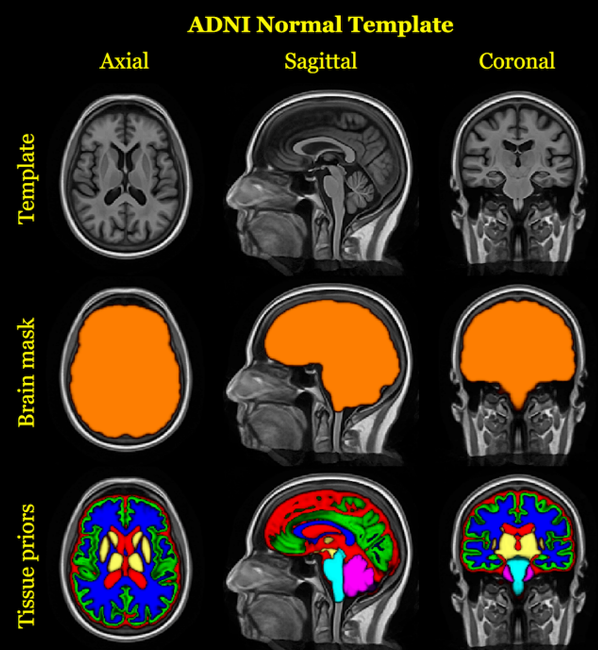
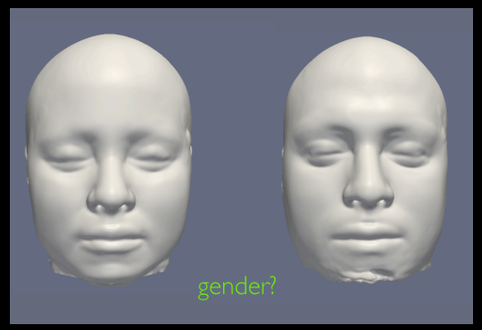
Toward large-scale image science with ANTsX

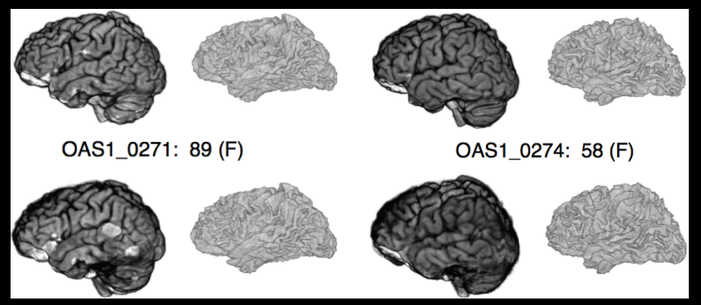
(large scale processing/evaluation, open science, and current trends)

