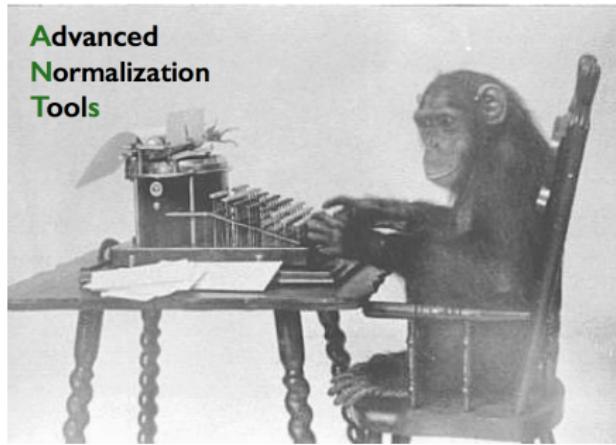


“Dr. Tustison (UVA) presentation”

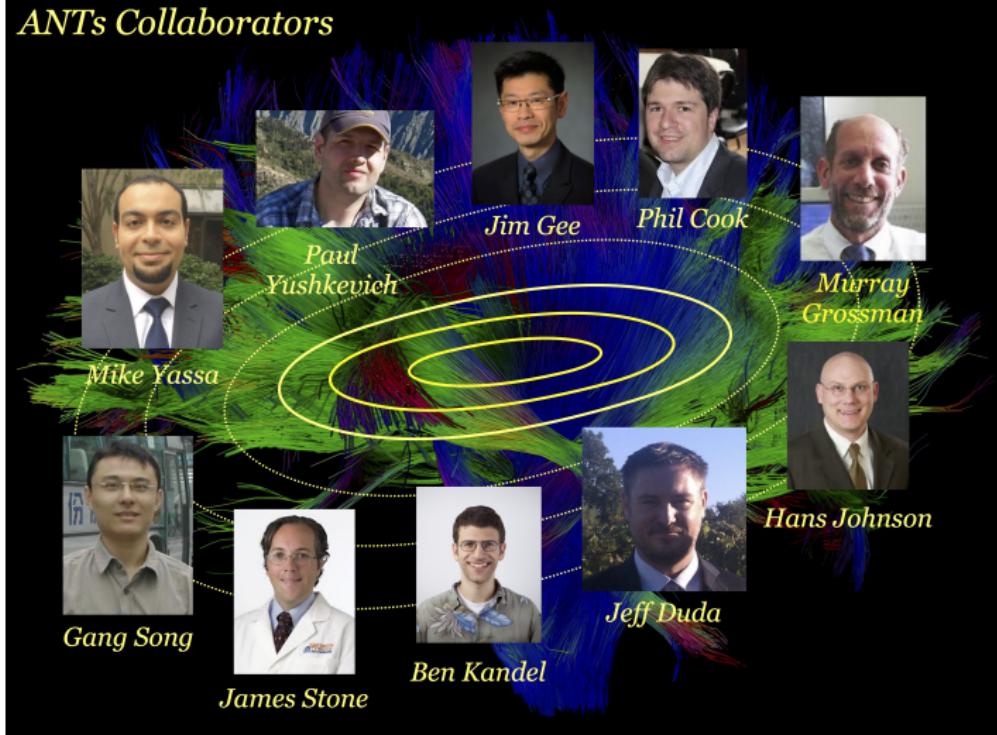
Nick Tustison

University of Virginia



Developers and collaborators

ANTs Collaborators



Why would you care?

Software for medical image analysis

- FSL
- SPM
- FreeSurfer
- MIPAV
- AFNI
- Slicer, Elastix, SimpleITK, ANTs \longleftrightarrow Insight Toolkit
- Many more at idoimaging.com

International competitions

- Klein 2009: MRI brain registration
- EMPIRE 2010: CT lung registration
- Multi-Atlas Label Challenge 2012: MRI brain registration and segmentation
- SATA Challenge 2013: MRI cardiac and canine hind leg registration
- BRATS 2013: Multi-modal MRI brain segmentation
- STACOM 2014 MoCo Challenge: MRI cardiac motion estimation

Major ANTs utilities

Donoho?

“Papers are just advertisements for the science.”

