ANTs brain morphology

Nick (UVa) and Brian (Penn)

1. But, wait, there's more!
2. But the best part is . . .
3. Longitudinal processing (current work)

Cortical thickness studies

Column1	Column2
Tetris-playing ability	chronic pancreatitis
Huntington's disease	obsessive-compulsive disorder
schizophrenia	ADHD
bipolar disorder	obesity
Alzheimer's disease	heritable depression
frontotemporal dementia	elderly depression
Parkinson's disease	age
Williams syndrome	gender
multiple sclerosis	handedness
autism	intelligence

ANTs-related background

- Sandy, Brian, and DiReCT

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- *“Let’s evaluate on open data.”*

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- *"Let's evaluate on open data."*
- and, eventually, *"Let's compare with FreeSurfer."*

Basic components of the pipeline

1. template building (offline)

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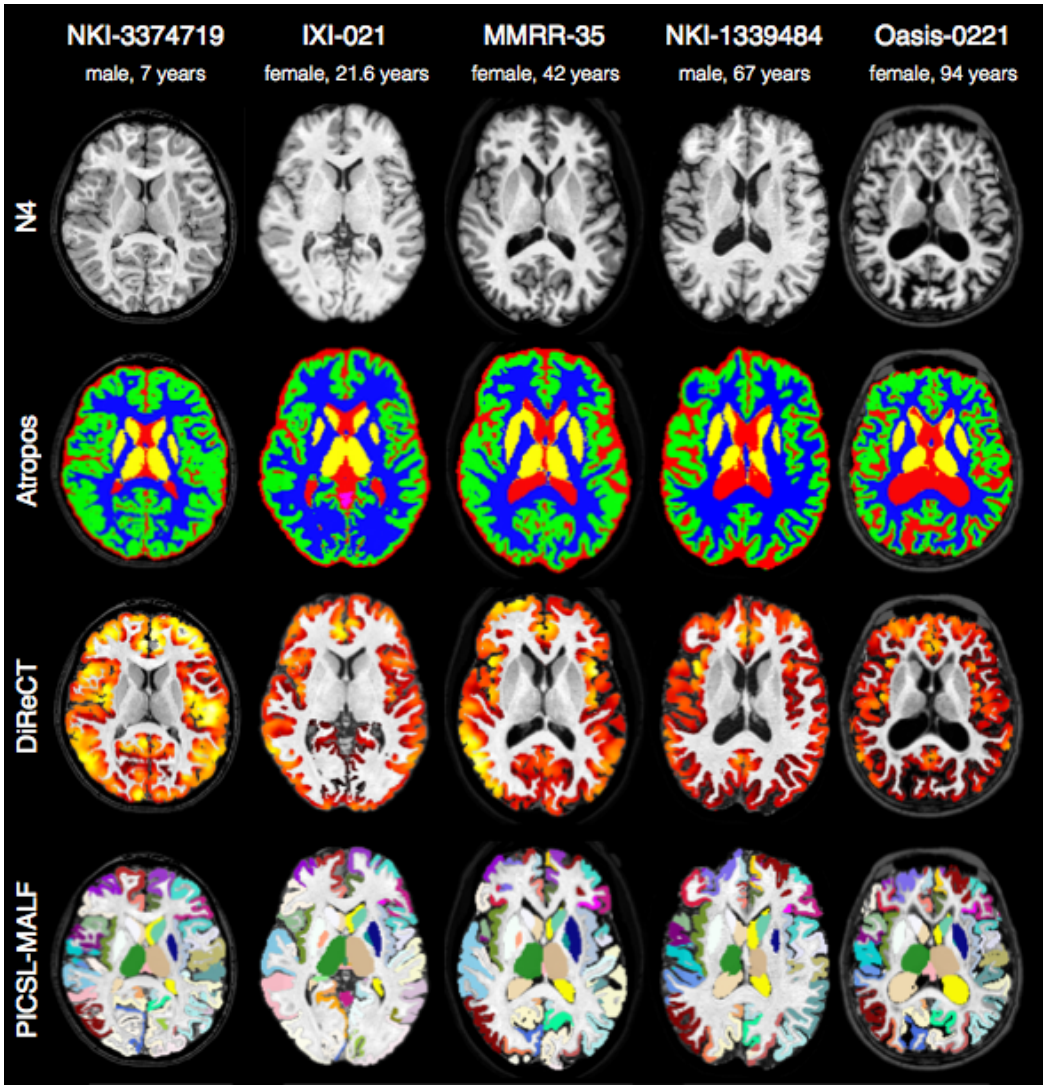
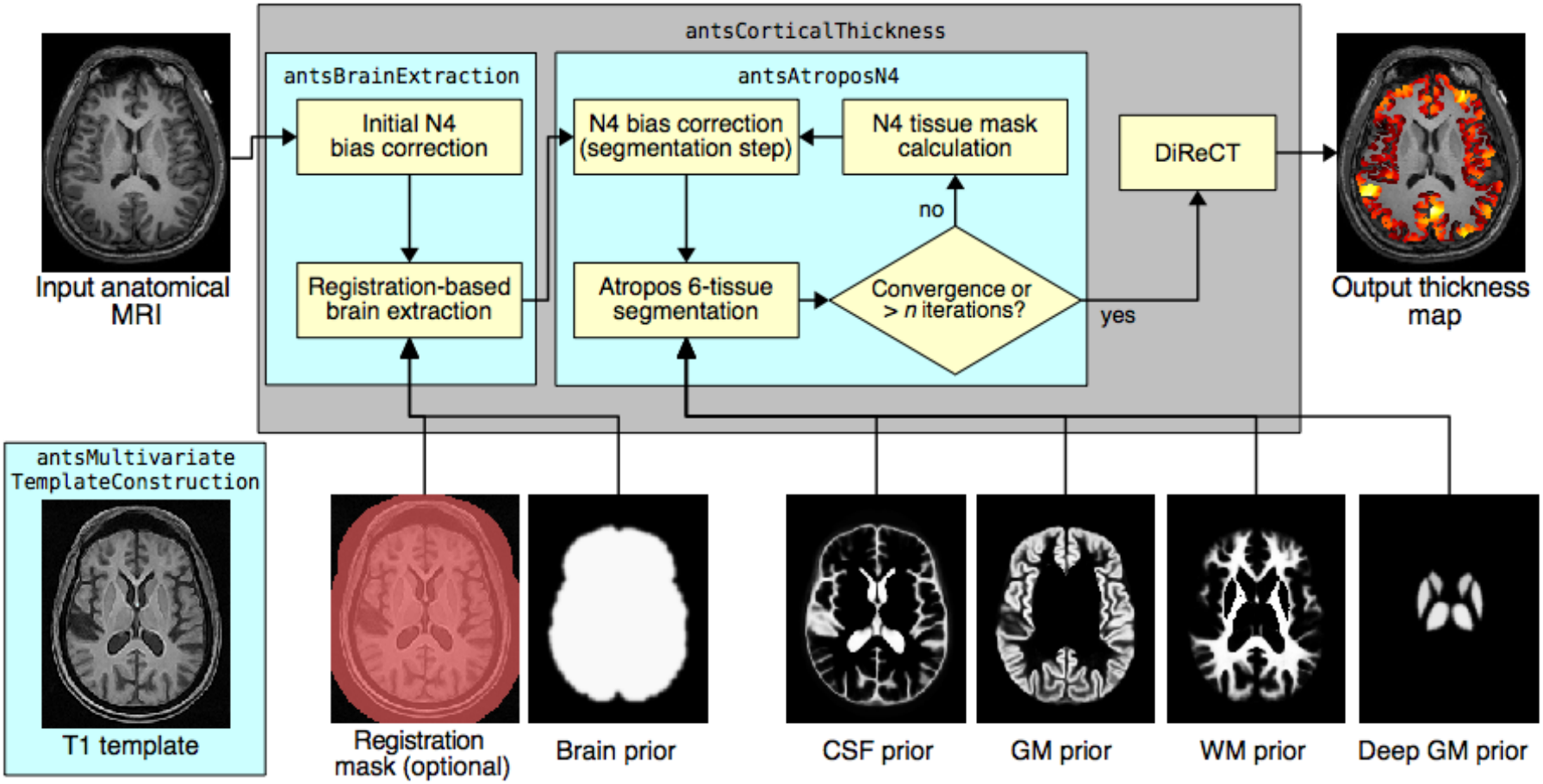
2. brain extraction
3. cortical thickness estimation
4. cortical parcellation

