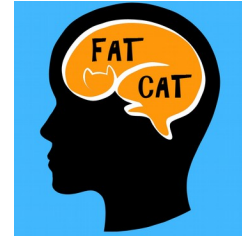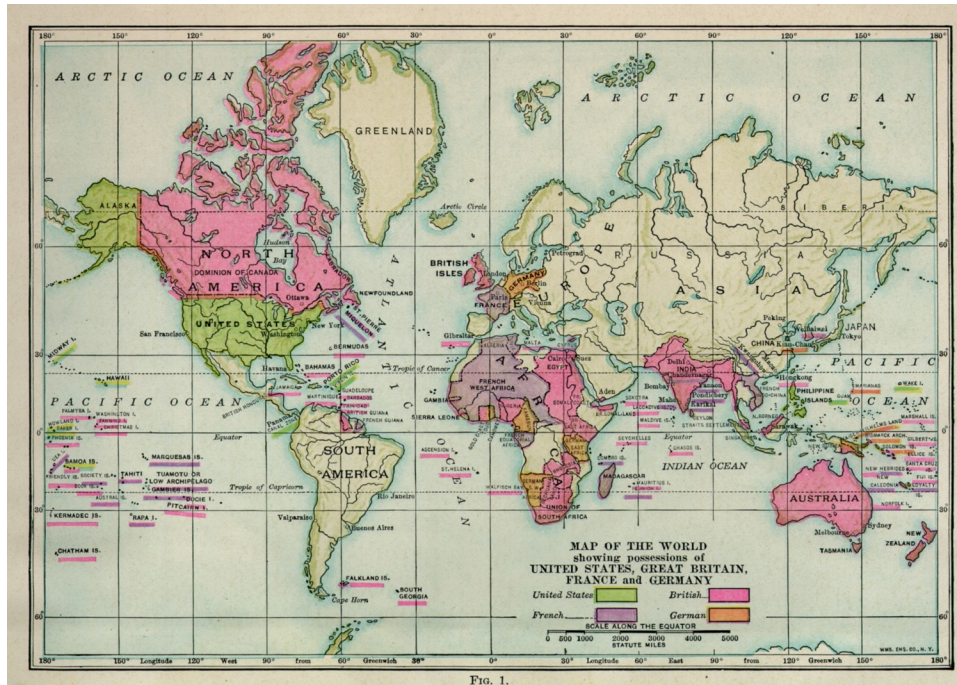# Didactics and Demonstrations
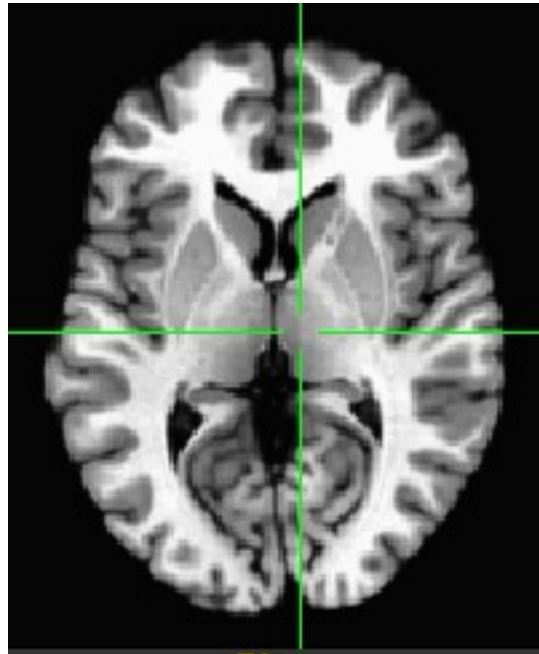
ATLASES AND TEMPLATES

FIG. 1.

Definitions

Template

A reference dataset (typically whole brain) to which we align our subjects' data. We report coordinates of results relative to this template.

Examples: TT_N27+tlrc, MNI152_2009c+tlrc, HaskinsPeds_NL_template1.0_SSW.nii.gz, D99_macaque+tlrc
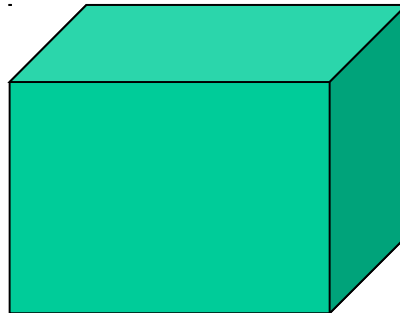

TT_N27+tlrc

Definitions

Template Space

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

Ex: TLRC (Talairach-Tournoux), 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":