Beyond original SyN

frontiers in
NEUROINFORMATICS

ORIGINAL RESEARCH ARTICLE

published: 28 April 2014
doi: 10.3389/fninf.2014.00044



The Insight ToolKit image registration framework

Brian B. Avants^{1*}, Nicholas J. Tustison², Michael Stauffer¹, Gang Song¹, Baohua Wu¹ and James C. Gee¹

¹ Penn Image Computing and Science Laboratory, Department of Radiology, University of Pennsylvania, Philadelphia, PA, USA

² Department of Radiology and Medical Imaging, University of Virginia, Charlottesville, VA, USA

frontiers in
NEUROINFORMATICS

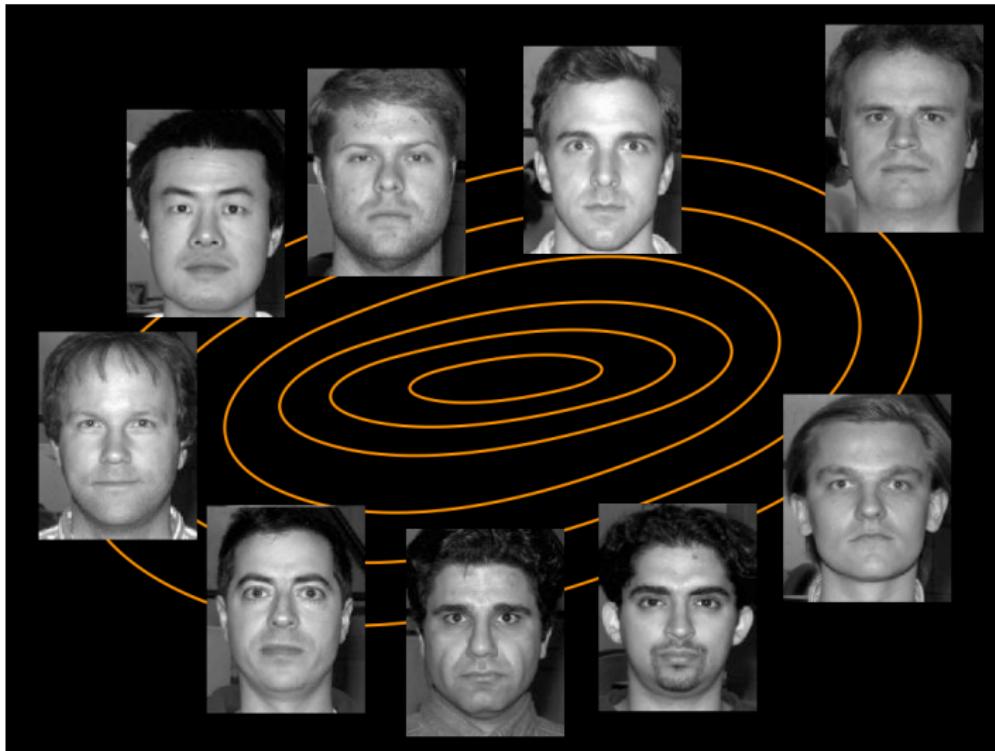
METHODS ARTICLE
published: 23 December 2013
doi: 10.3389/fninf.2013.00039



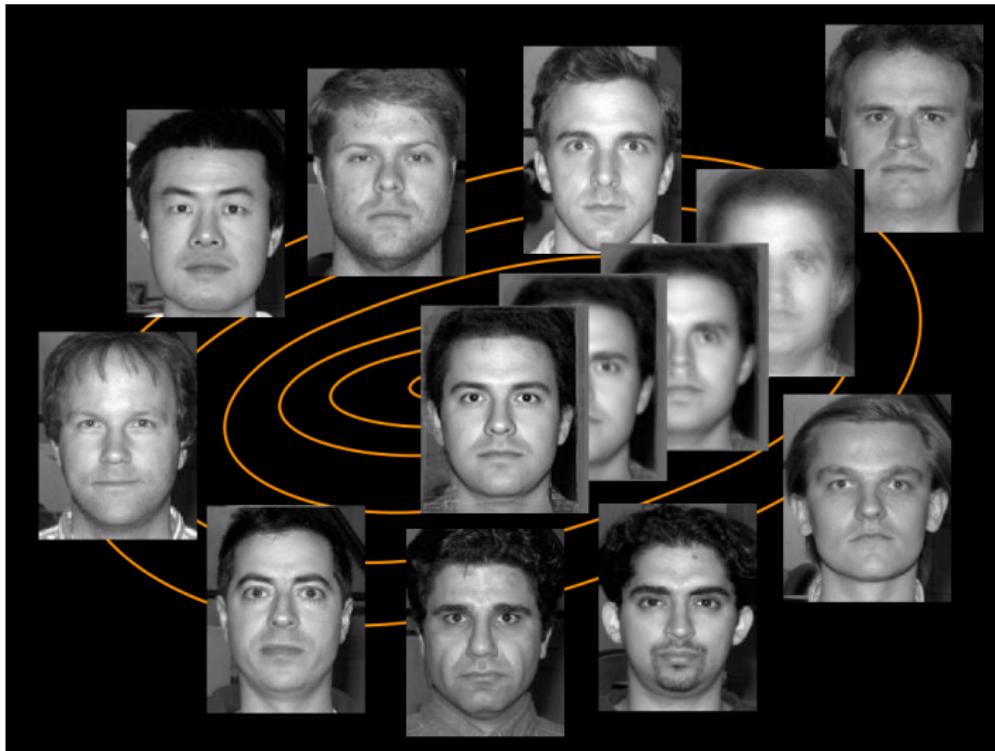
Explicit B-spline regularization in diffeomorphic image registration