Sample results

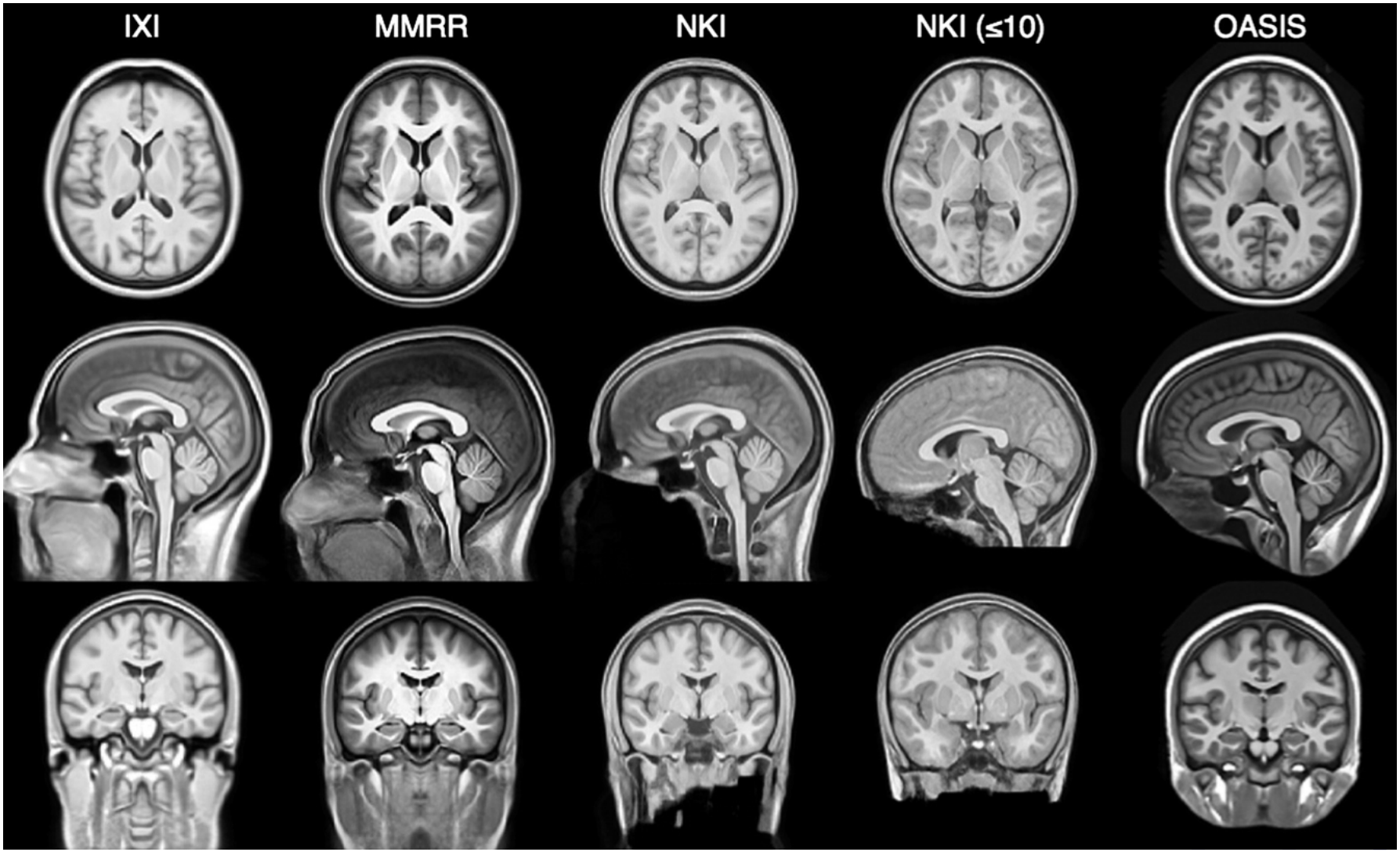


The ANTs structural brain mapping workflow

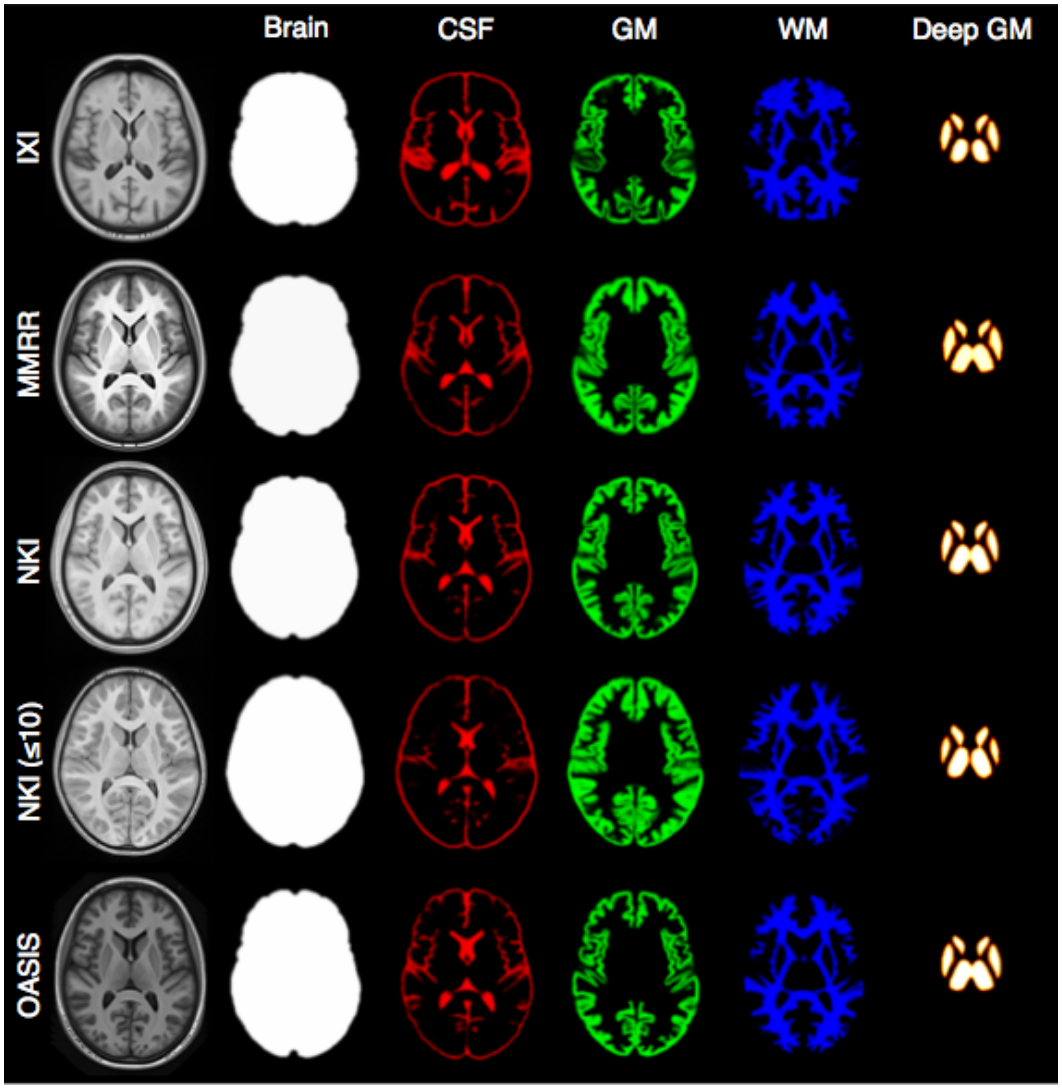


Template building

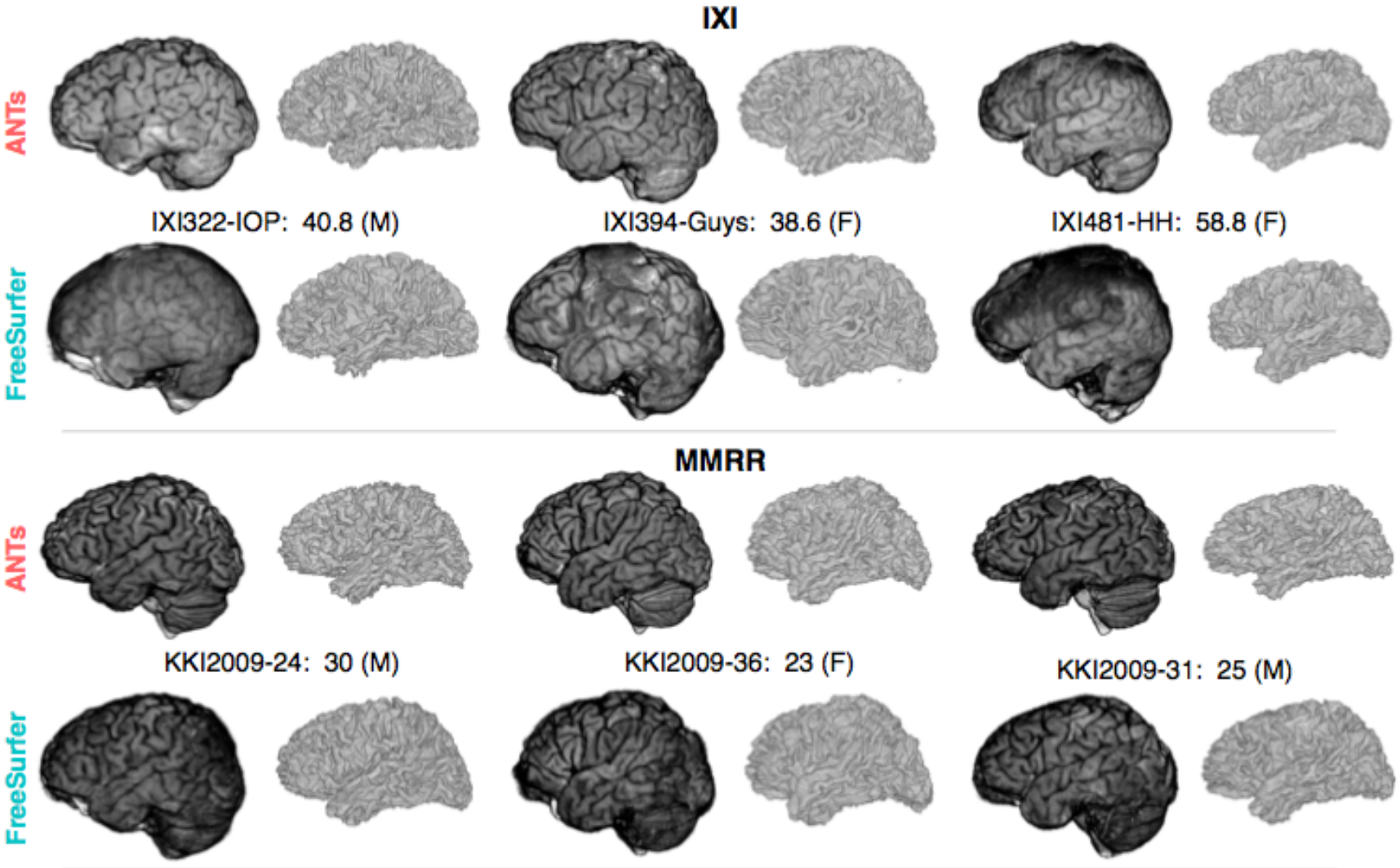
Tailor data to your specific cohort