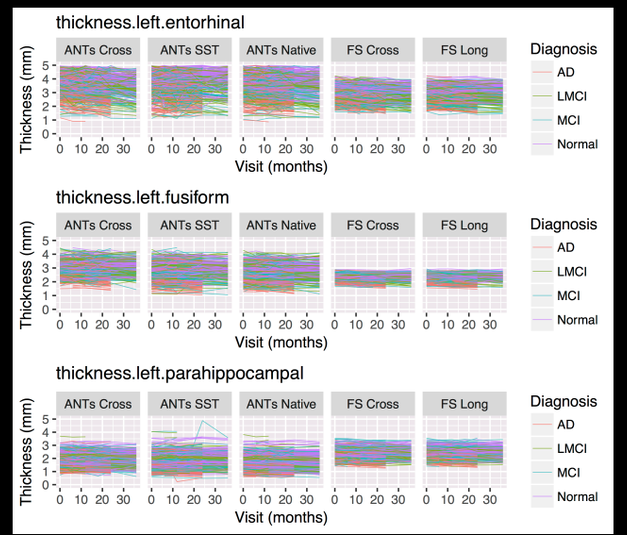
UNIVERSITY of VIRGINIA

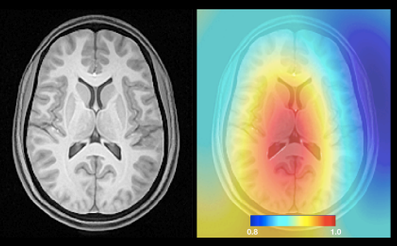
Penn
UNIVERSITY of PENNSYLVANIA

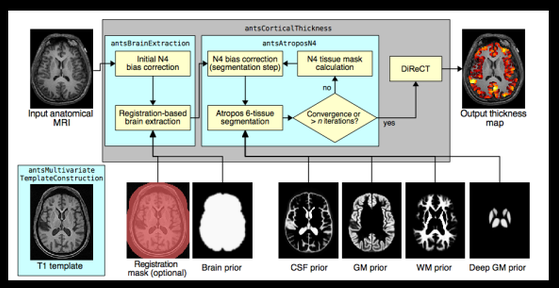


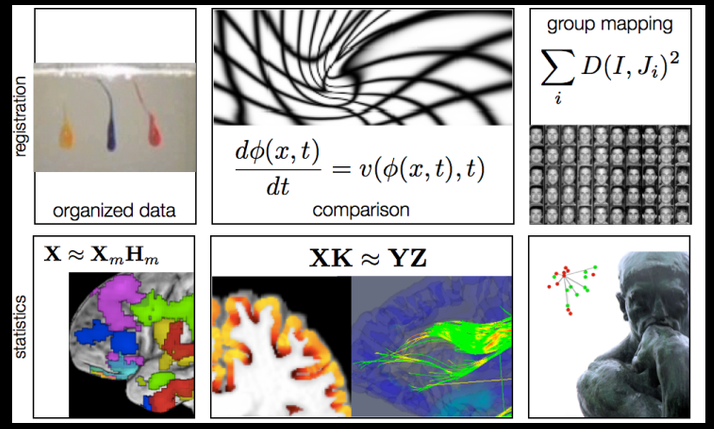


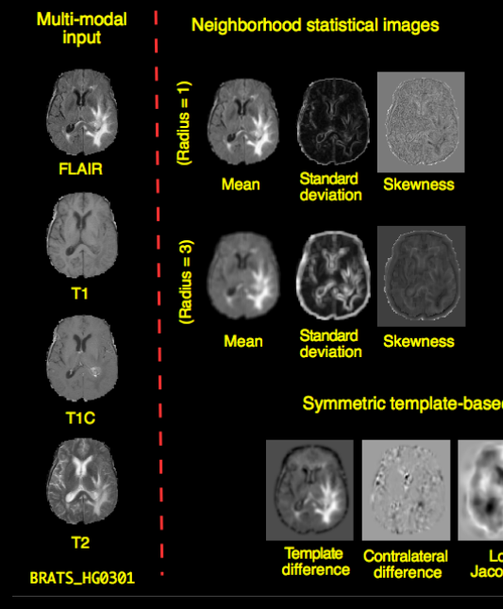


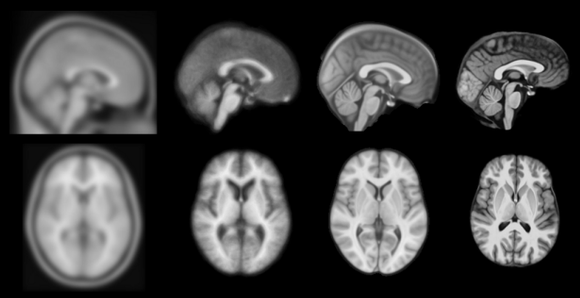


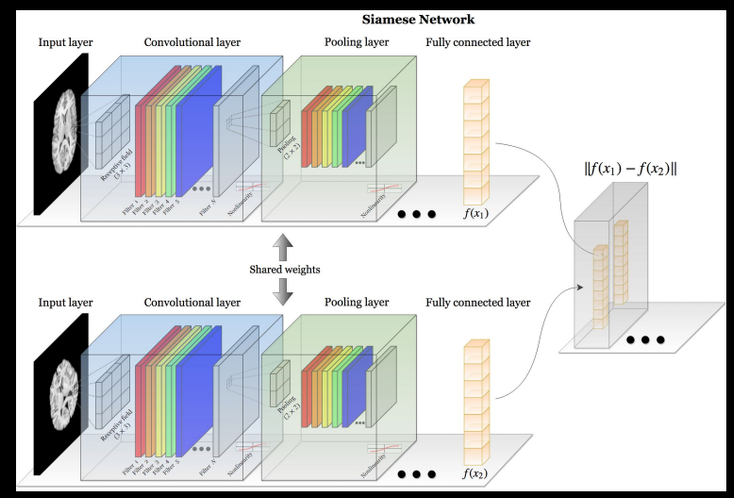


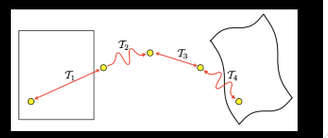


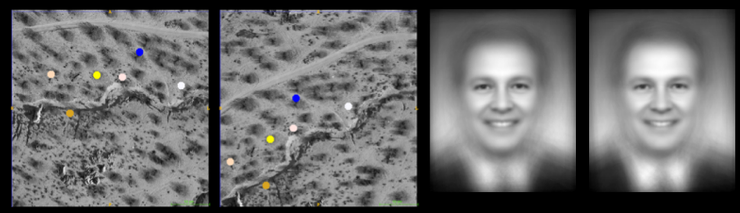