Nicholas J. Tustison^{1*} and Brian B. Avants²

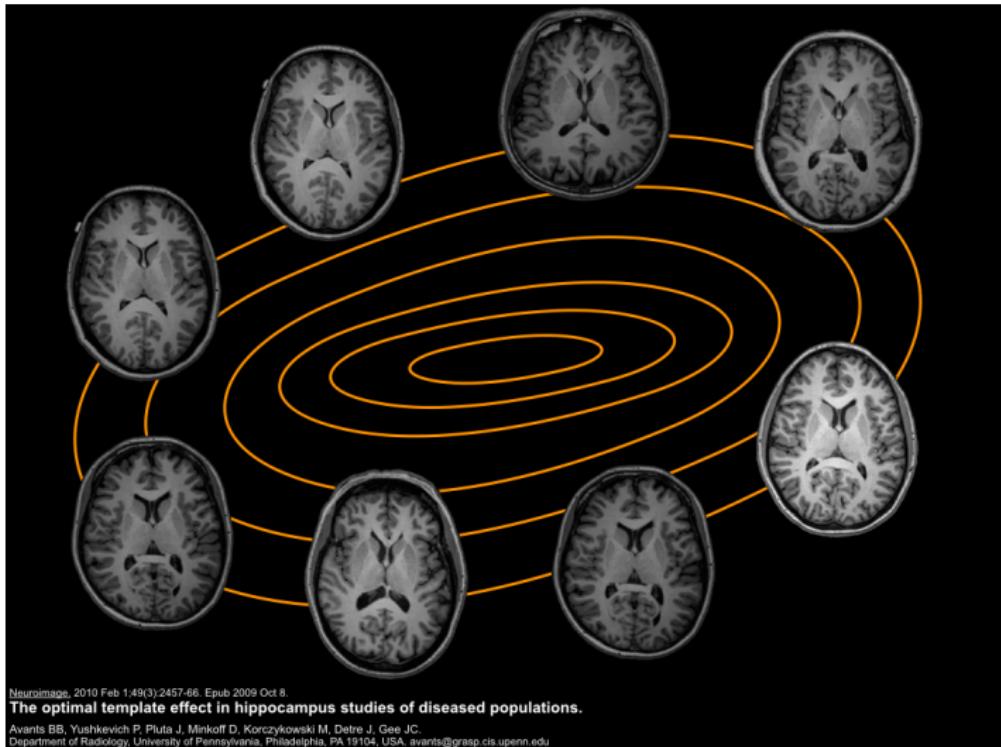
Template building: creating the average Joe



“Attractiveness” → mental processing?



What about brains?



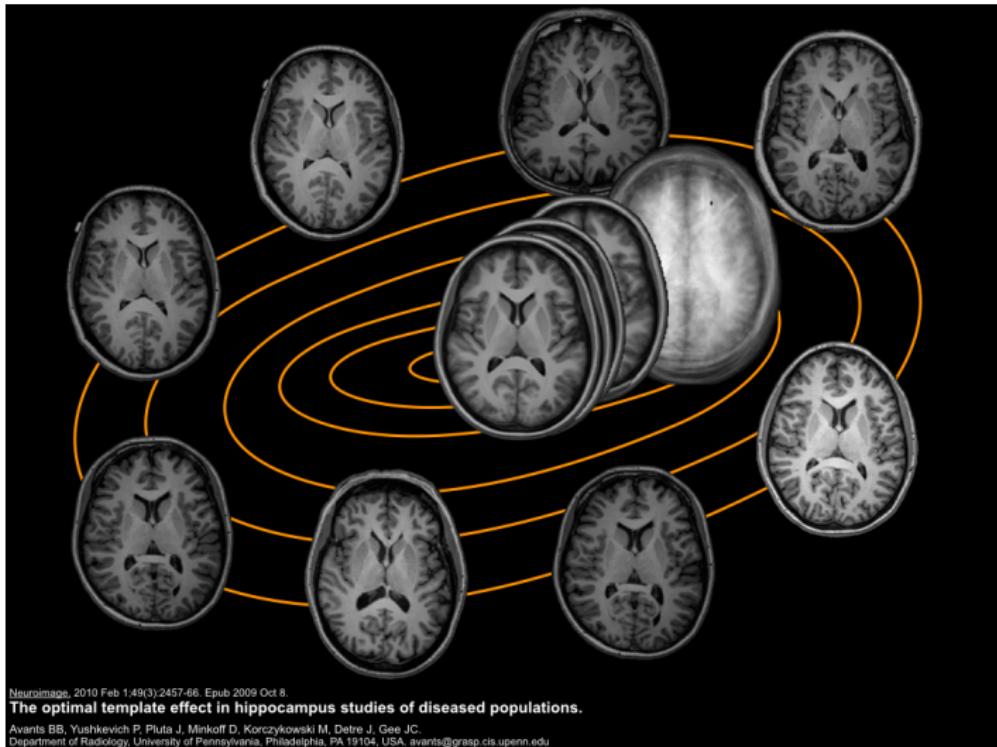
Neuroimage, 2010 Feb 149(3):2457-66. Epub 2009 Oct 8.

