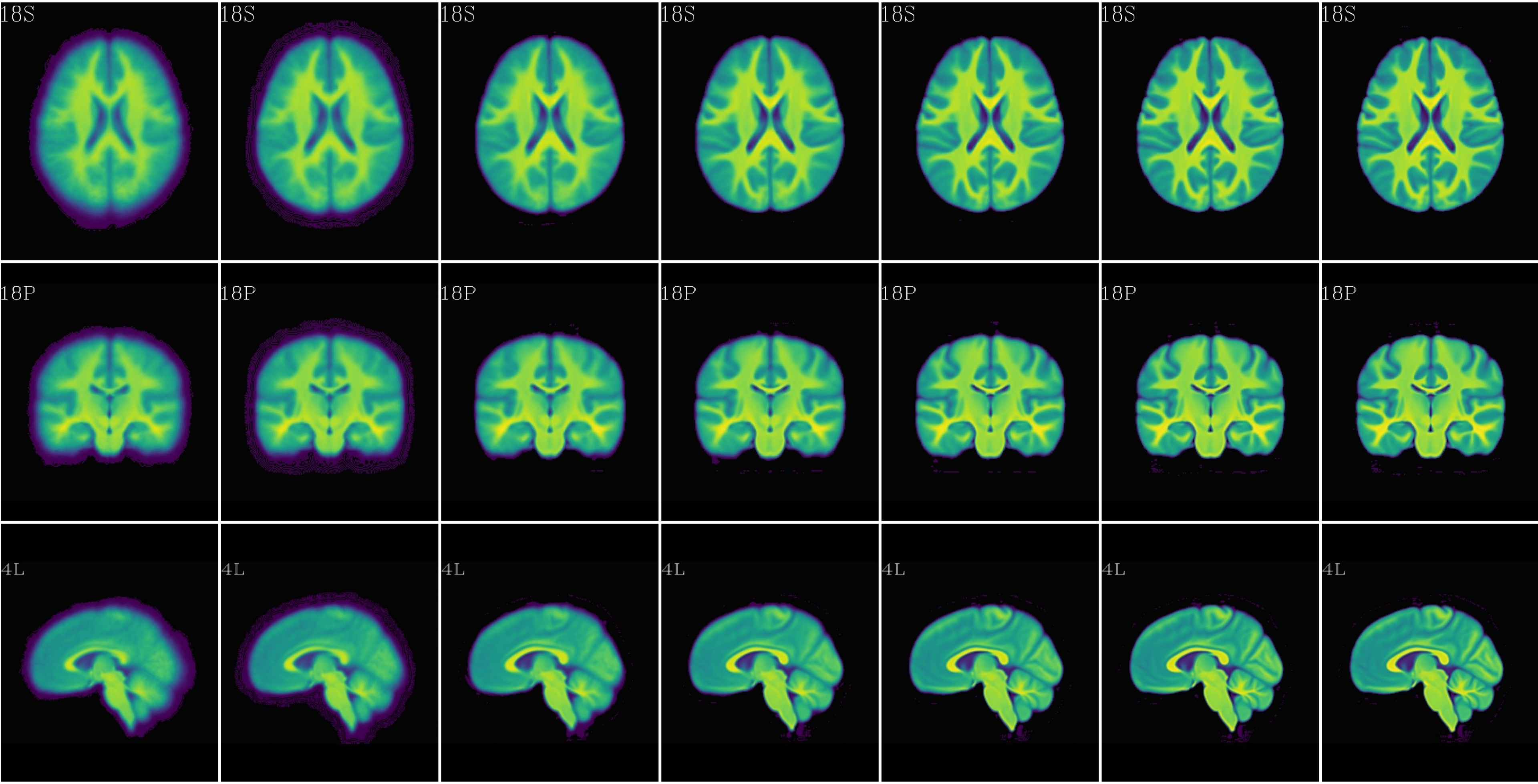
- New templates and template spaces – fully supported in AFNI
  - macaque
  - rat, mouse, (zebrafish?)
  - human

    toddler, elderly, Indian
- Extra information about atlas structures – long names, web links, ...
- HAWG standardized format – atlases for everyone!