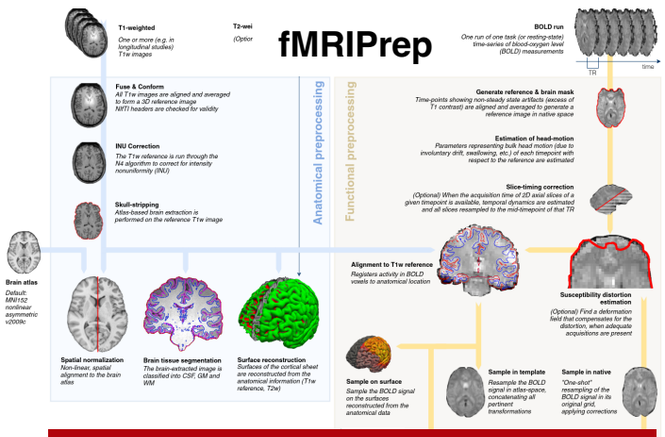






Advanced Normalization Tools

The user base spans academia and industry

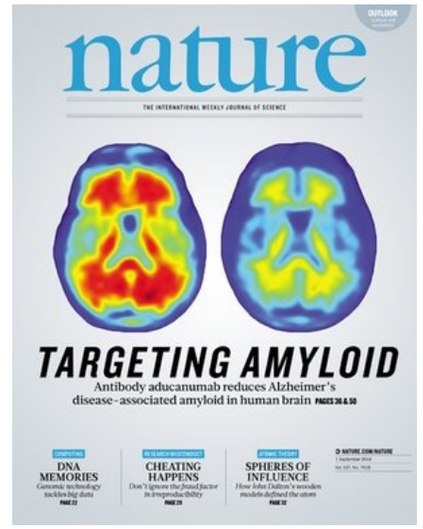


Stanford University

NeuroDebian

KONICA MINOLTA

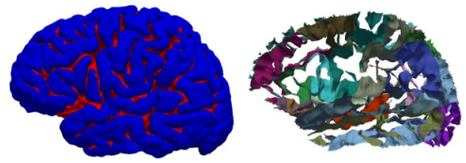
USC Laboratory of Neuro Imaging



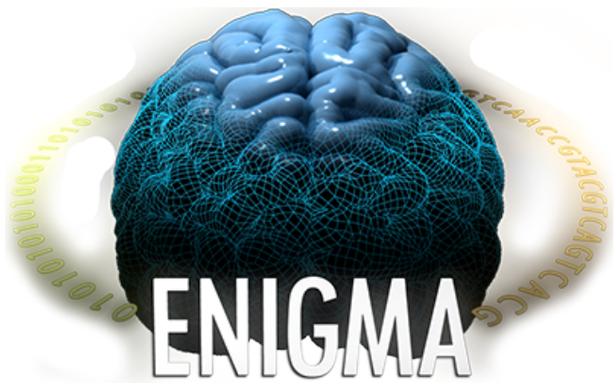
hhmi | Howard Hughes Medical Institute

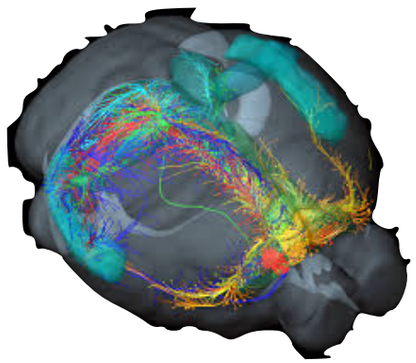
LEAD DBS

ADNI
Alzheimer's Disease Neuroimaging Initiative