The optimal template effect in hippocampus studies of diseased populations.

Avants BB, Yushkevich P, Pluta J, Minkoff D, Korczykowski M, Detre J, Gee JC.

Department of Radiology, University of Pennsylvania, Philadelphia, PA 19104, USA, avants@grasp.cis.upenn.edu

Templates facilitate computation



Neuroimage, 2010 Feb 149(3):2457-66. Epub 2009 Oct 8.

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Nonparametric nonuniform intensity normalization (N3)

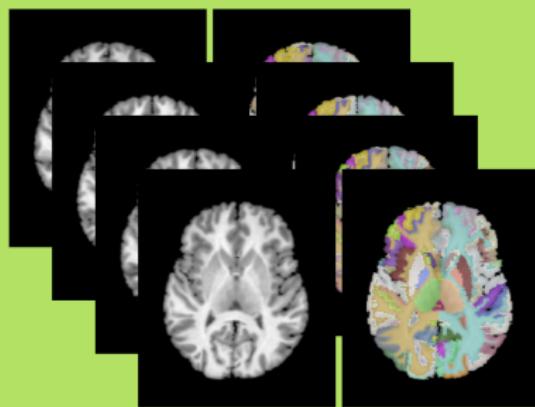
- Developed at the Montreal Neurological Institute (John Sled, 1998)
- Part of the standard preprocessing protocol in large scale projects such as ADNI
- The traditional de facto standard in MRI bias correction
 - good performance
 - *public availability*
- Public availability — set of perl scripts coordinating various C++ programs
- “*Let's incorporate N3 into ANTs!*”

N4 (“Nick’s N3”)

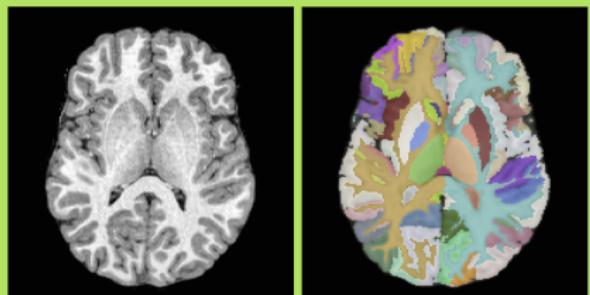
- comparative evaluation
- small spline distances (useful for higher magnet strengths)
- multiresolution
- weighted regional mask (used in `antsAtroposN4.sh`)
- fast execution times
- *publicly available*
- tested nightly within the ITK dashboard system

Multi-atlas segmentation

Joint label fusion



Atlases
(grayscale + segmentation)



Target image

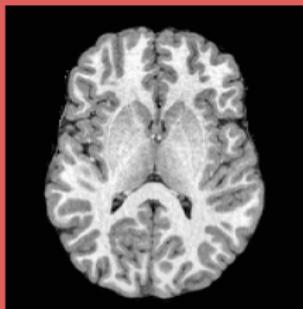
Target segmentation

New work: joint intensity fusion

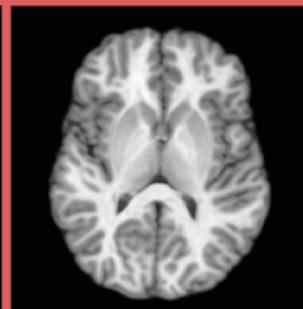
Joint intensity fusion



Atlases
(grayscale only)