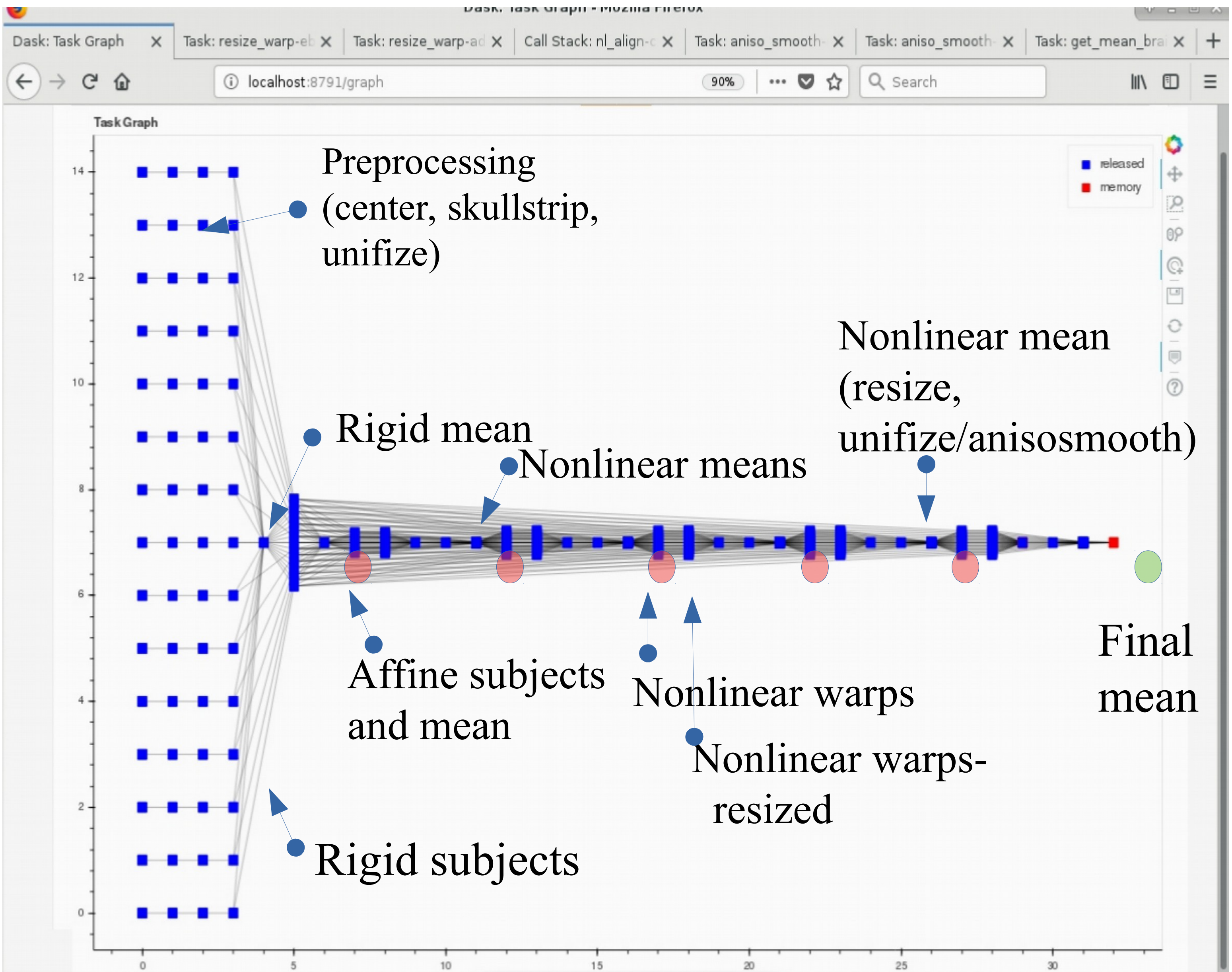
HCP Atlas - Glasser → Megan Robinson and Mike Beauchamp