MINDBOGGLE





Princeton Neuroscience Institute

GE

SCT
Spinal Cord Toolbox

Google

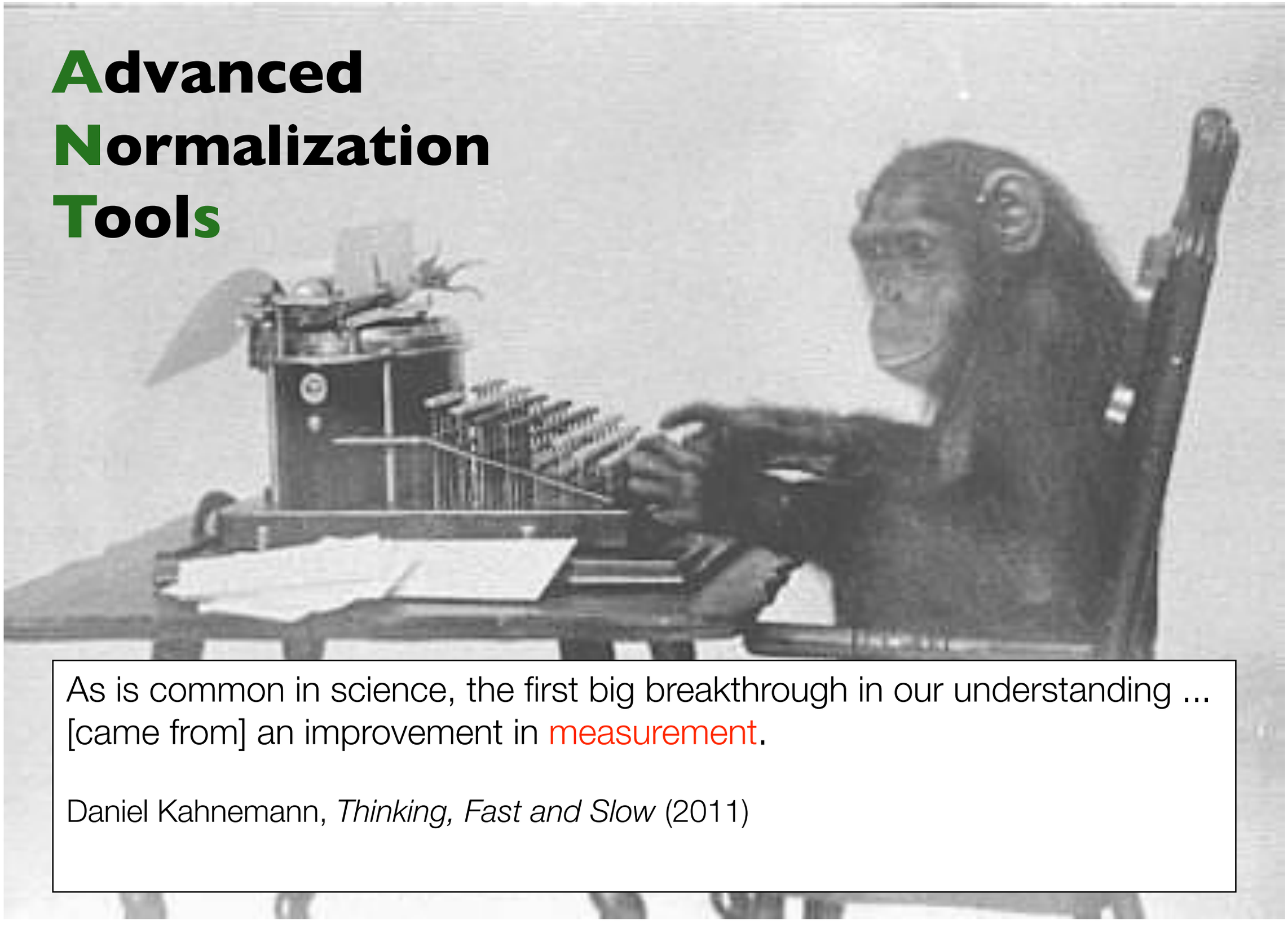
ALLEN INSTITUTE for BRAIN SCIENCE

ITK

CHILD MIND® INSTITUTE
big data analytics

C-PAC

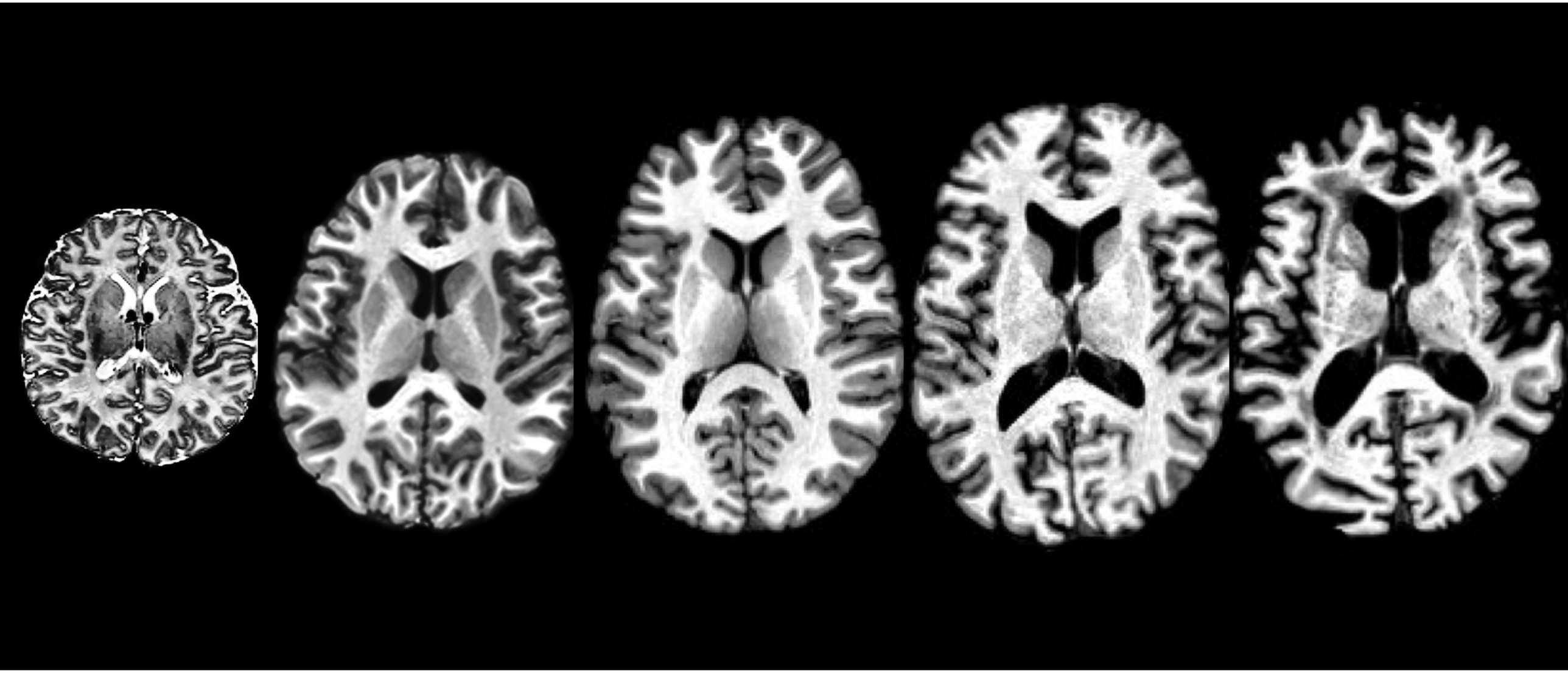
Advanced Normalization Tools



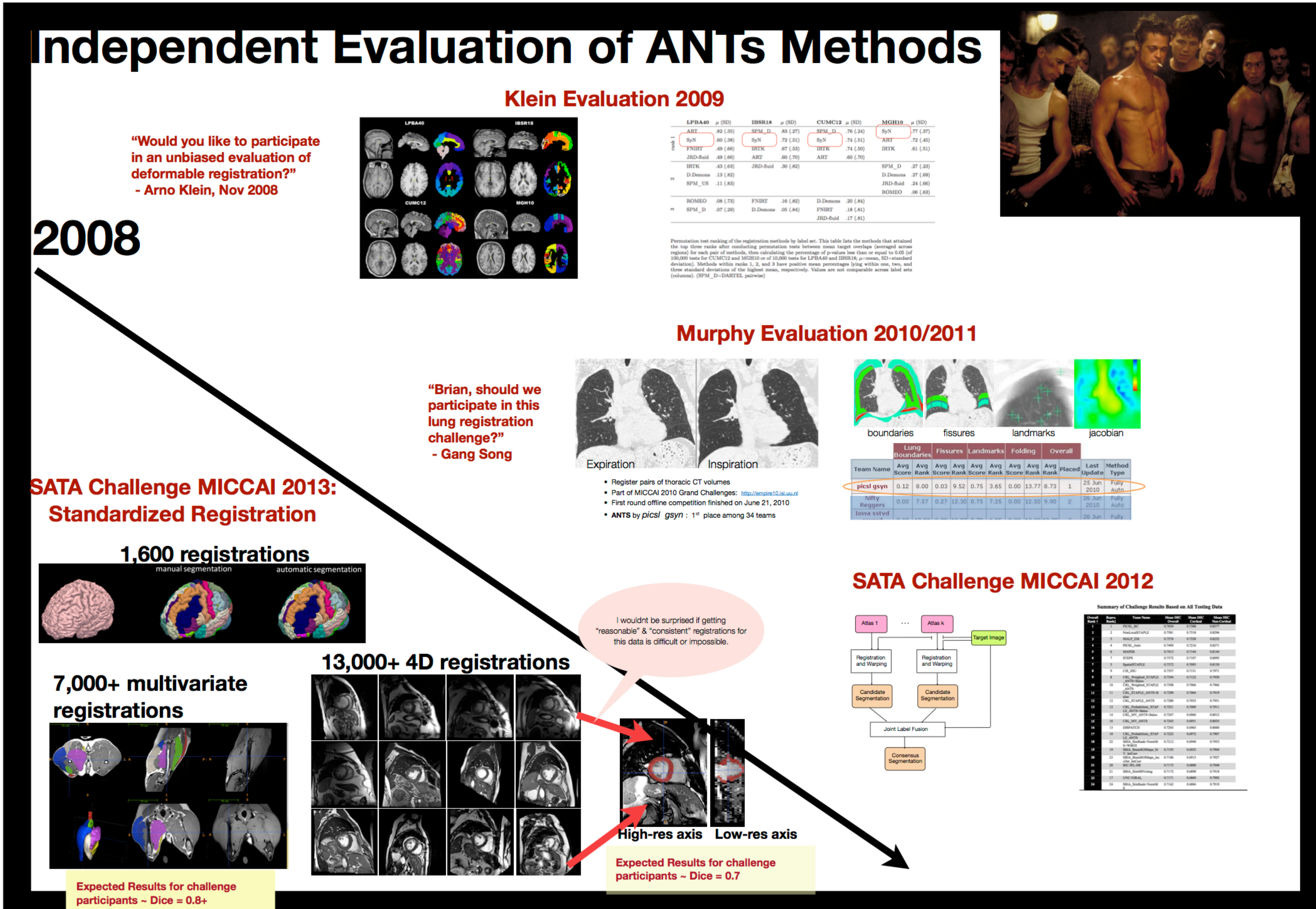
As is common in science, the first big breakthrough in our understanding ... [came from] an improvement in measurement.