AFNI format "+tlrc" view - means in a "standard" space - e.g. Talairach-Tournoux, MNI, pediatric template, macaque, …

anat**+tlrc.**HEAD, anat**+tlrc.**BRIK
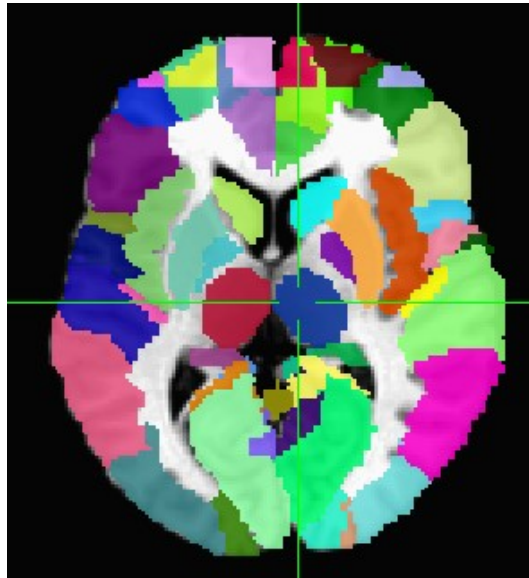
Space names

MNI,TLRC, ….

Lots of variants - specify the template explicitly in your papers

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
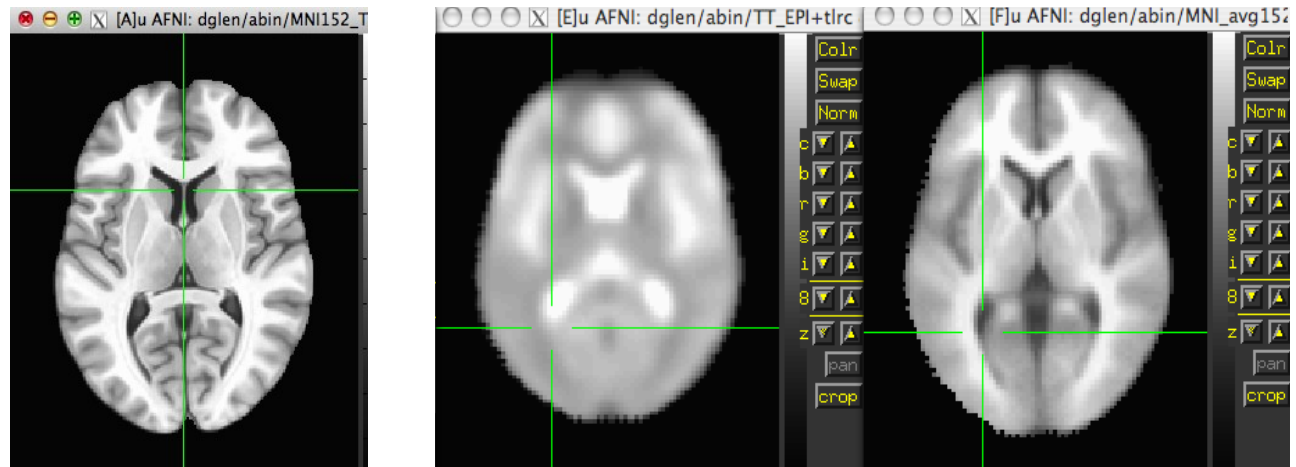
After default AFNI installation, these templates (and others) would be in **~/abin/:**
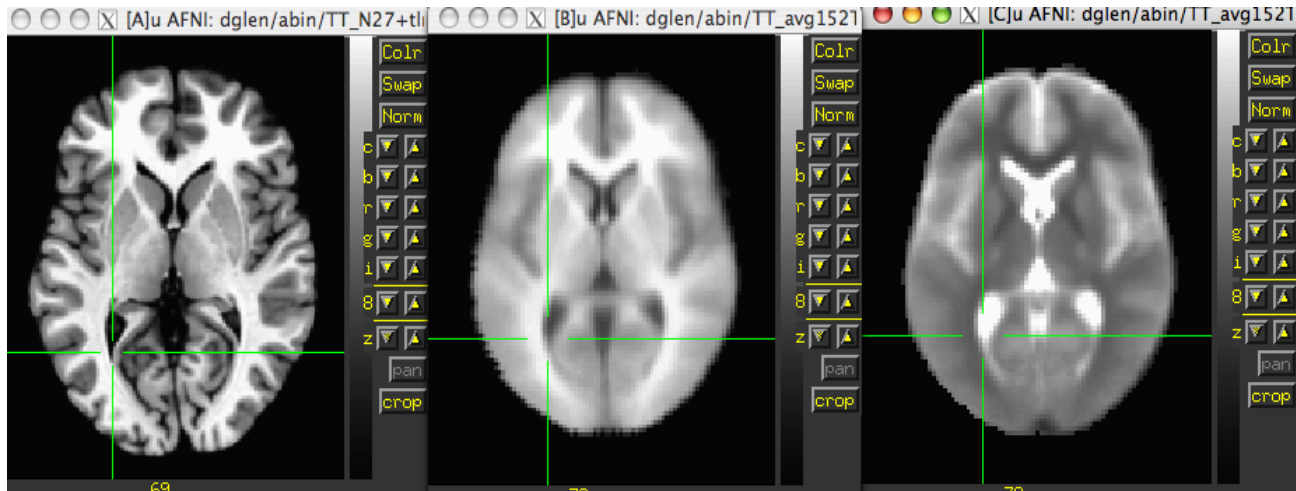
TT_N27   TT_avg152T1   TT_avg152T2