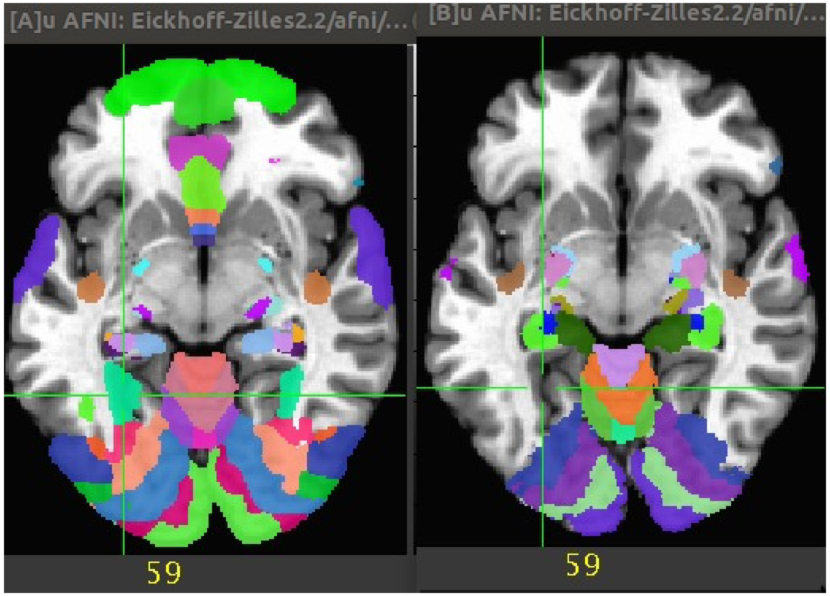
Indian Brain Template C2: IBT



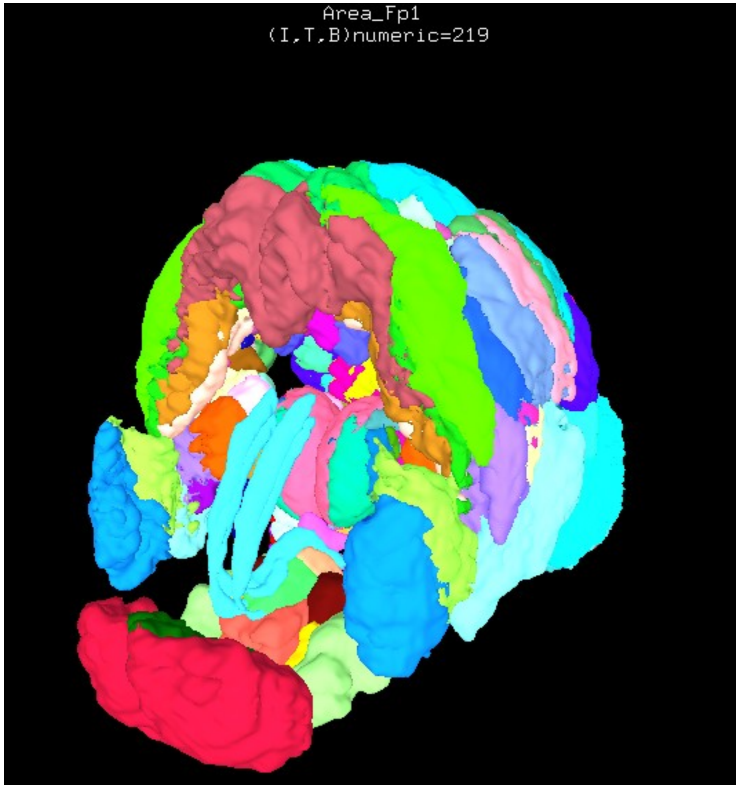
Dask Template task graph

Upcoming atlases

- Eickhoff-Zilles 2.2 cytoarchitectonic atlas

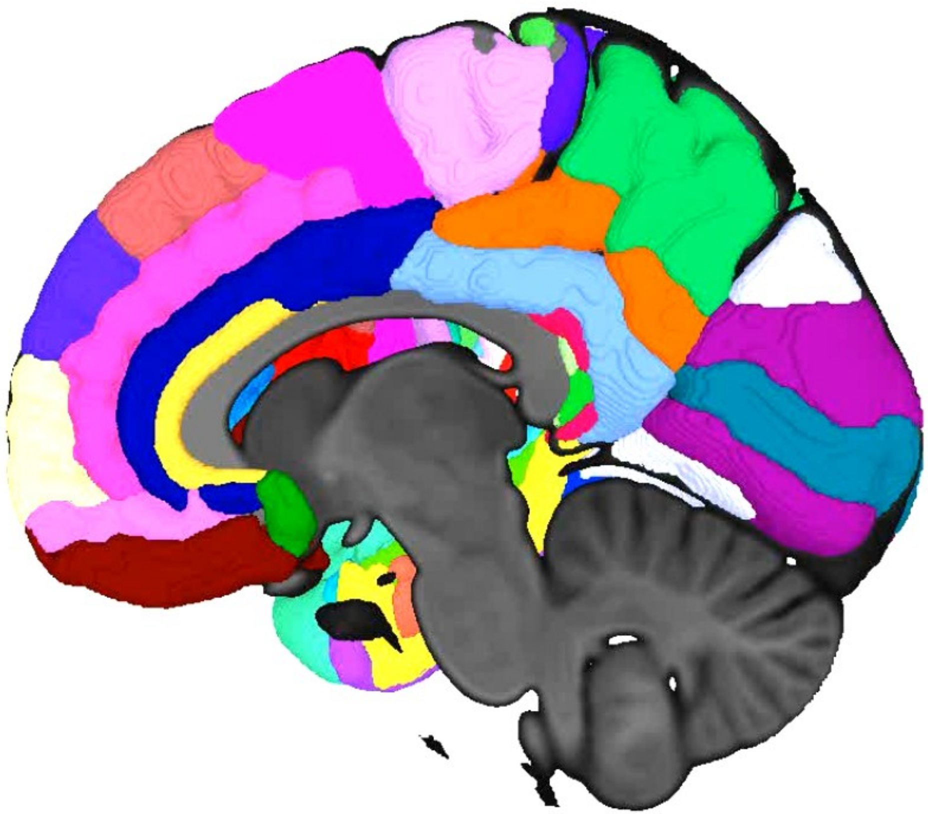


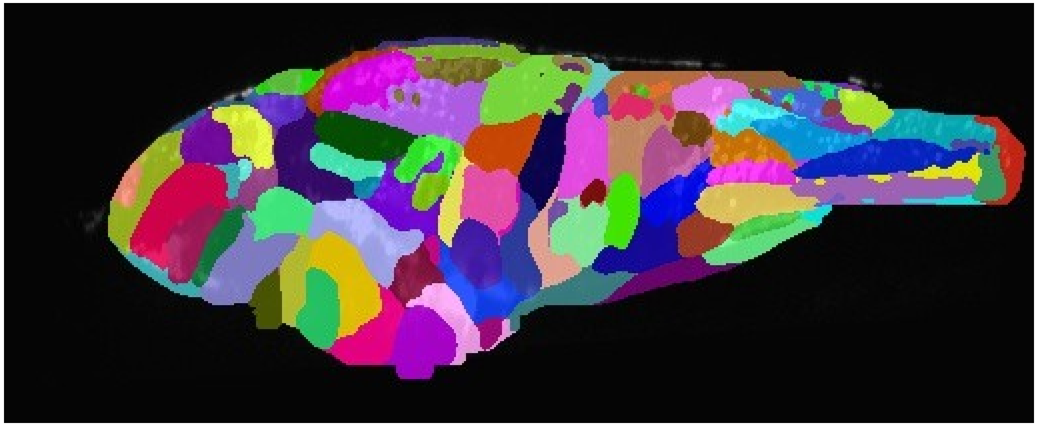
Version 2.2 vs Version 1.8



Upcoming atlases

- Jurgen Mai Human Brain Atlas -
  Brodmann Areas!





Zebrafish atlas 2 micron data!
Harold Burgess, NIH

Supplements

extra stuff

S1: Labeltables

Reading/creating labeltables

The text or string description of each ROI can be added to a dset by creating a “labeltable” that is either added to a file’s header or is a separate file pointed to in the header.

To view a labeltable on a dset:

```
3dinfo -labeltable DSET_NAME
```

```
<VALUE_LABEL_DTABLE
  ni_type="2*String"
  ni_dimen="118" >
 "4" "Left-Inf-Lat-Vent"
 "10" "Left-Pallidum"
 "79" "ctx-lh-transversetemporal"
 "88" "ctx-rh-inferiorparietal"
 "97" "ctx-rh-paracentral"
 "5" "Left-Cerebellum-White-Matter"
 "11" "3rd-Ventricle"
 "20" "Left-choroid-plexus"
 "89" "ctx-rh-inferiortemporal"
 "98" "ctx-rh-parsopercularis"
```