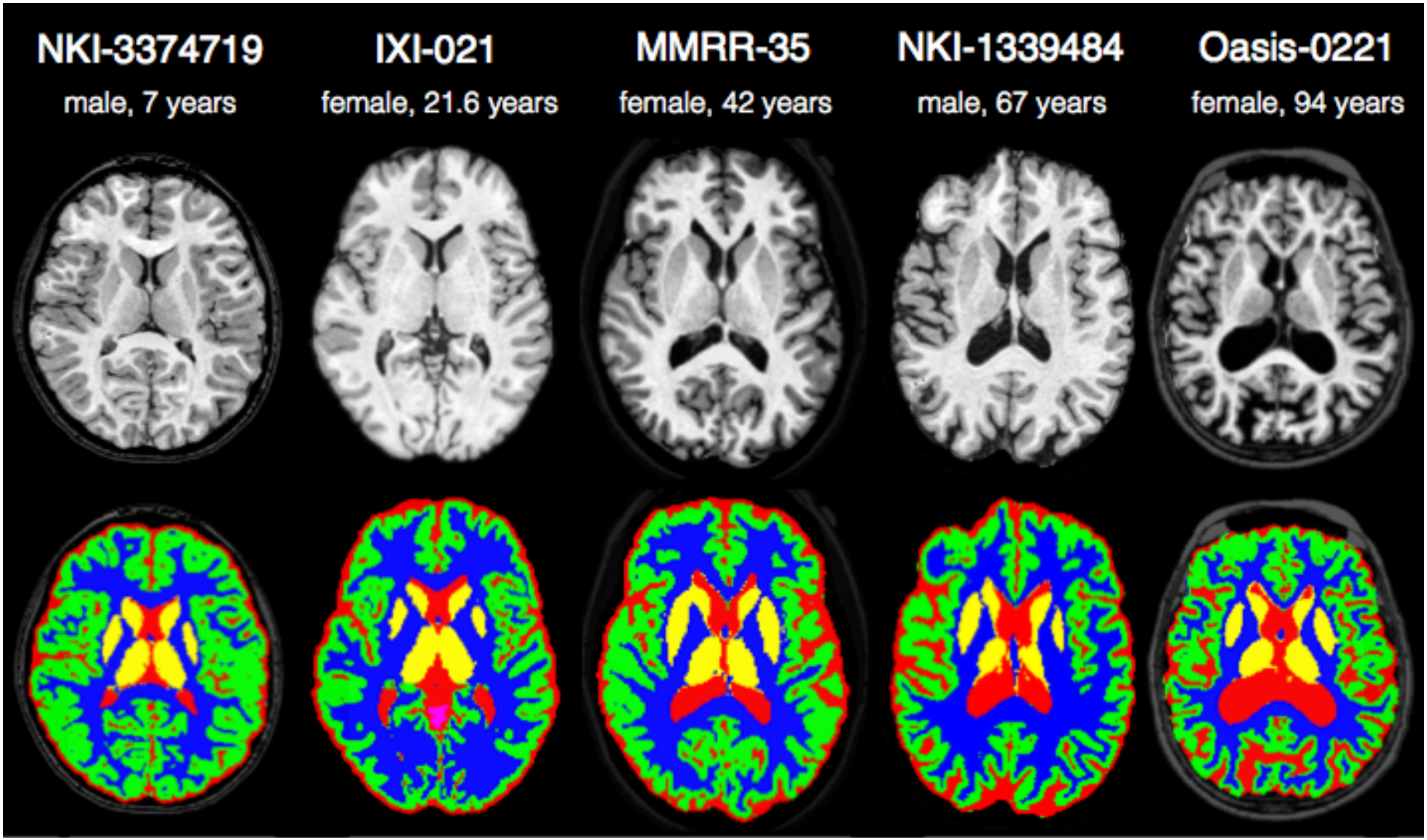
Template priors



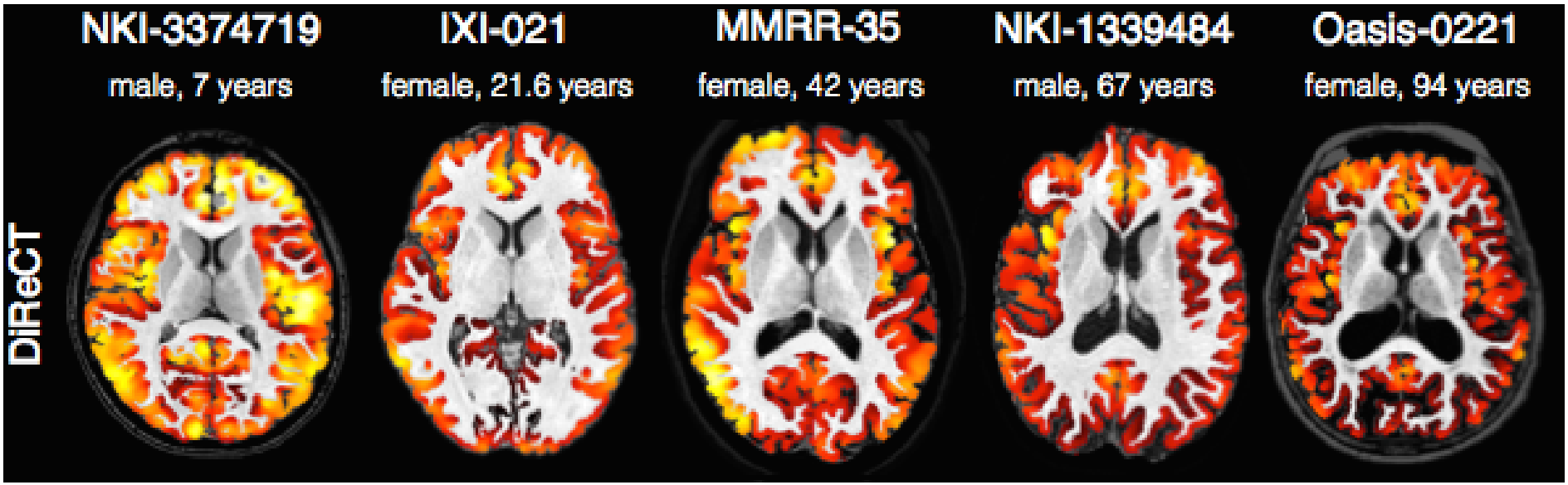
Brain extraction comparison



Brain segmentation



Cortical thickness estimation

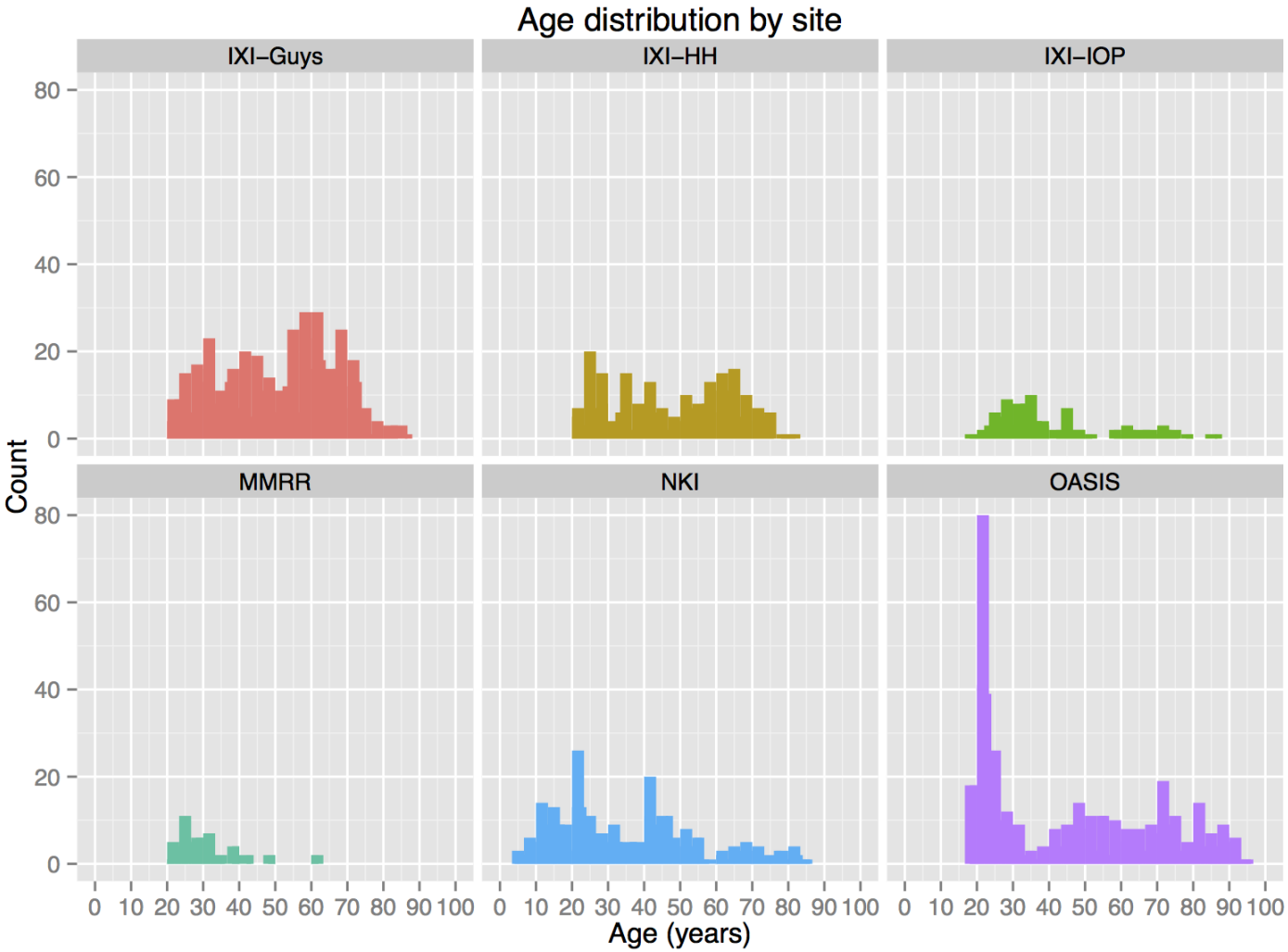