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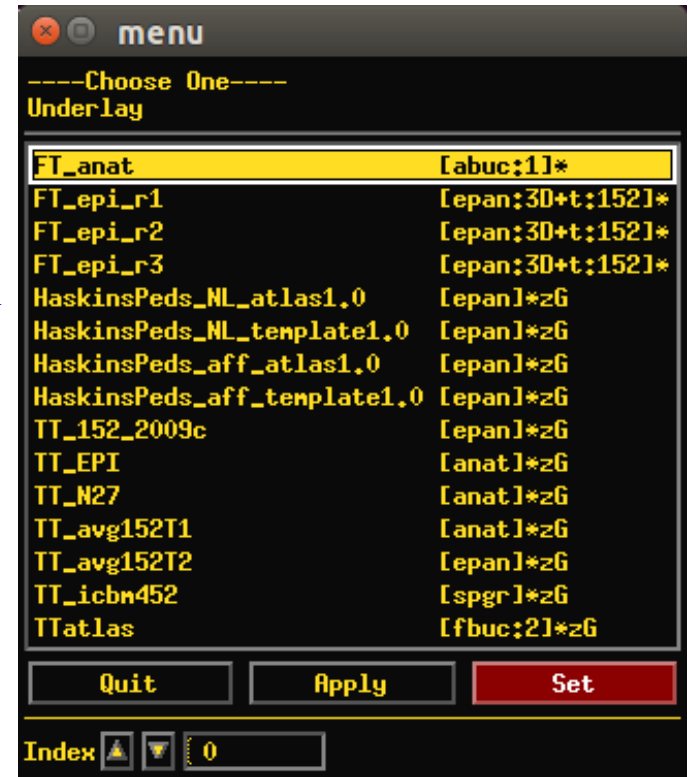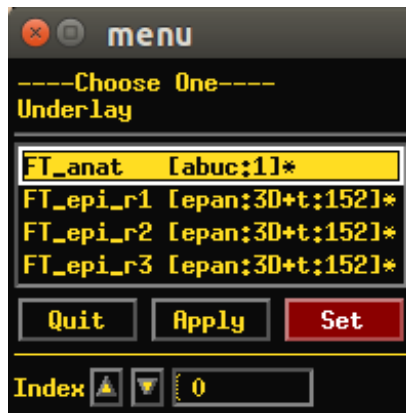
All dsets there will appear in your "Underlay" or "Overlay" menu in the AFNI GUI.
(Use full path of directory, no "~" or "$HOME".)

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

"Standard" spaces - Some History

Talairach - Tournoux - 1988 (1957)

- **Stereotaxic system - no MRI template**
- **One of the first uses of AFNI ! (1994)**
- **Brodmann atlas (1907-09) UTHSCSA - Talairach Daemon (1997)**