Daniel Kahnemann, *Thinking, Fast and Slow* (2011)

Contemporaneous state-of-the-art in image registration

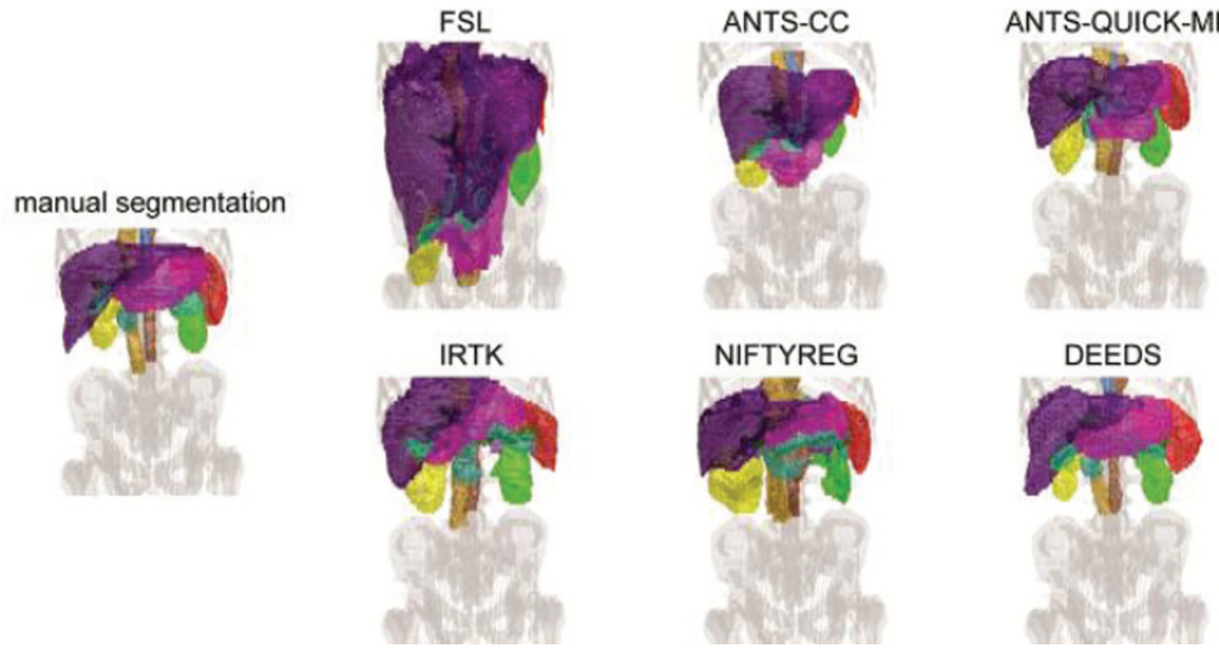


SyN-related evaluations



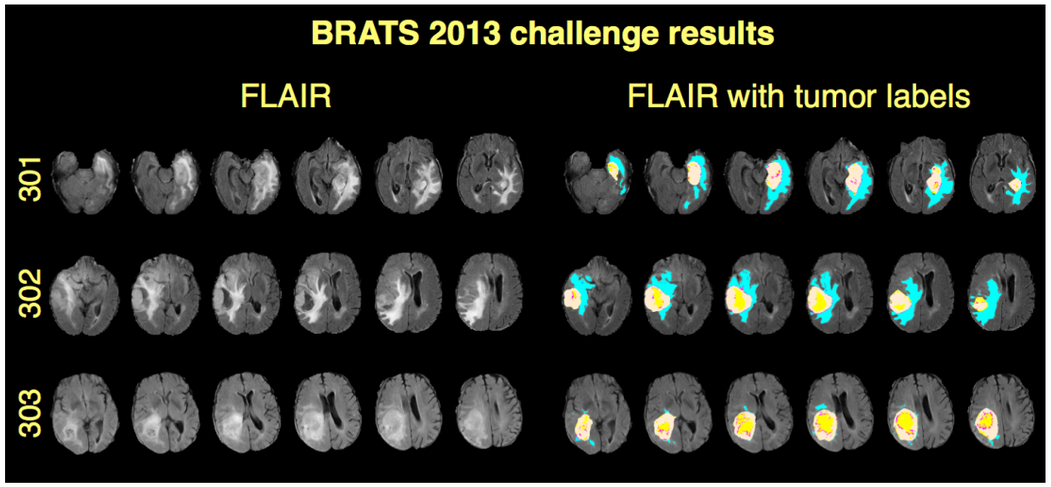
SyN-related evaluations (part 2)

Evaluation of Six Registration Methods for the Human Abdomen on Clinically Acquired CT



"…because ANTS was almost always at the top when we (internally) optimized it to the task…"