But without ground truth, how does one evaluate the pipeline?

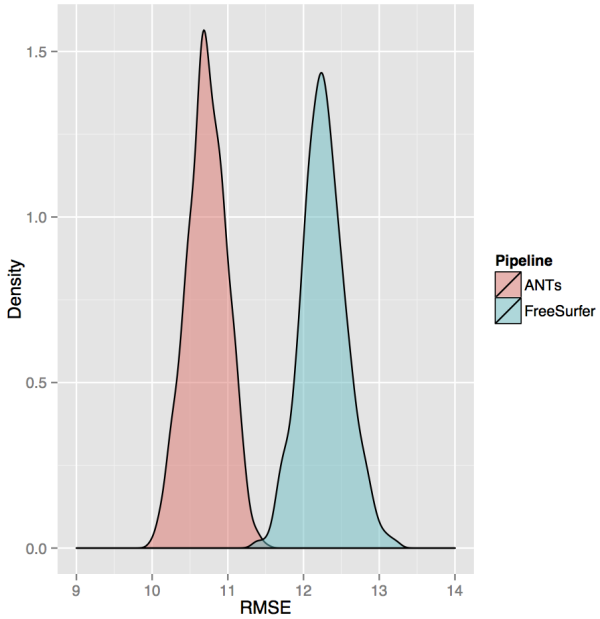
Predict age and gender

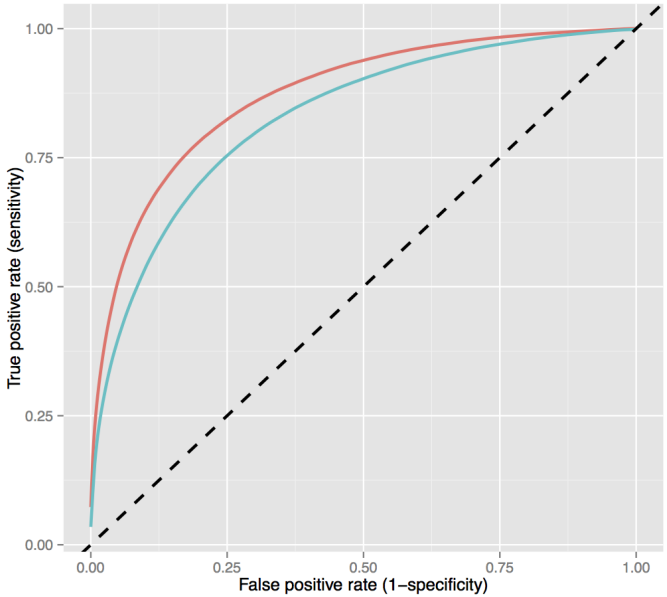
$$AGE \sim VOLUME + GENDER + \sum_{i=1}^{62} T(DKT_i)$$