MNI - 1992 - 2009

- **MNI-305 1992 - Approximately Talairach**
- **MNI-N27 1998 - Single brain affinely aligned to MNI-305**
- **MNI-152 - 2001, linear affine (ICBM-UCLA, MNI, UTHSCSA)**
- **MNI-152 - 2006, nonlinear, symmetric/asymmetric (FSL and maybe SPM too use asymmetric version)**
- **MNI-152 - 2009, nonlinear 1mm, 0.5mm**
  - **a,b,c x2 (symmetric/asymmetric) AFNI includes 2009c-asymmetric 1mm3 (unifized and original)**
- **MNI-Anat - 2005, SPM Anatomy toolbox - Eickhoff-Zilles Cytoarchitectonic Atlas and Macrolabel atlas. Shifted coordinate system for N27. 2020 update, atlases for version 3.0 moves to MNI152-2009?**
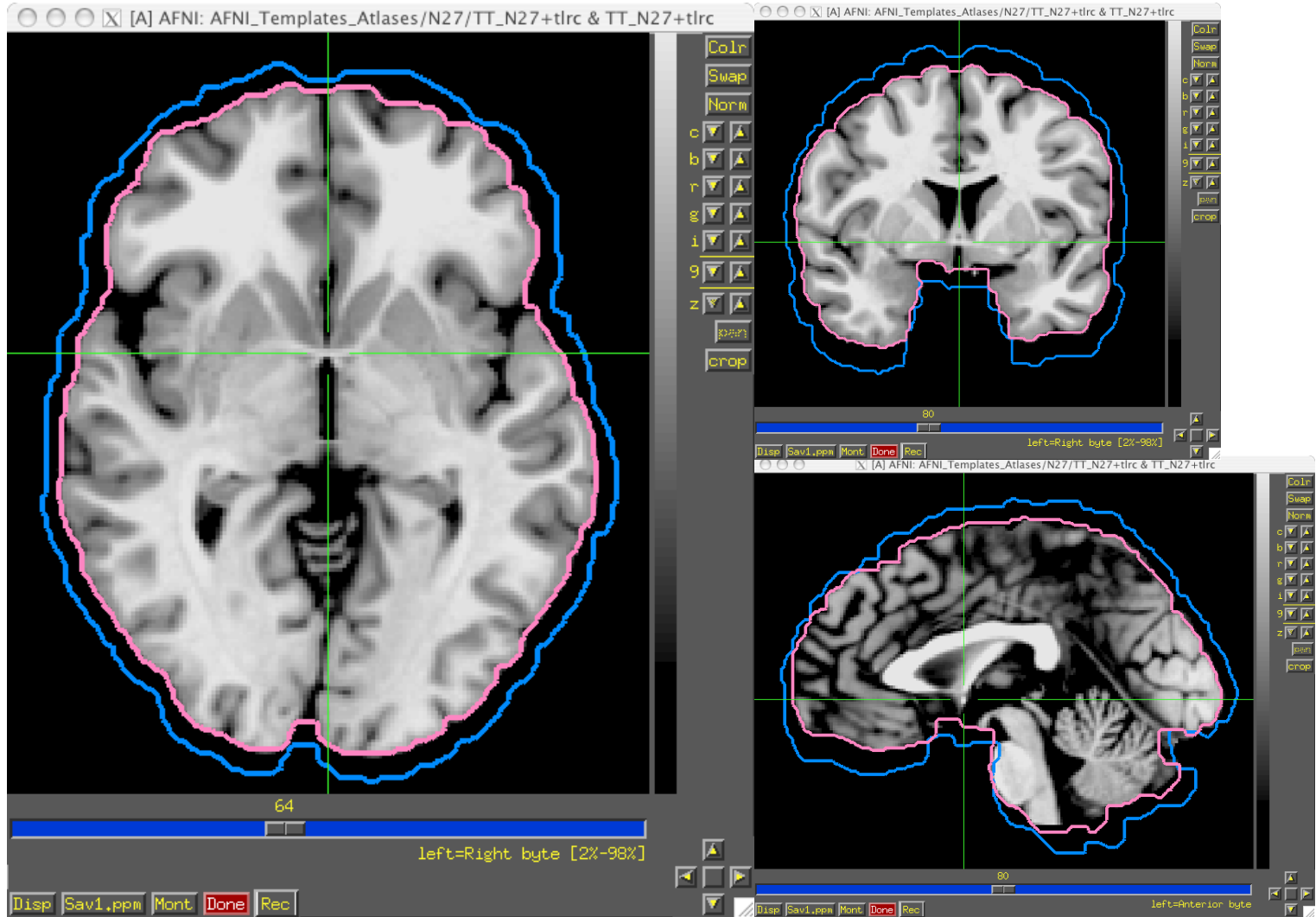
Template spaces differ in origin