Target image



Target fusion image

Possible uses

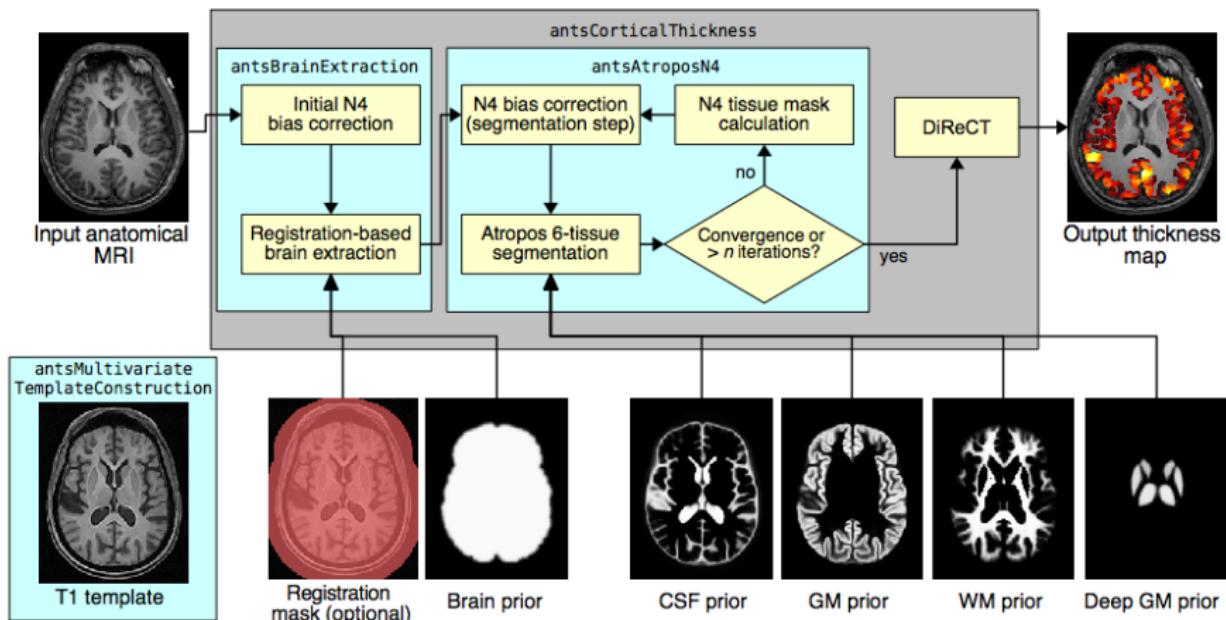
- “Correct” images
 - motion correction
 - “remove” lesions
- Project atlas set intensity signature
- Use in “corrective learning”

Putting it all together—the ANTs cortical thickness pipeline

Cortical thickness studies

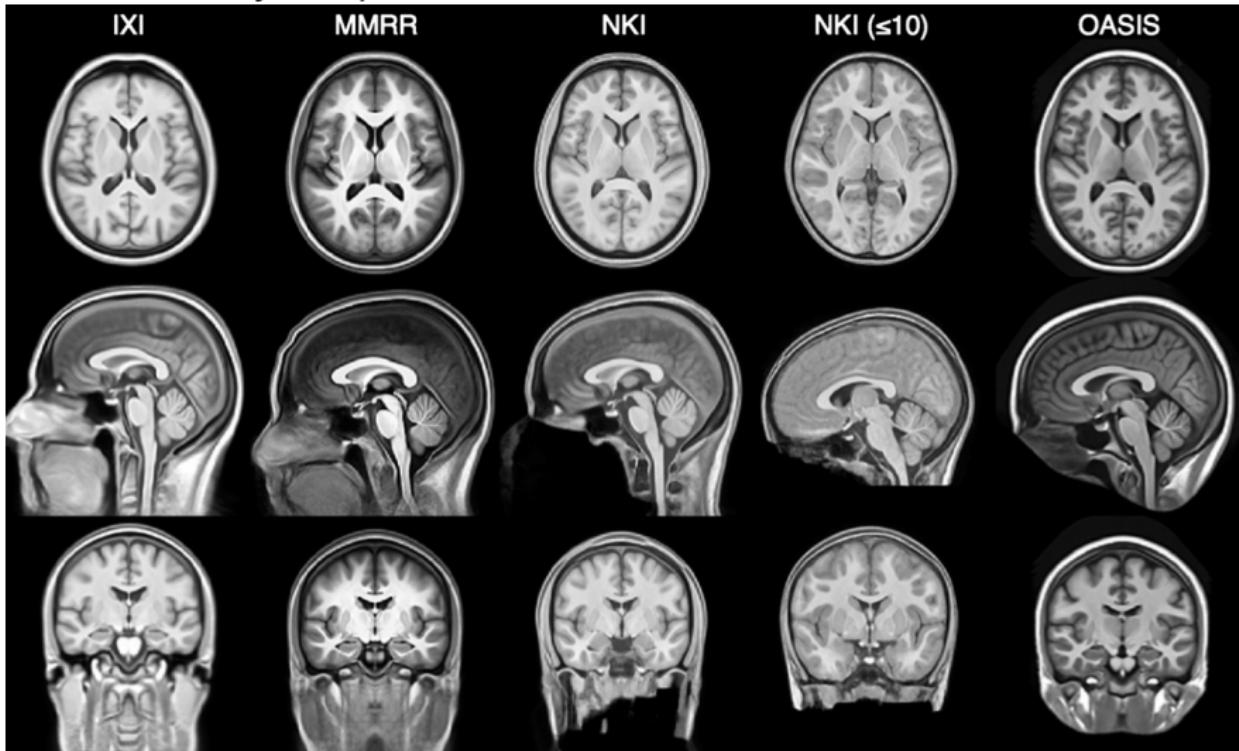
Column1	Column2
Tetris-playing ability	chronic pancreatitis
Huntington's disease	obsessive-compulsive disorder
schizophrenia	ADHD
bipolar disorder	obesity
Alzheimer's disease	heritable depression
frontotemporal dementia	elderly depression
Parkinson's disease	age
Williams syndrome	gender
multiple sclerosis	handedness
autism	intelligence
migraines	athletic ability
chronic smoking	meditative practices
alcoholism	musical ability
cocaine addiction	tendency toward criminality