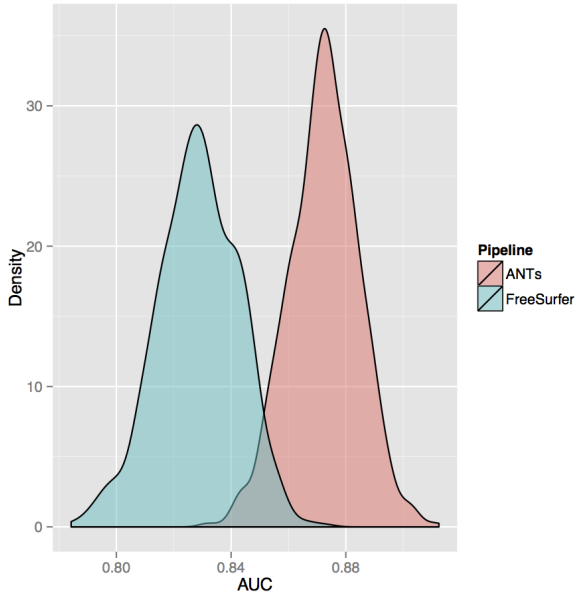
Open science prinicples



Prediction from cortical thickness data







Age **Gender**

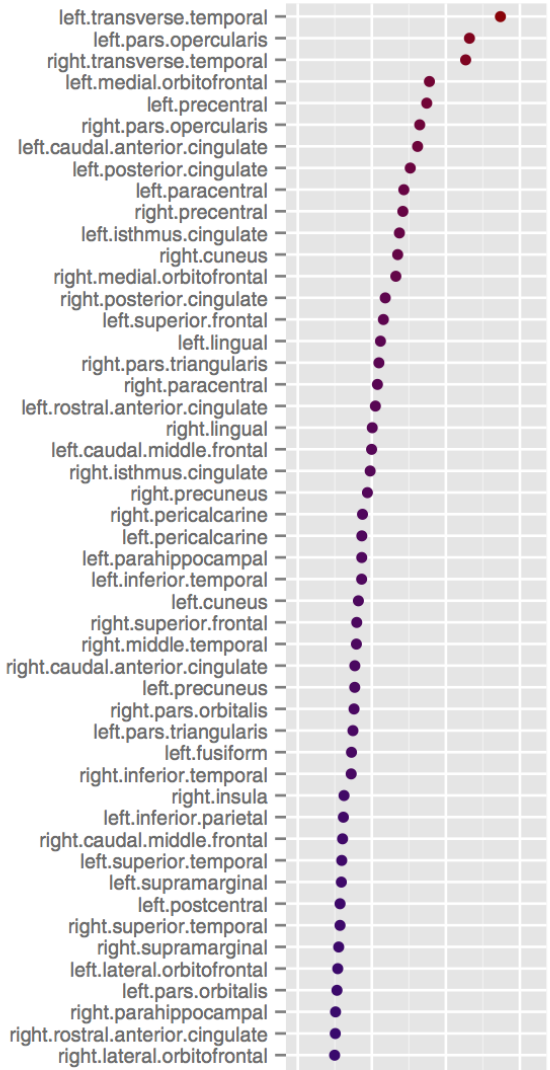
Age prediction per site

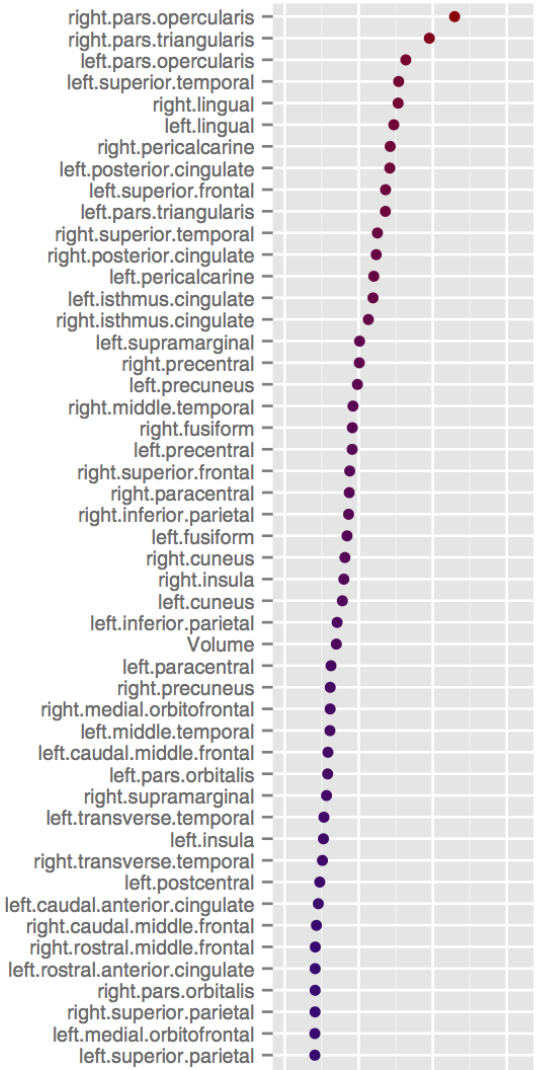
Table 3
Mean RMSE for age prediction in years.

	Linear model	Random forest
ANTs (combined)	10.7	10.2
FreeSurfer (combined)	12.3	11.9
ANTs (IXI)	9.3	8.6
FreeSurfer (IXI)	12.3	11.7
ANTs (NKI)	NA[a]	10.9
FreeSurfer (NKI)	NA[a]	13.3
ANTs (OASIS)	15.0	12.4
FreeSurfer (OASIS)	15.0	11.4

[a] Fitting error.

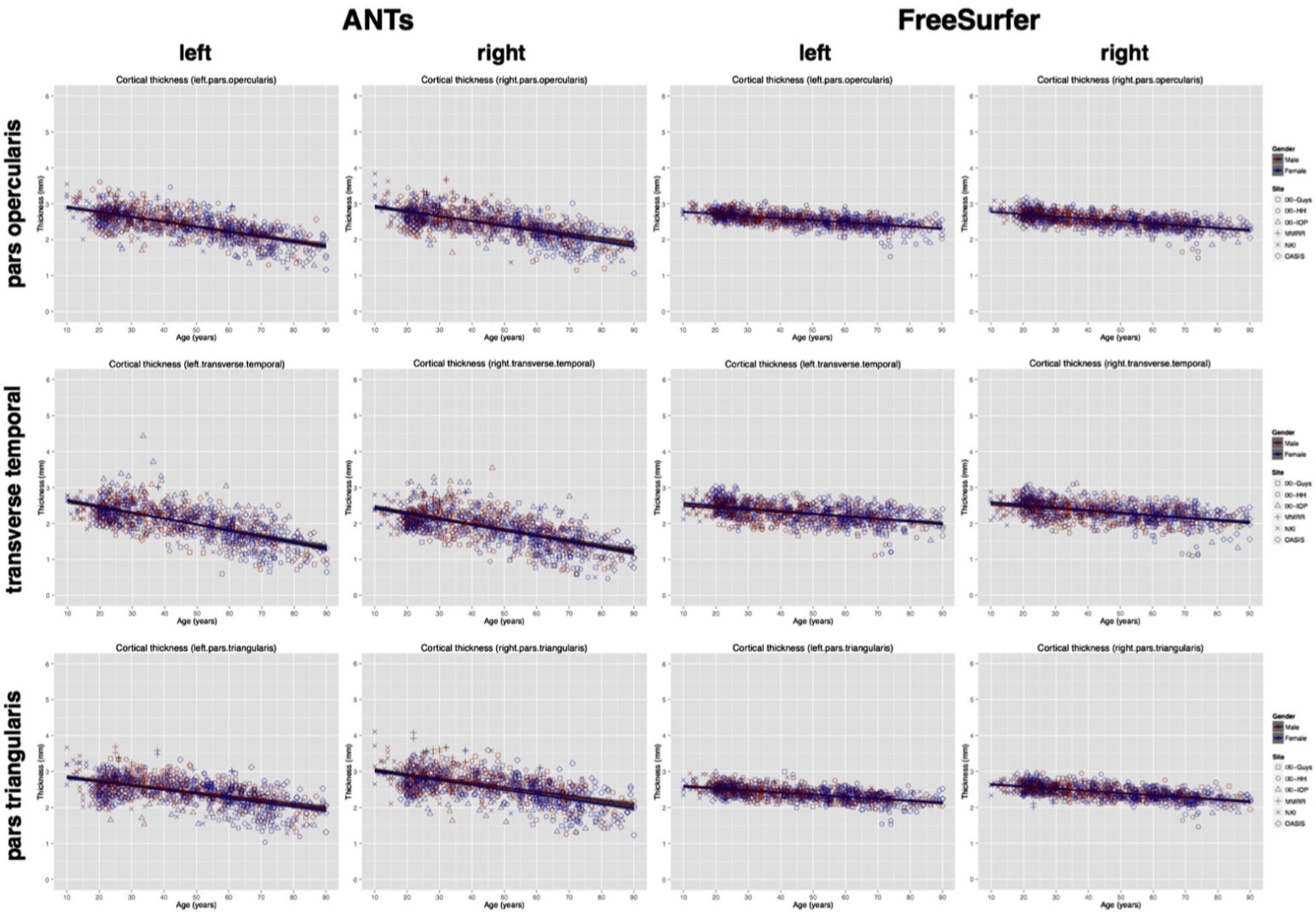
Regional importance comparison





ANTs (left) vs. FreeSurfer (right)

Regional measurements



But, wait, there's more!