TLRC, MNI, and MNI-Anat
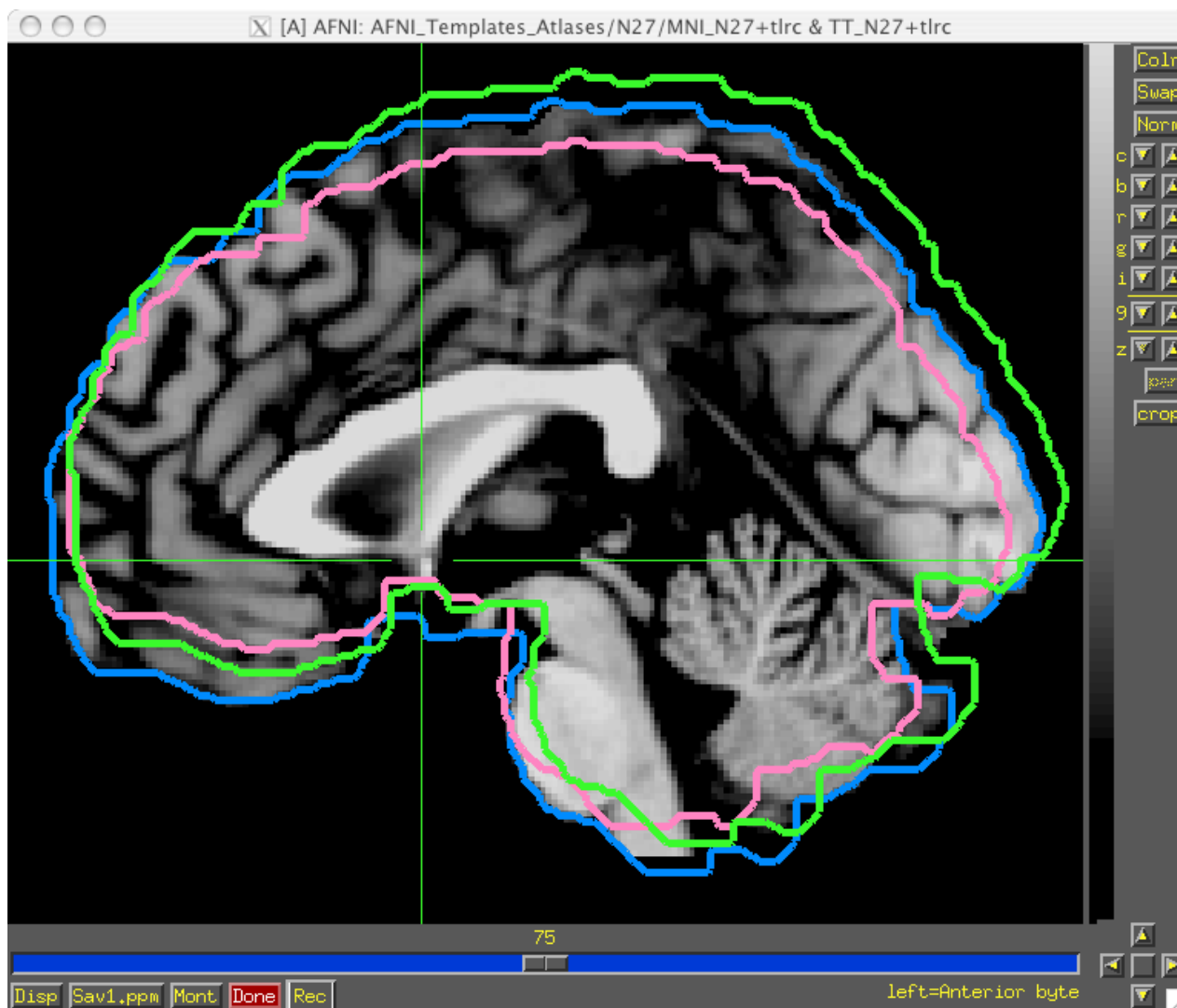
Template spaces differ in size

The MNI brain is larger than the TLRC brain.

From space to space

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`)

TLRC, MNI, and MNI-Anat
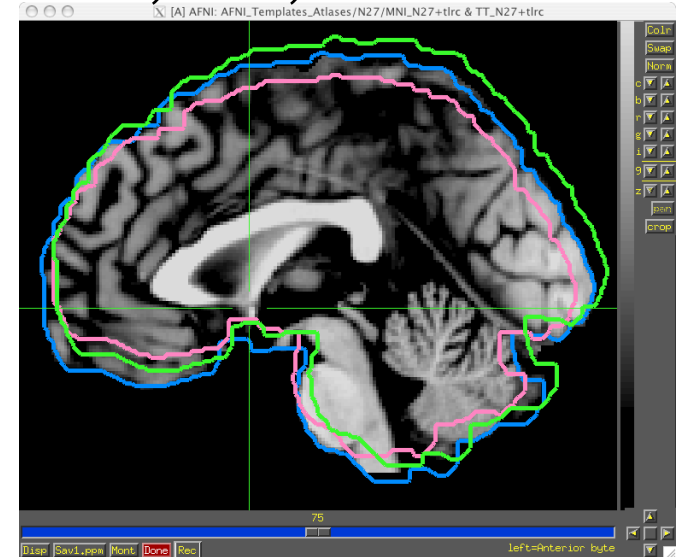
For going between MNI and MNI Anat (Eickhoff et al., 2005):
MNI + (0, 4, 5) = MNI Anat. (in RAI coordinate system)

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.

Choosing a template

Try to pick a template that...

- is similar to the subject group: neonates, pediatric, young adults, elderly, macaque, rabbit...
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- has a relevant atlas segmentation.

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

- Scripts/commands exist in AFNI
    - *Ex.* Haskins pediatric atlas
    - several methods tested
    - best approach: *iterative nonlinear alignment*
        - **make_template_dask.py**
        - **Previously @toMNI_Awarp, @toMNI_Qwarpar**