The ANTs structural brain mapping workflow

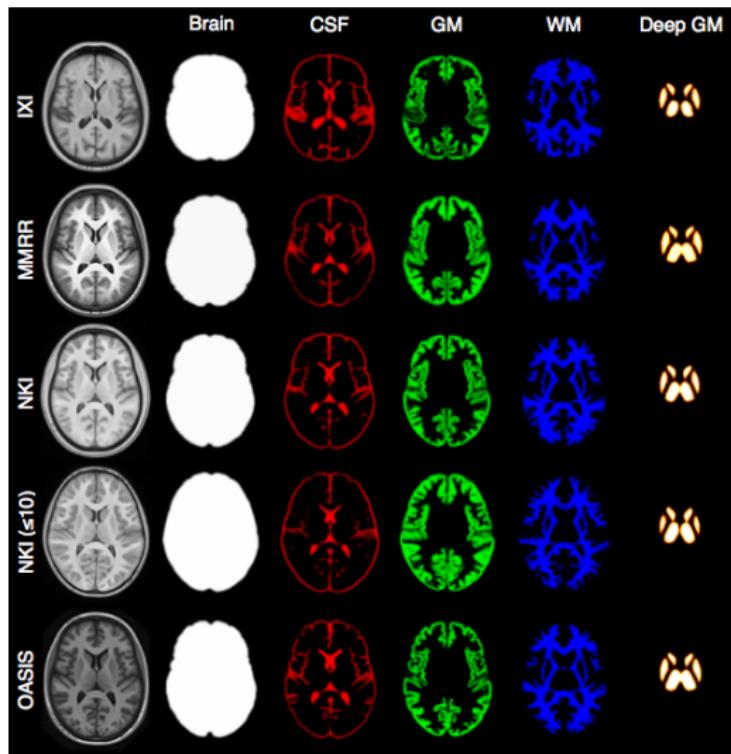


Template building

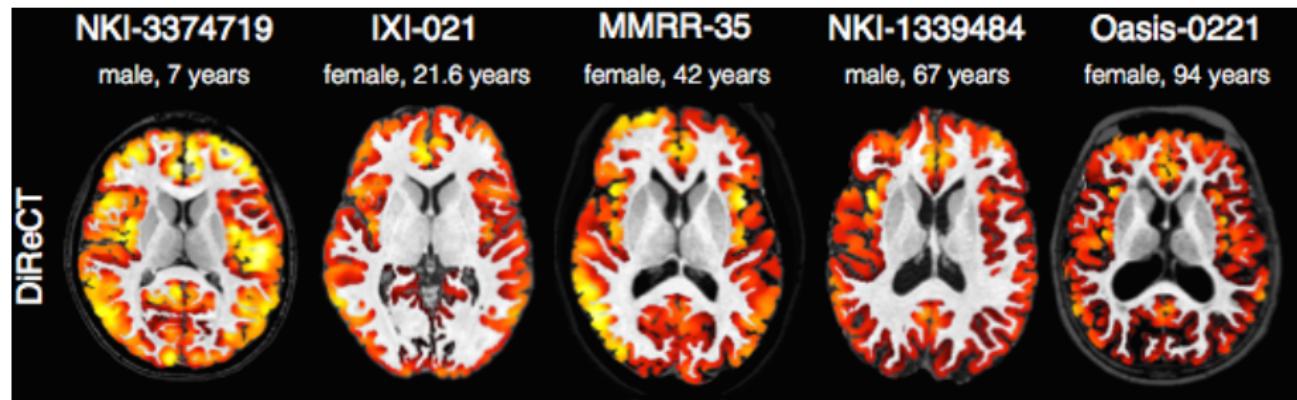
Tailor data to your specific cohort



Template priors



Cortical thickness maps



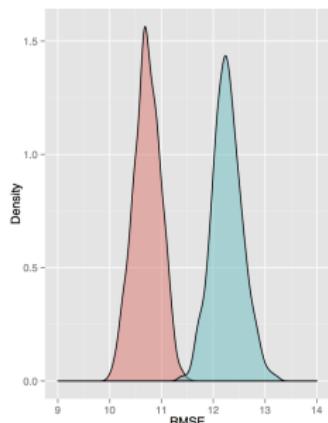
In contrast to FreeSurfer which warps coupled surface meshes to segment the gray matter, *ANTs* diffeomorphically registers the white matter to the combined gray/white matters while simultaneously estimating thickness.

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

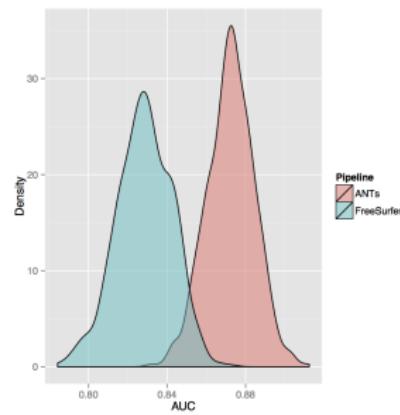
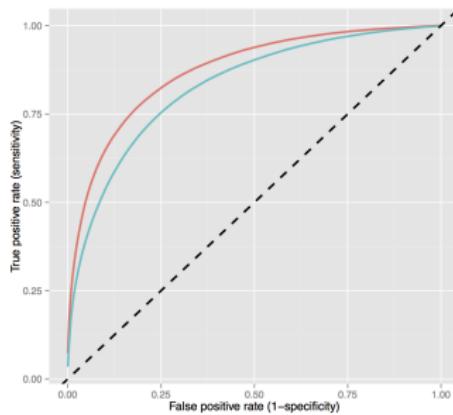
Predict age and gender