Data availability

- "*Hey, can I have the FreeSurfer measurements for the entorhinal cortex?*" Sure, why not?

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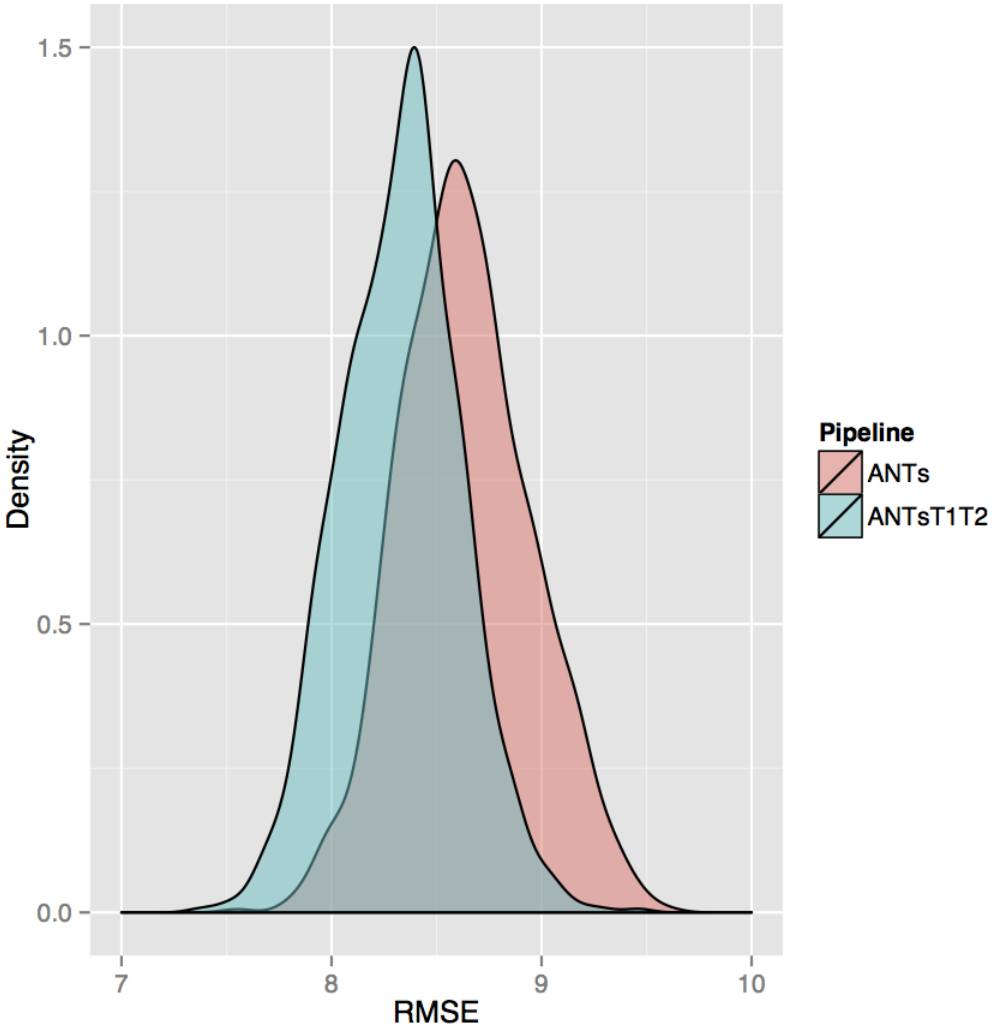
- "*I was wondering if you would make available the CT in each ROI for each subject. . .*" Sure, why not? Would you also like the surface areas and volumes?
- "*Can I have one or more of the templates that you used for your study?*" Would you like the priors as well?

What about using both the T1 & T2?

ANTs tools are multivariate

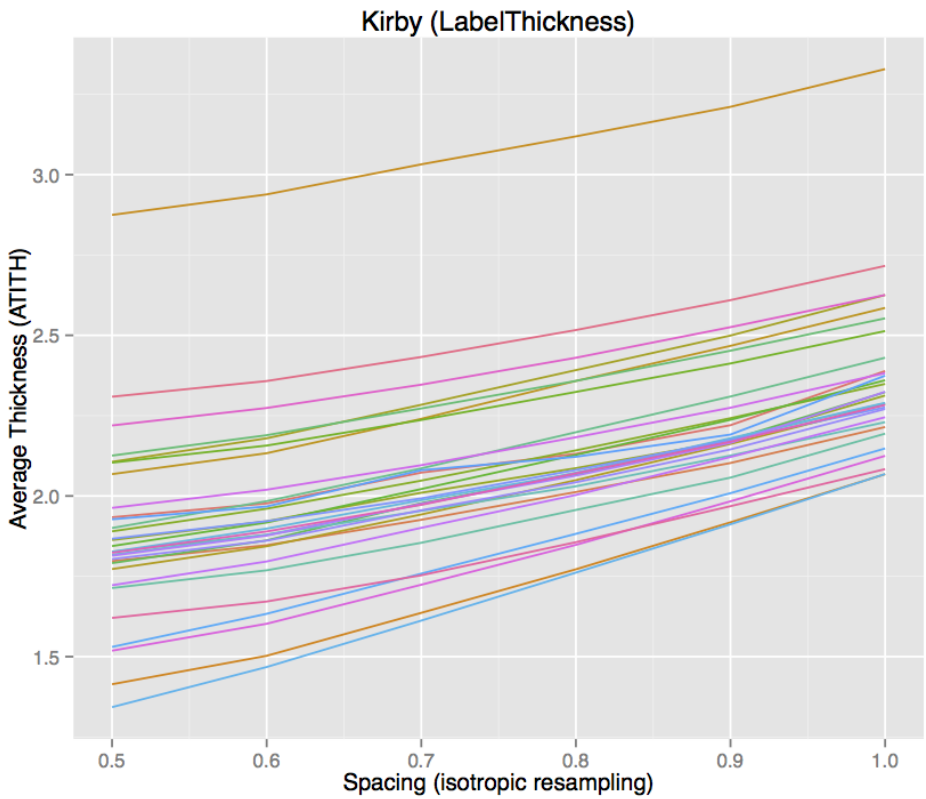


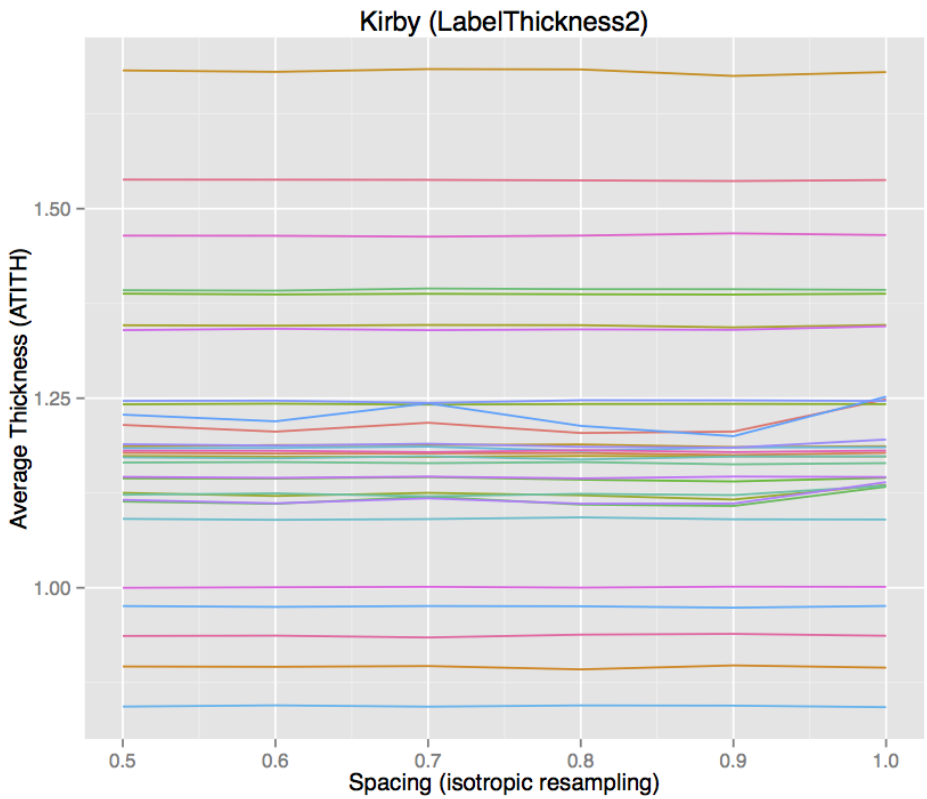
Arno-thick-in-the-head (ATITH)