Finding templates and atlases

Good places to find templates and atlases

AFNI!- abin directory
AFNI! - http://afni.nimh.nih.gov:/pub/dist/atlases

NITRC - https://www.nitrc.org/

PRIME-RE - https://prime-re.github.io/

Allen Brain Project -
   https://portal.brain-map.org/

BrainMaps.org - http://brainmaps.org/

MNI - http://nist.mni.mcgill.ca

Scalable Brain -
   https://scalablebrainatlas.incf.org

UCLA - http://www.bmap.ucla.edu/portfolio/atlases


```
←  →  C    afni.nimh.nih.gov/pub/dist/atlases/
dir    2017.11.21.2129   bist
dir    2019.04.11.1640   brainnetome
dir    2019.04.07.2131   caez
file   2012.09.04.1626   caez_18_all_atlases.tgz
dir    2019.09.24.1357   cat
dir    2020.01.24.1623   current
dir    2019.04.05.1617   currentpmaps
file   2019.03.14.1818   current.tgz
dir    2017.11.21.2129   elsedemo
file   2014.10.22.1800   Haskins_MNI152.jpg
dir    2017.11.21.2129   HaskinsPeds
dir    2020.05.05.1745   IBT
dir    2017.10.25.1407   keuken
dir    2019.07.22.1638   macaque
dir    2020.04.29.1719   marmoset
dir    2017.11.21.2129   MNI
dir    2017.03.27.1023   mni_acpc
dir    2013.04.16.1734   MNI_atlases
file   2013.04.16.1738   MNIatlases.tgz
dir    2019.04.19.1846   MNI_HCP
dir    2017.11.21.2129   MNI_VmPFC
dir    2019.04.03.1224   mouse
dir    2019.01.24.1816   Pauli_subcortical
dir    2019.12.12.2304   Princeton_visual
dir    2019.07.30.1723   rat
dir    2020.04.30.2132   SchaeferYeo
dir    2017.11.21.2129   SUIT_Cerebellum
dir    2019.07.30.1718   UNC_Infant_Atlases
dir    2017.11.21.2129   VmPFC
dir    2017.11.21.2130   waxrat
```
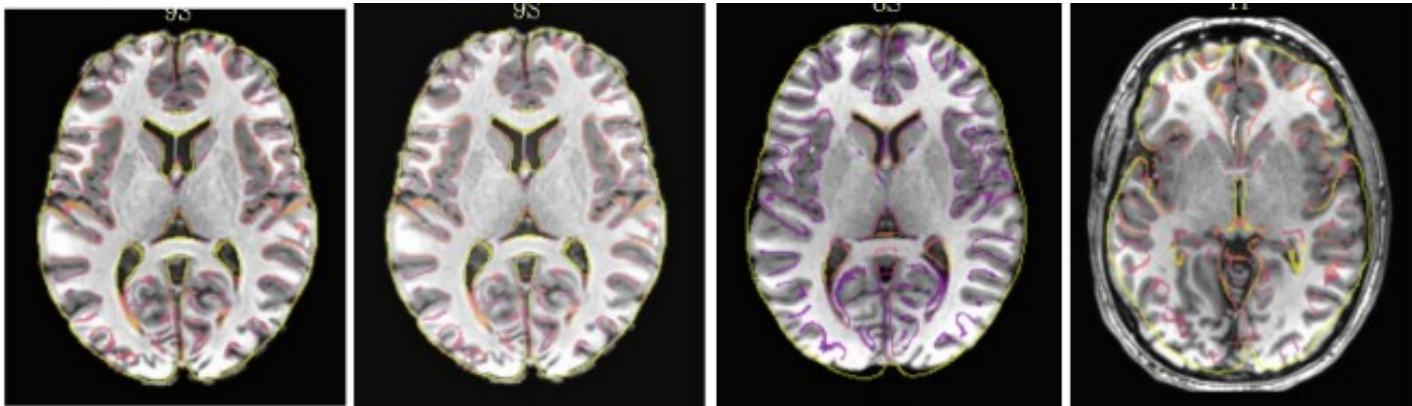
Trading Spaces