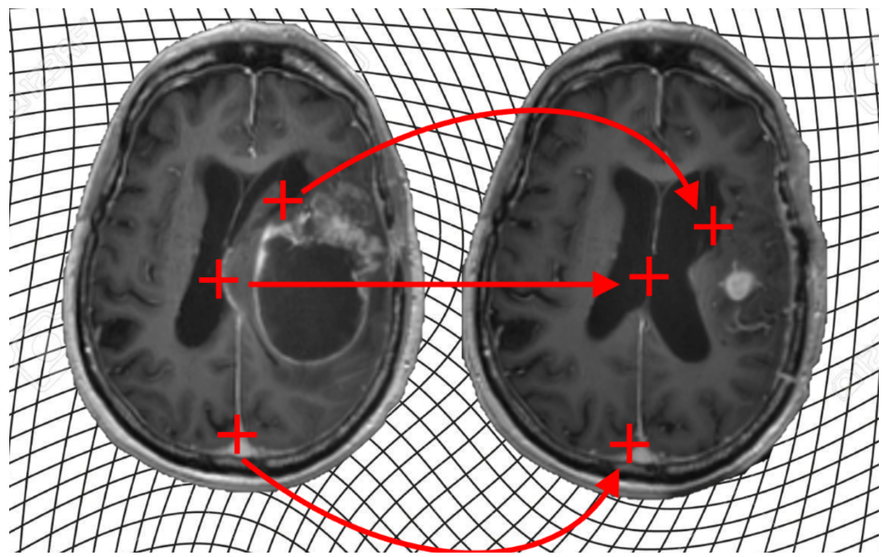
BraTS-Seg 2013



Patient

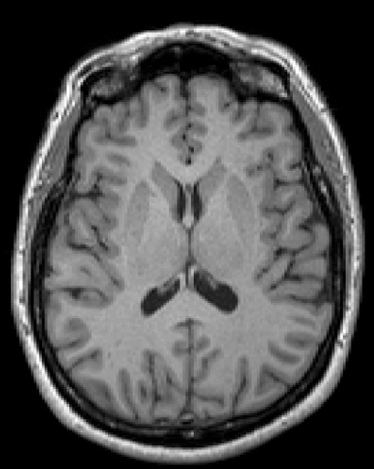
Position	User	Dice			Positive Predictive Value			Sensitivity			Kappa	Complete tumor Rank	Tumor core Rank	Enhancing tumor Rank
		complete	core	enhancing	complete	core	enhancing	complete	core	enhancing				
1	Nick Tustison	0.87 (1)	0.78 (1)	0.74 (1)	0.85 (2)	0.74 (4)	0.69 (4)	0.89 (2)	0.88 (1)	0.83 (1)	0.99 (1)	1.67	2.00	1.89
2	Raphael Meier	0.82 (5)	0.73 (2)	0.69 (3)	0.76 (6)	0.78 (2)	0.71 (1)	0.92 (1)	0.72 (4)	0.73 (3)	0.99 (4)	4.00	2.67	3.00
3	Syed Reza	0.83 (4)	0.72 (3)	0.72 (2)	0.82 (3)	0.81 (1)	0.70 (3)	0.86 (5)	0.69 (6)	0.76 (2)	0.99 (3)	4.00	3.33	3.22
4	Liang Zhao	0.84 (3)	0.70	0.65 (5)	0.80 (4)	0.67	0.65 (6)	0.89 (3)	0.79	0.70 (4)	0.99 (5)	3.33	4.00	4.11