What if we made a crude estimate of the cortical thickness?

$$thickness_{ROI} = \frac{volume_{ROI}}{area_{ROI}}$$

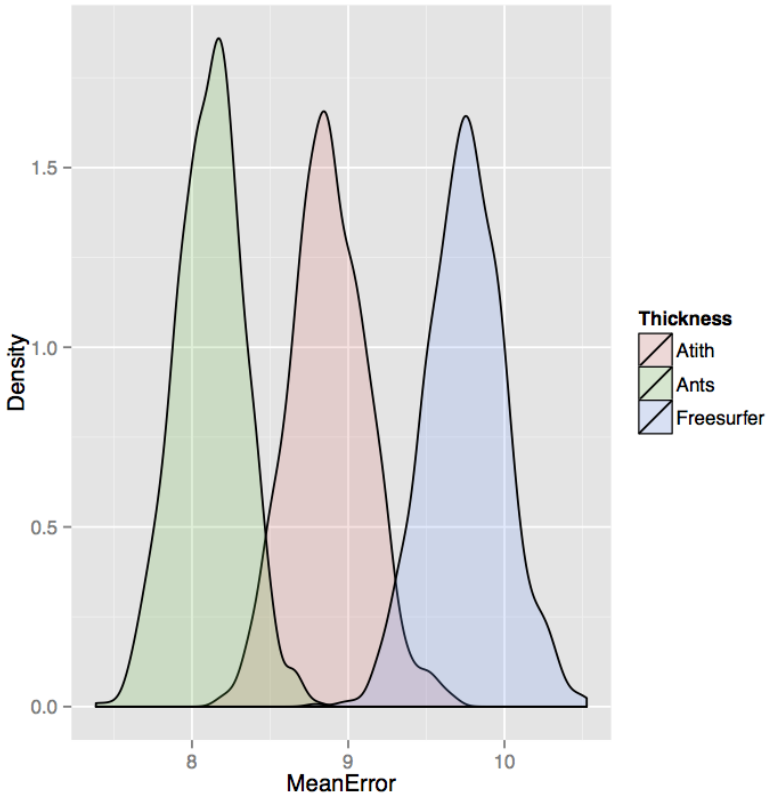
Make sure you estimate the surface area correctly!

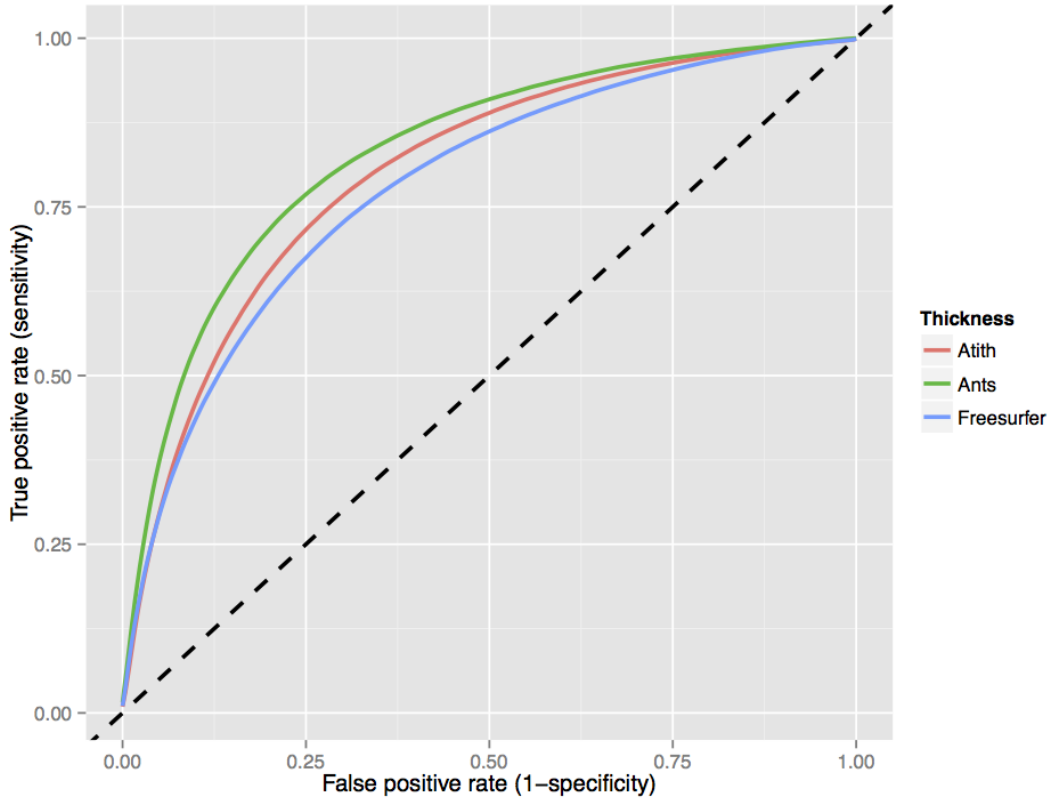




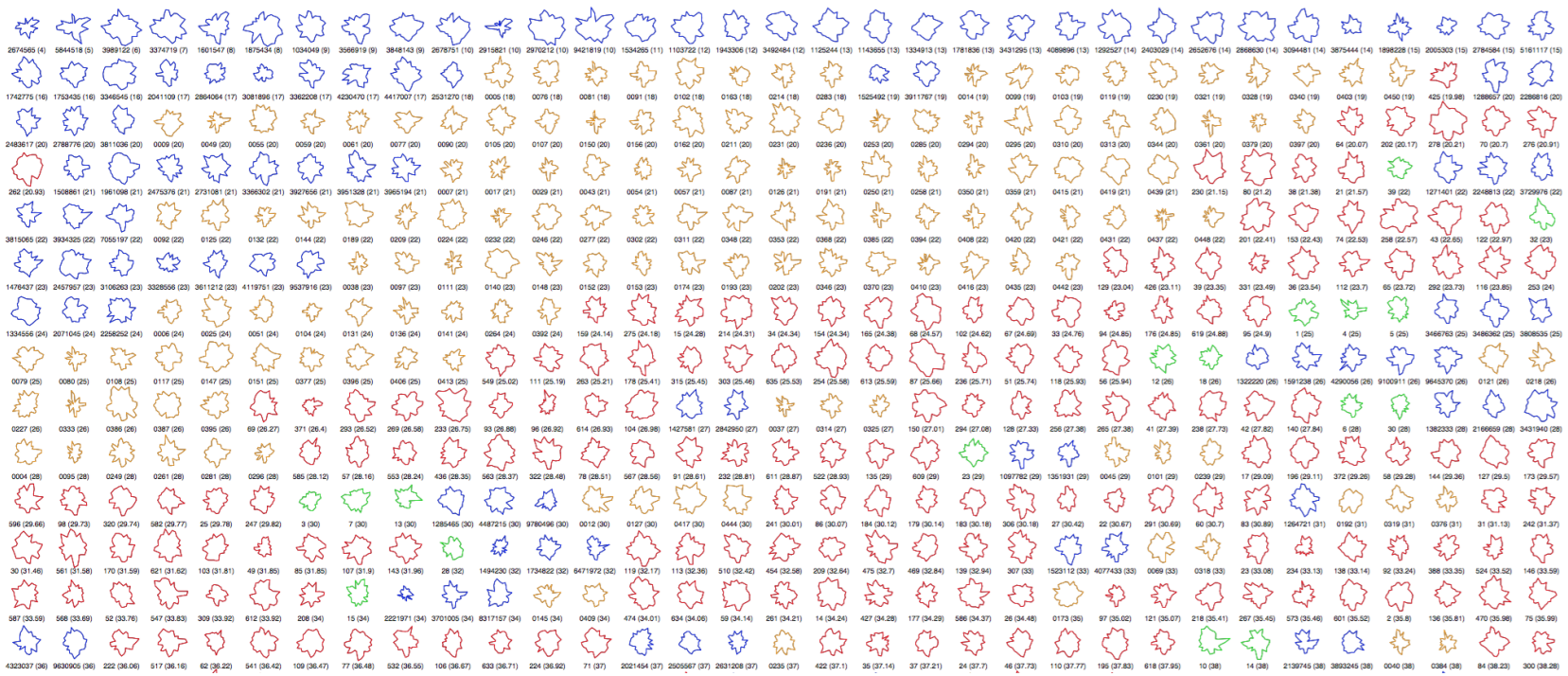
So how does ATITH compare with ANTs, FS?