S1: Labeltables

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 "88"  "ctx-rh-inferiorparietal"
 "97"  "ctx-rh-paracentral"
 "5"  "Left-Cerebellum-White-Matter"
 "11"  "3rd-Ventricle"
 "20"  "Left-choroid-plexus"
 "89"  "ctx-rh-inferiortemporal"
 "98"  "ctx-rh-parsopercularis"
```

To make a labeltable and attach it to a file:

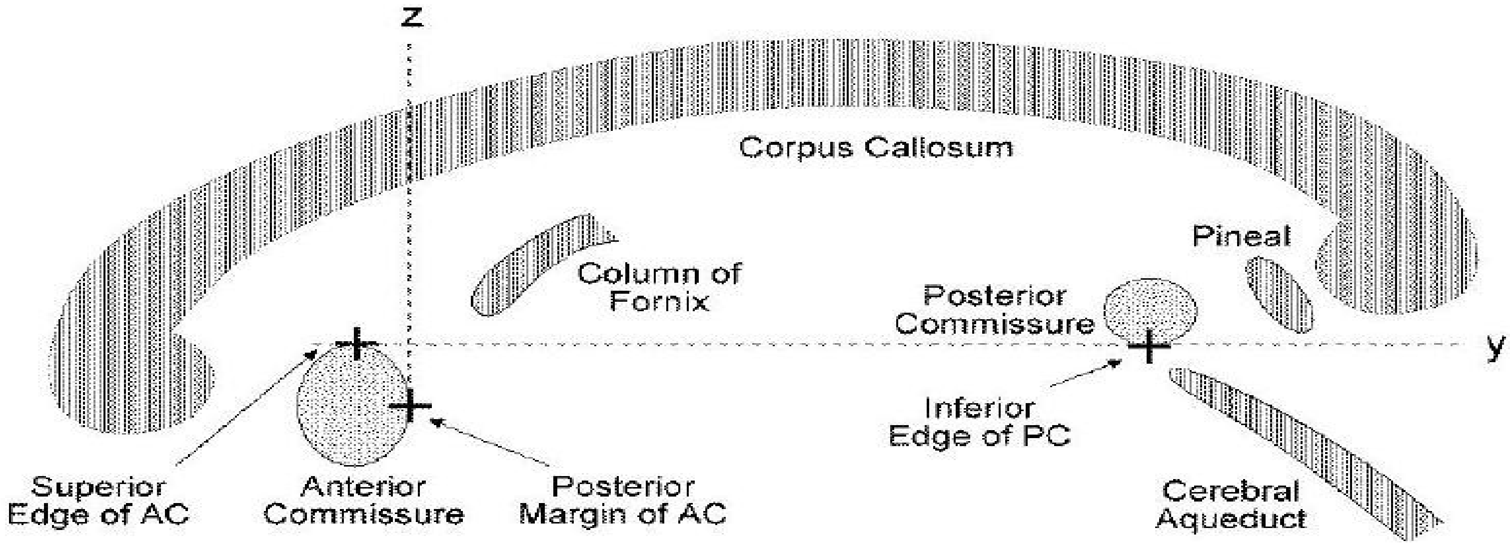
```
@MakeLabelTable                        \
     -lab_file    LABEL_FILE 1 0       \
     -labeltable OUTPUT_LT             \
     -dset        DSET_NAME
```

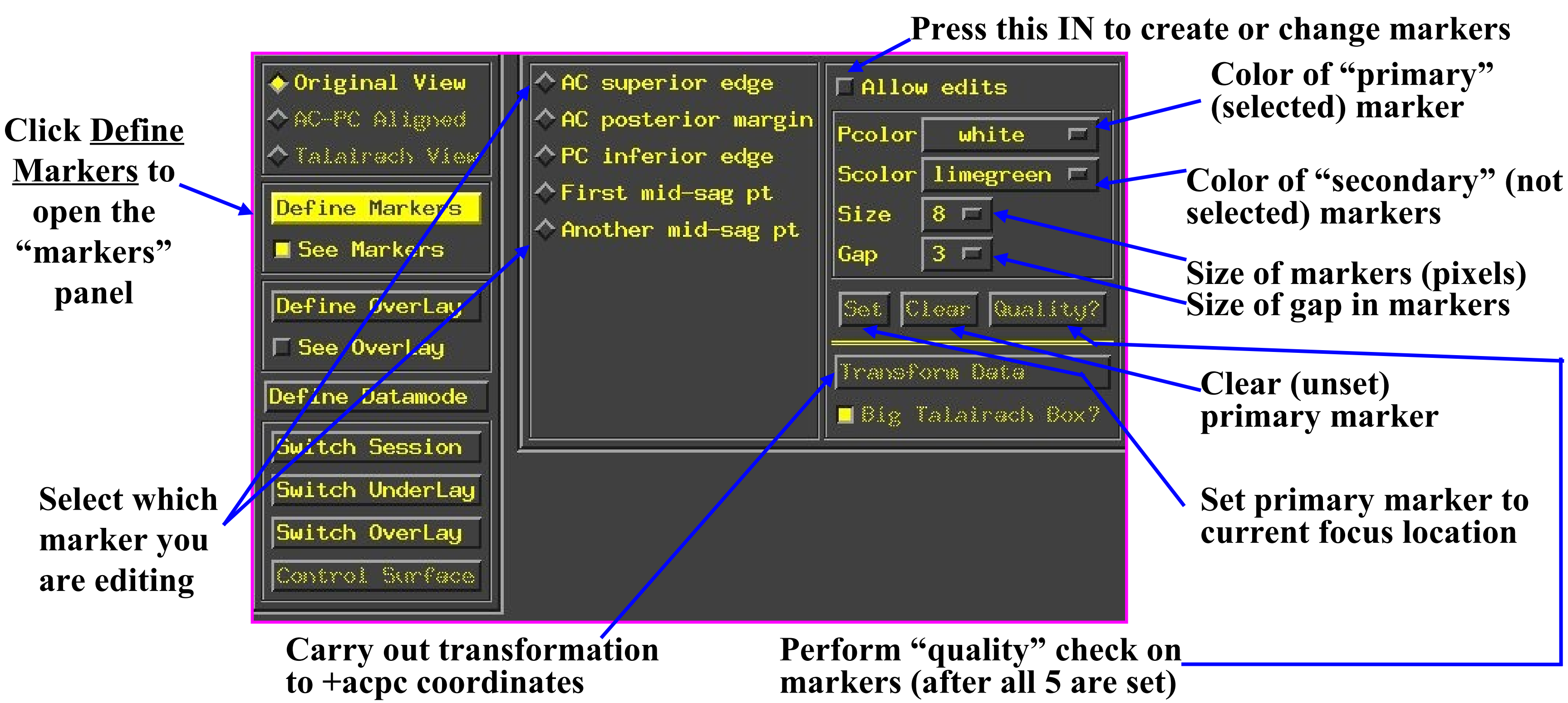
where LABEL_FILE contains one column of integer keys and one column of string values; OUTPUT_LT is the name for the created new table; and DSET_NAME is the dset it gets attached to.

S2: Manual transform to Talairach space using AFNI GUI

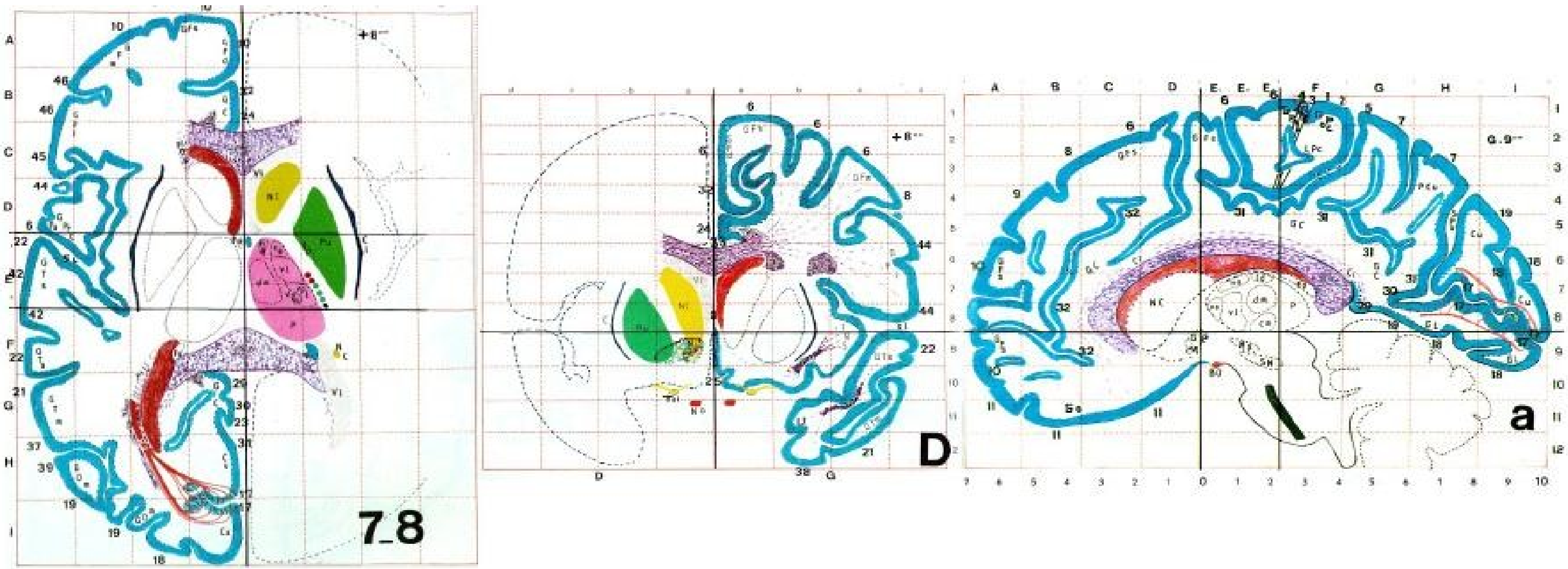
To start, right click on "DataDir" in the GUI or set AFNI_ENABLE_MARKERS to YES in ~/.afnirc.
Manual Transformation proceeds in two stages:
1) Alignment of AC-PC and I-S axes (to +acpc coordinates)
2) Scaling to Talairach-Tournoux Atlas brain size (to +tlrc coordinates)