BraTS-Reg 2021-22*

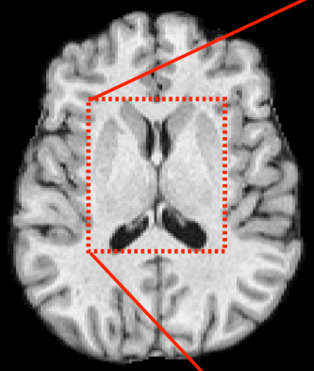


ANTs core processing tools

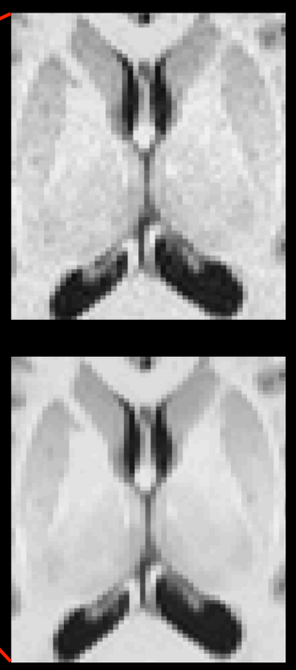
ANTs core processing tools



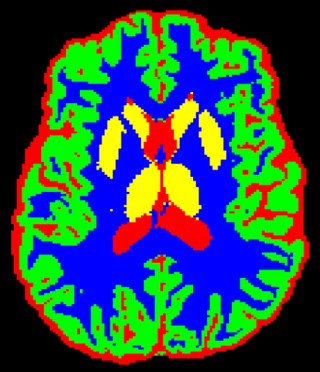
IXI 061



N4 bias correction

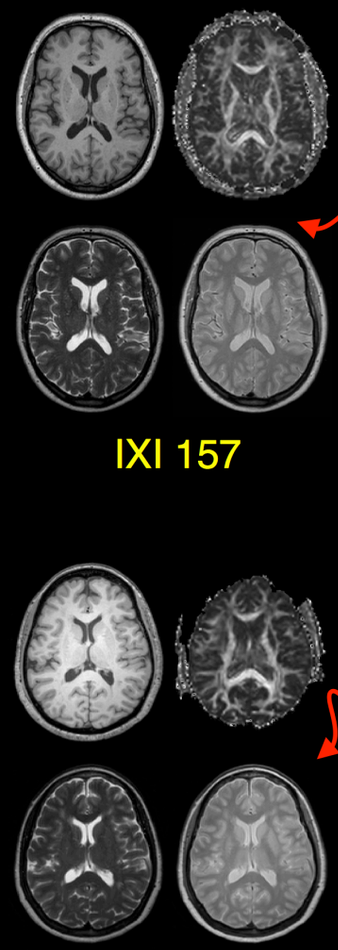


Denoising



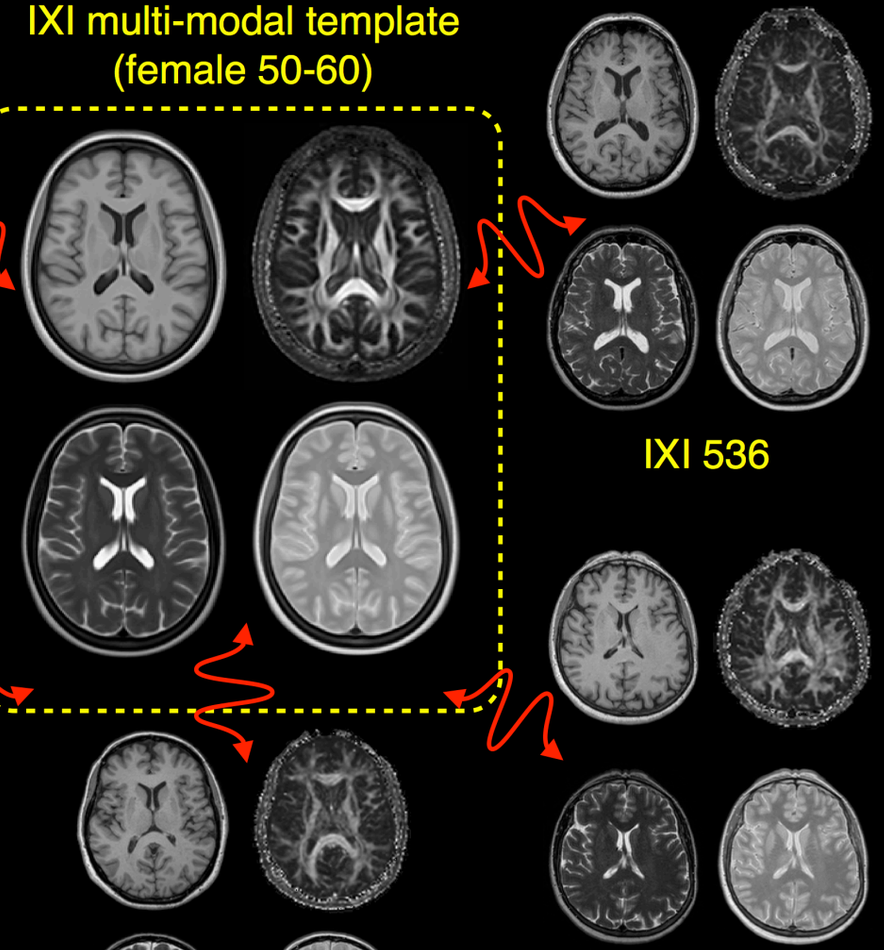
Atropos segmentation

Joint label fusion



IXI 157

IXI multi-modal template (female 50-60)



IXI 536

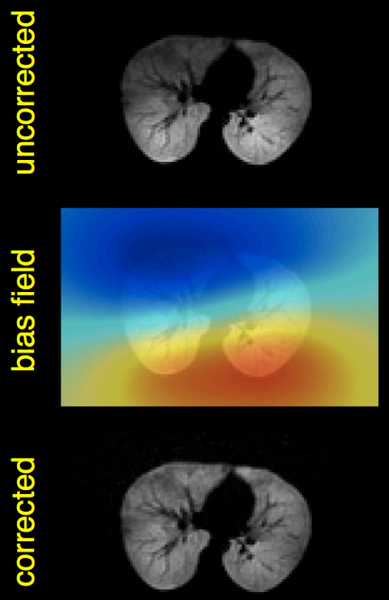
IXI 259

IXI 312

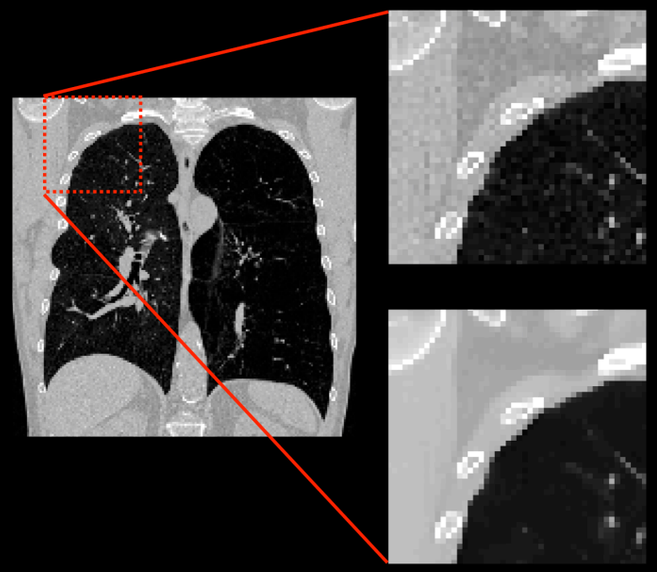
IXI 400

ANTs core processing tools (adapted)

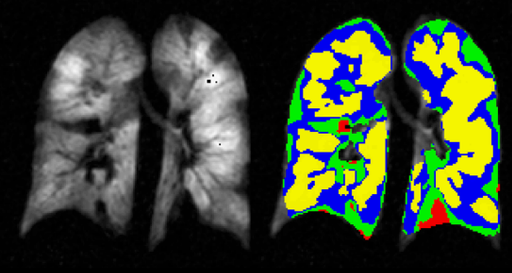
ANTs core processing tools for multi-modal lung imaging studies