Prediction from cortical thickness data





Brain constellation maps



And currently brewing on the UVa cluster...

Does denoising help?

Contribution from Jose

- itkAdaptiveNonLocalMeansDenoisingImageFilter.h

```
$ DenoiseImage

COMMAND:
     DenoiseImage
          Denoise an image using a spatially adaptive filter c
          Manjon, P. Coupe, Luis Marti-Bonmati, D. L. Collins,
          Non-Local Means Denoising of MR Images With Spatiall
          Journal of Magnetic Resonance Imaging, 31:192-203, J

OPTIONS:
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But the best part is . . .

it is absolutely free!

```
${ANTSPATH}/antsCorticalThickness.sh \
  -a IXI/T1/IXI002-Guys-0828-T1.nii.gz \
  -e IXI/template/T_template0.nii.gz \
  -m IXI/template/T_template0ProbabilityMask.nii.gz \
  -f IXI/template/T_template0ExtractionMask.nii.gz \
  -p IXI/template/Priors/priors%d.nii.gz \
  -o IXI/ANTsResults/IXI002-Guys-0828-
```

(as in speech, not beer)

We'll discuss more this afternoon

https://github.com/ntustison/antsCorticalThicknessExample

Longitudinal processing (current work)

Previous ANTs work

Bias in estimation of hippocampal atrophy using deformation-based morphometry arises from asymmetric global normalization: An illustration in ADNI 3 T MRI data

Paul A. Yushkevich [a,*], Brian B. Avants [a], Sandhitsu R. Das [a], John Pluta [b], Murat Altinay [a], Caryne Craige [a] and the Alzheimer's Disease Neuroimaging Initiative [1]

[a] Penn Image Computing and Science Laboratory (PICSL), Department of Radiology, University of Pennsylvania, 3600 Market St., Ste 370, Philadelphia, PA 19104, USA
[b] Center for Functional Neuroimaging, Department of Neurology, University of Pennsylvania, Philadelphia, PA, USA

Methodological considerations in longitudinal morphometry of traumatic brain injury

Junghoon Kim[1], Brian Avants[2], John Whyte[1] and James C. Gee[2]*

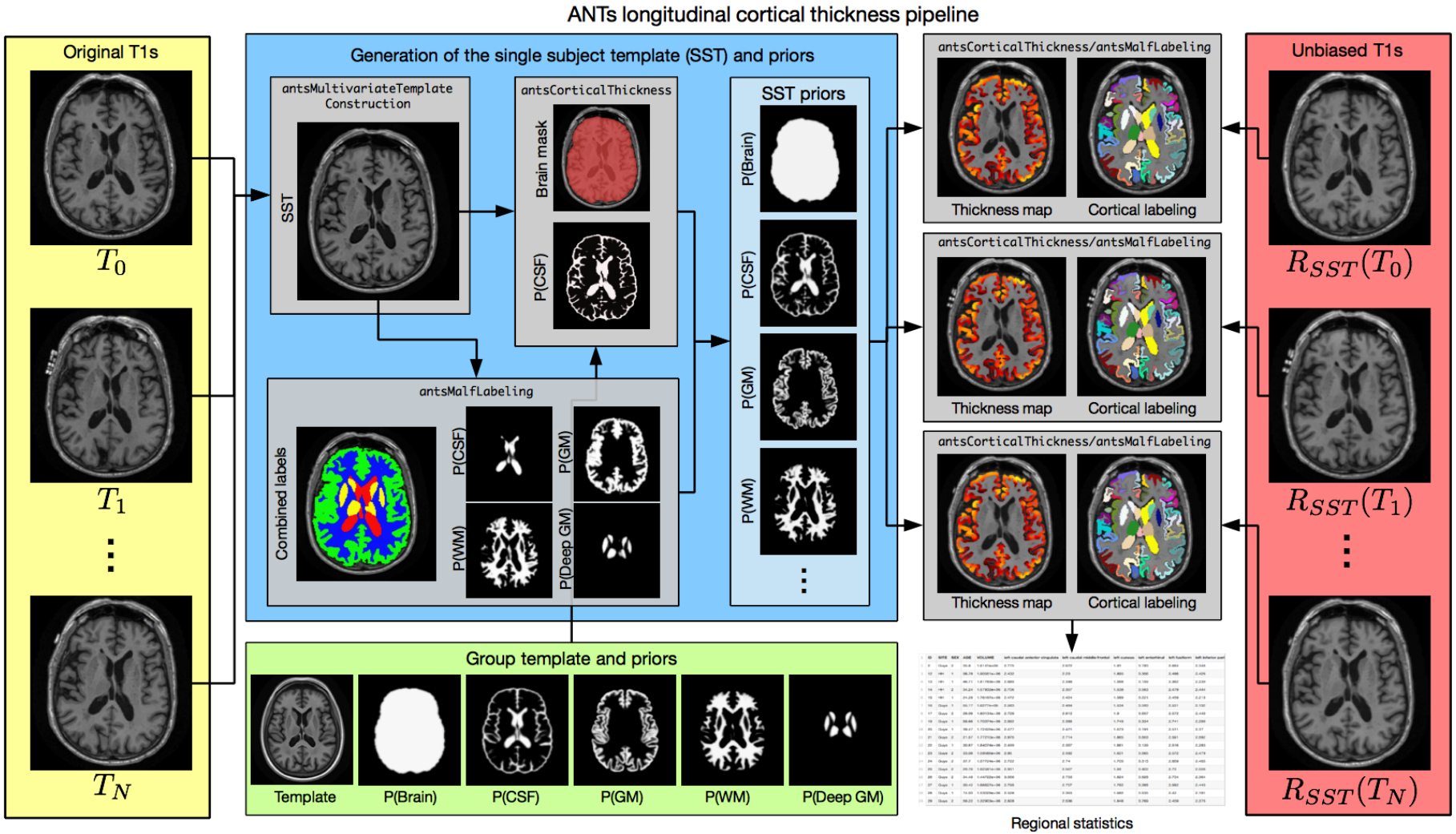
[1] Moss Rehabilitation Research Institute, Elkins Park, PA, USA
[2] Department of Radiology, University of Pennsylvania, Philadelphia, PA, USA

Sparse Unbiased Analysis of Anatomical Variance in Longitudinal Imaging

Brian Avants, **Philip A. Cook**, **Corey McMillan**, **Murray Grossman**, **Nicholas J. Tustison**, **Yuanjie Zheng**, and **James C. Gee**
Depts. of Radiology and Neurology, University of Pennsylvania, Philadelphia, PA 19104-6389

Brian Avants: avants@grasp.cis.upenn.edu

ANTs longitudinal pipeline



antsLongitudinalCorticalThickness.sh

```
$ antsLongitudinalCorticalThickness.sh -h 1

antsLongitudinalCorticalThickness.sh performs a longitudinal c
are performed:
  1. Create a single-subject template (SST) from all the data
  2. Create priors for the SST
     a. Run the SST through the individual cortical thickness
     b. The brain extraction SST prior is created by smoothing
        mask created during 2a.
     c. If labeled atlases are not provided, we smooth the pos
        the SST segmentation priors, otherwise we use antsMali
        posteriors (https://github.com/ntustison/antsCookTempl
  3. Using the SST + priors, we run each subject through the a
     pipeline.

Usage:
```