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

Nonlinear alignment to template

Multiple nonlinear alignment tools in AFNI

3dQwarp: the standard nonlinear workhorse

@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
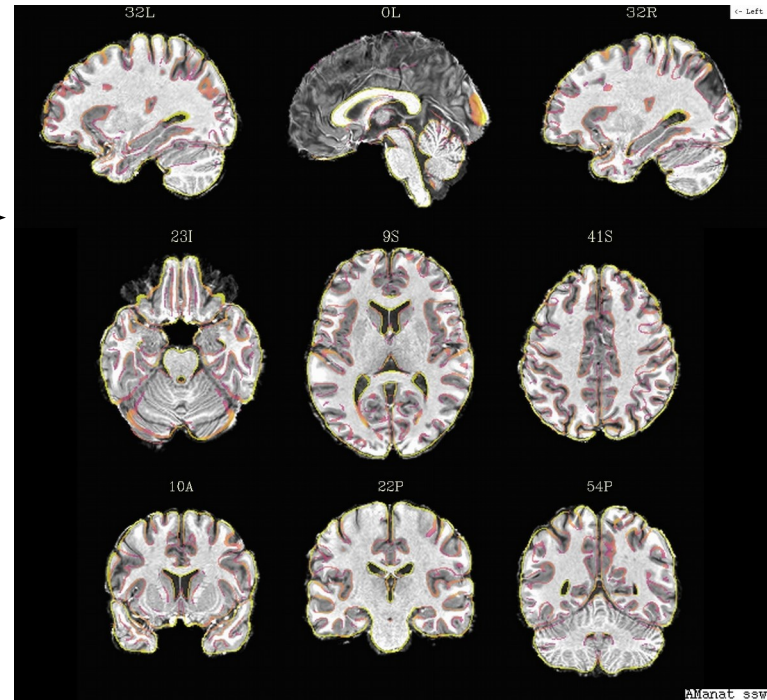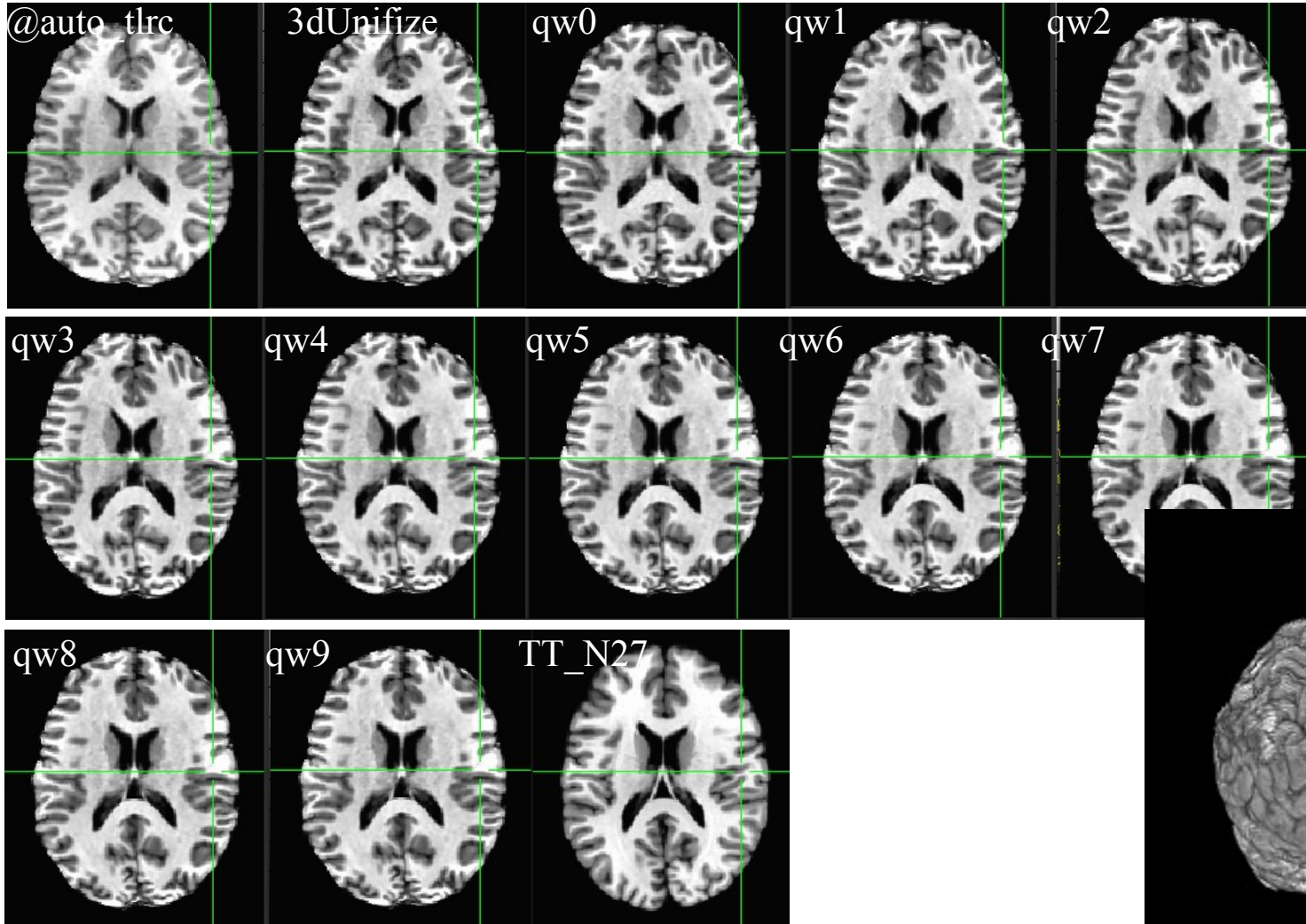

auto_warp.py: wrapper for alignment functionality, ~simpler syntax
  (@auto_tlrc + 3dQwarp together)
Ex: `auto_warp.py -base MNI152_T1_2009c+tlrc. \`
        `-suffix _awarp -input strip+orig.`