- Stage 1: Alignment to **+acpc** coordinates:
  - Anterior commissure (AC) and posterior commissure (PC) are aligned to be the y-axis
  - The longitudinal (inter-hemispheric or mid-sagittal) fissure is aligned to be the yz-plane, thus defining the z-axis
  - The axis perpendicular to these is the x-axis (right-left)
  - Five markers that you must place using the [Define Markers] control panel:
    - AC superior edge = top middle of anterior commissure
    - AC posterior margin = rear middle of anterior commissure
    - PC inferior edge = bottom middle of posterior commissure
    - First mid-sag point = some point in the mid-sagittal plane
    - Another mid-sag point = some other point in the mid-sagittal plane
  - This procedure tries to follow the Atlas as precisely as possible
    - Even at the cost of confusion to the user (e.g., you)


z
Corpus Callosum
Column of Fornix
Pineal
Posterior Commissure
y
Inferior Edge of PC
Superior Edge of AC
Anterior Commissure
Posterior Margin of AC
Cerebral Aqueduct

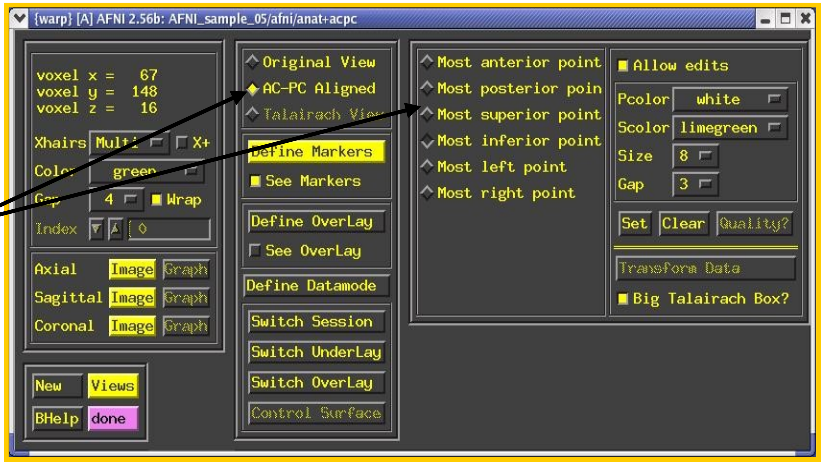