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

Prediction from cortical thickness data



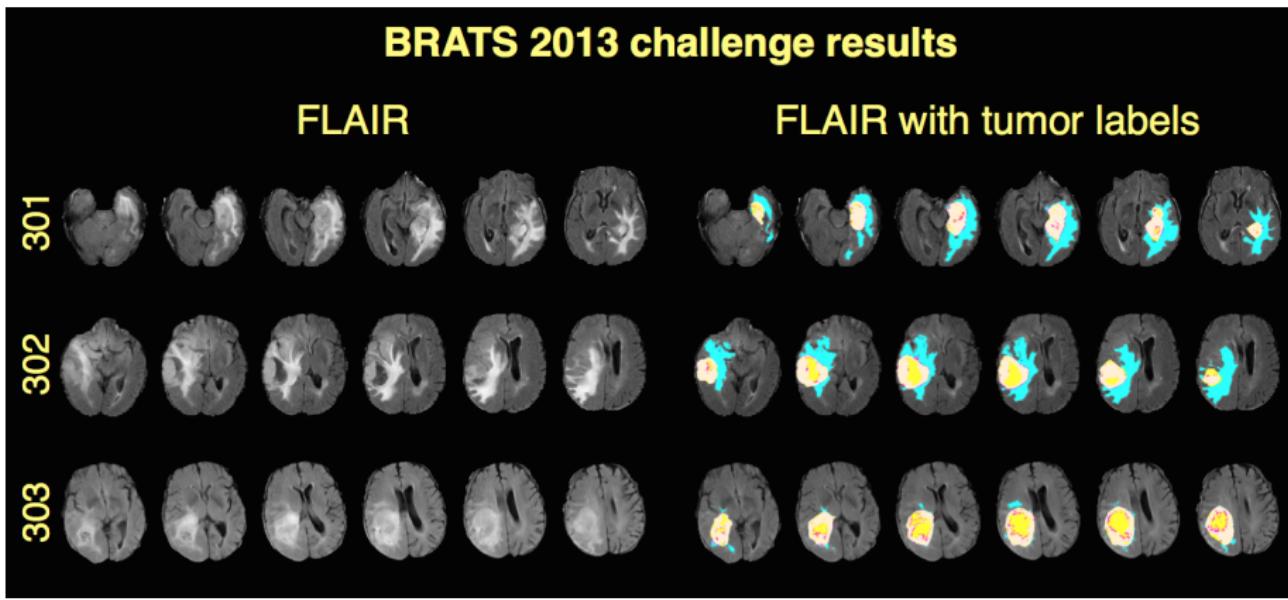
Age



Gender

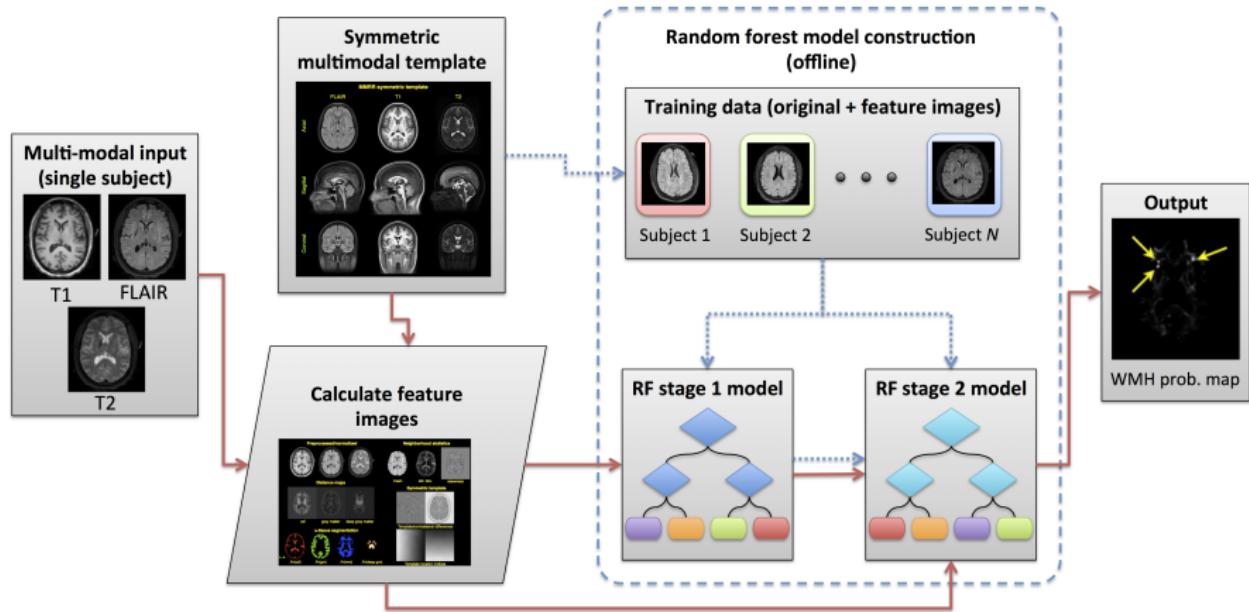
Current work and Advanced Normalization Tools in R (ANTsR)

Multimodal Brain Tumor Segmentation (BRATS 2013)

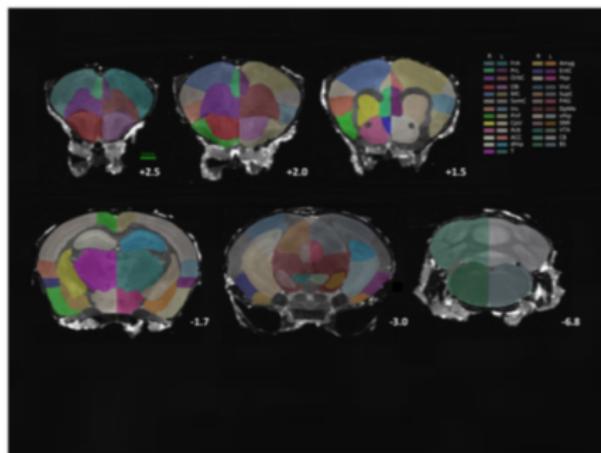
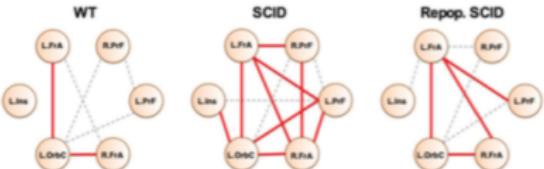


Tustison, et al., Optimal symmetric multimodal templates and concatenated random forests for supervised brain tumor segmentation (simplified) with ANTsR, *Neuroinformatics*.

White matter hyperintensities in TBI



Social behavior and immunity dysfunction in mice

a**b****c**