Nonlinear alignment to template

3dQwarp, through multiple levels of refinement →
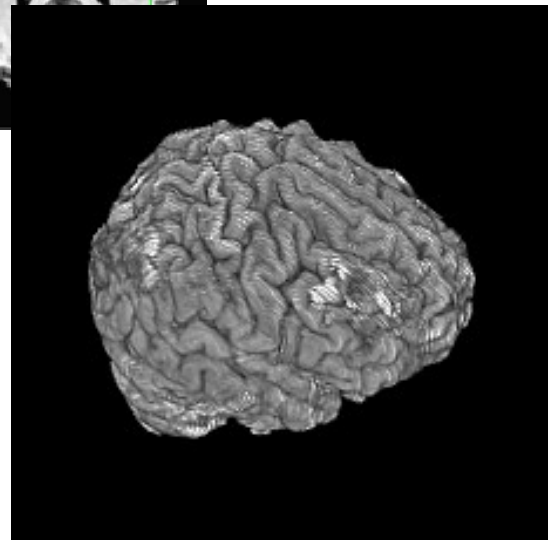
Trading Spaces

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
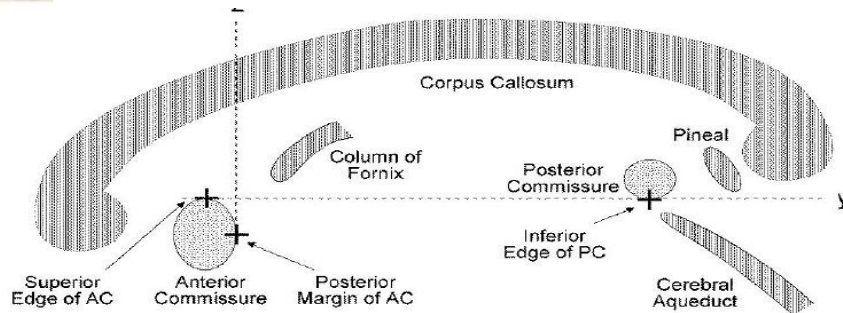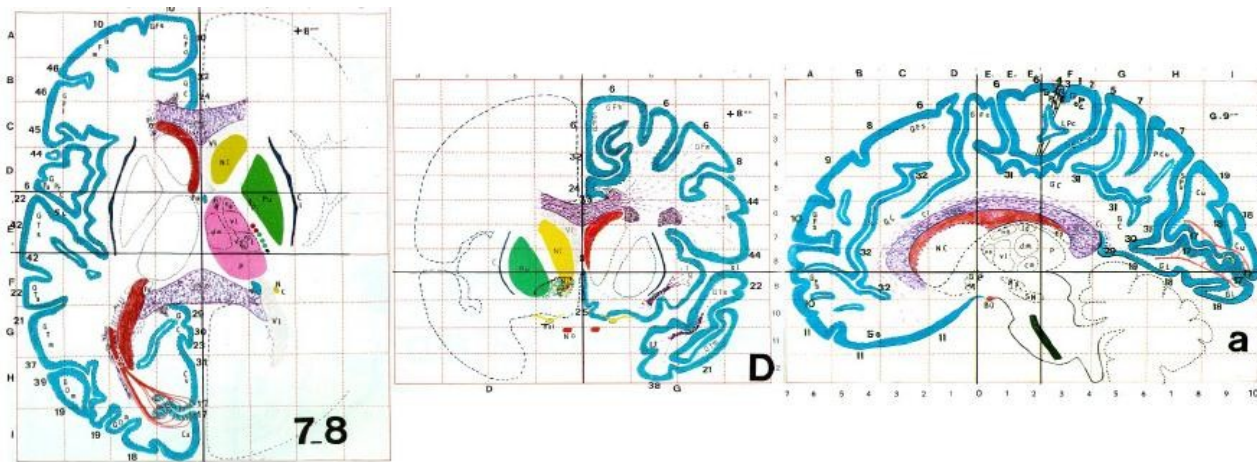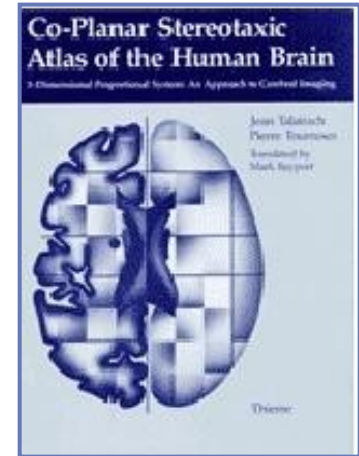
Space Travel -
Getting to Talairach Space

- The original purpose of AFNI transform datasets to Talairach-Tournoux (stereotaxic) coordinates
- Manual mode - 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,
>
> 1957 (original version introducing AC-PC stereotaxic system)

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)

That's All for Now