Press this IN to create or change markers
Original View
AC-PC Aligned
Talairach View
Define Markers
See Markers
Define OverLay
See OverLay
Define Datamode
Switch Session
Switch UnderLay
Switch OverLay
Control Surface
AC superior edge
AC posterior margin
PC inferior edge
First mid-sag pt
Another mid-sag pt
Allow edits
Pcolor
white
Scolor
limegreen
Size
8
Gap
3
Set
Clear
Quality?
Transform Data
Big Talairach Box?
Click Define Markers to open the "markers" panel
Color of "primary" (selected) marker
Color of "secondary" (not selected) markers
Size of markers (pixels)
Size of gap in markers
Clear (unset) primary marker
Set primary marker to current focus location
Select which marker you are editing
Carry out transformation to +acpc coordinates
Perform "quality" check on markers (after all 5 are set)

- **Stage 2: Scaling to Talairach-Tournoux (+tlrc) coordinates**:
  - Once the AC-PC landmarks are set and we are in ACPC view, we now stretch/shrink the brain to fit the Talairach-Tournoux Atlas brain size (sample TT Atlas pages shown below, just for fun)



- **Selecting the Talairach-Tournoux markers for the bounding box**:
  - There are 12 sub-regions to be scaled (3 A-P x 2 I-S x 2 L-R)
  - To enable this, the transformed `+acpc` dataset gets its own set of markers
    - Click on the **[AC-PC Aligned]** button to view our volume in ac-pc coordinates
    - Select the **[Define Markers]** control panel
  - A new set of six Talairach markers will appear and the user now sets the bounding box markers (see Appendix C for details):

Talairach markers appear only when the AC-PC view is highlighted

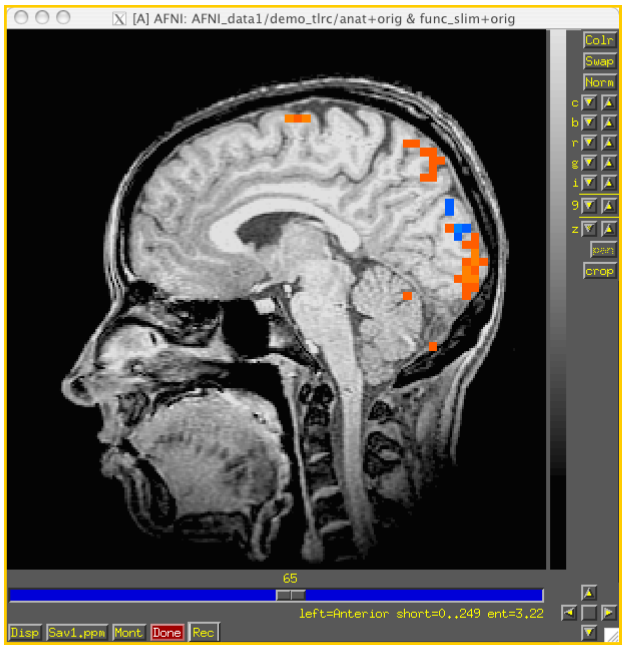


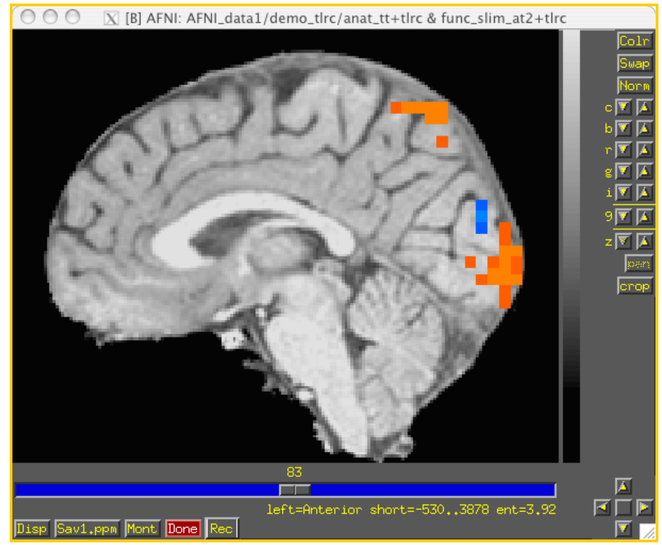
  - Once all the markers are set, and the quality tests passed. Pressing **[Transform Data]** will write new ***header*** containing the Talairach transformations (see Appendix C for details)
    - Recall: With AFNI, spatial transformations are stored in the header of the output

@auto_tlrc Results are Comparable to Manual TLRCing

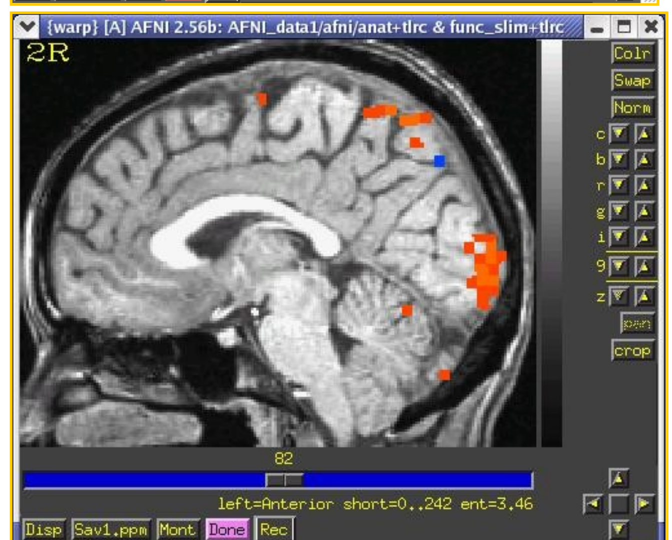
Comparison of results from “follower” func dsets: similar reduction in spurious voxels with high correlation.

Original





@auto_tlrc



Manual