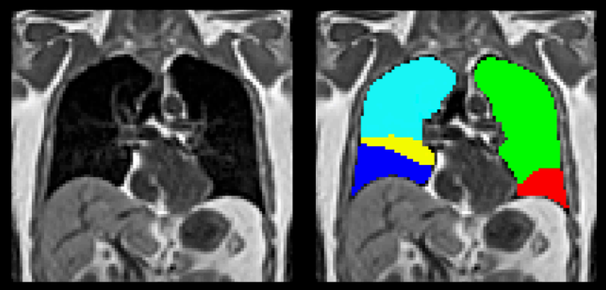
N4 bias correction



Denoising

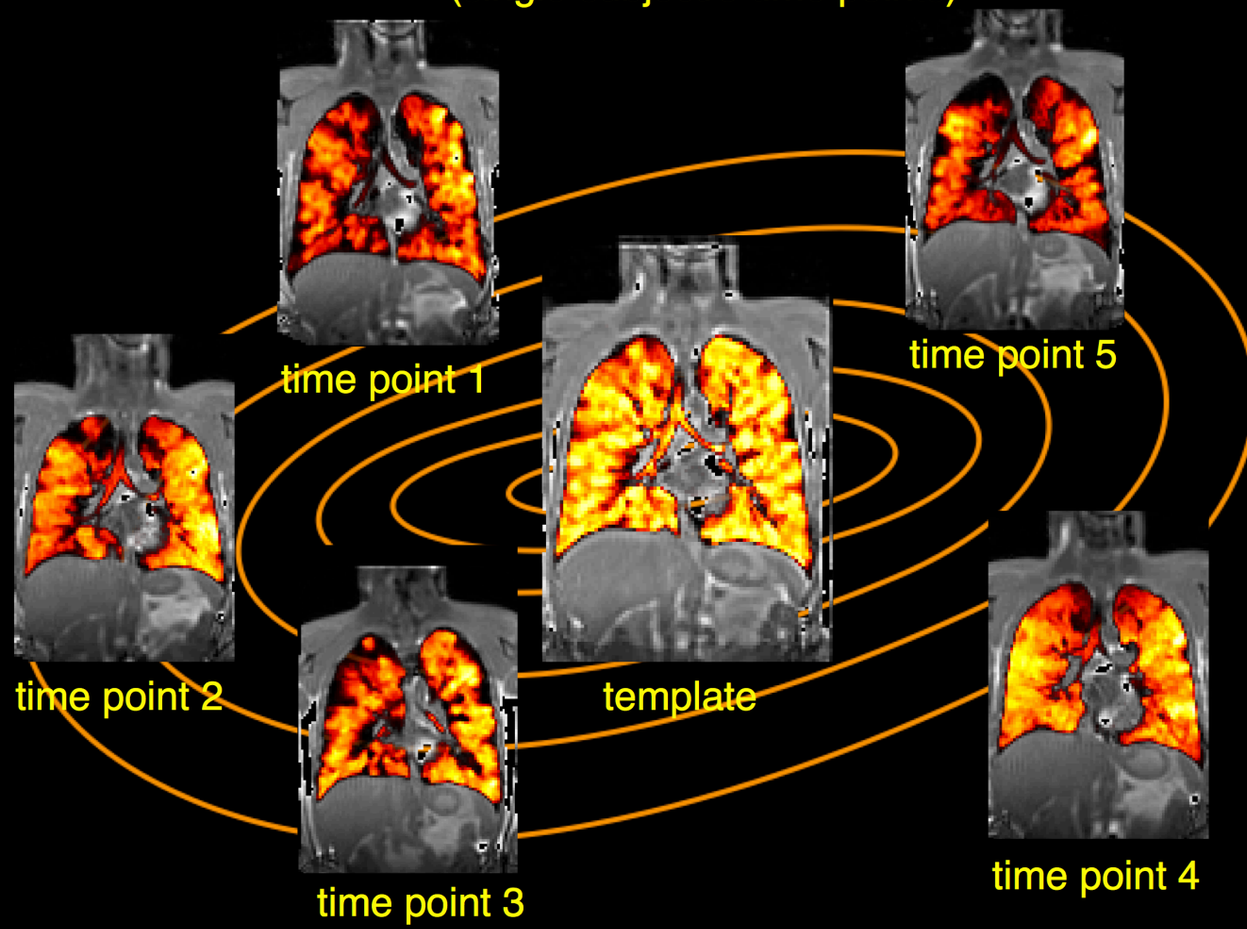


Atropos segmentation



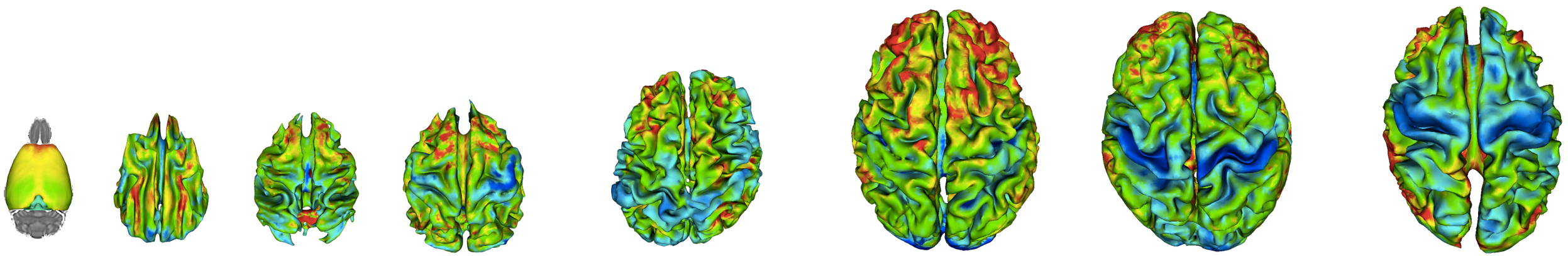
Joint label fusion

Multi-modal template
(single subject/5 time points)

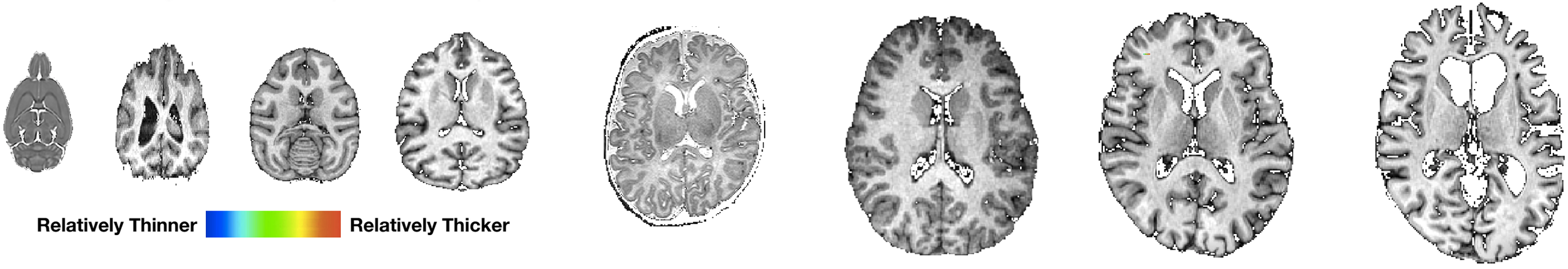


ANTs cortical thickness (other species)

DiReCT
cortical thickness



Rat Dog Monkey Chimp 4 Week Old Human Adolescent Human Middle-Aged Human Neurodegeneration



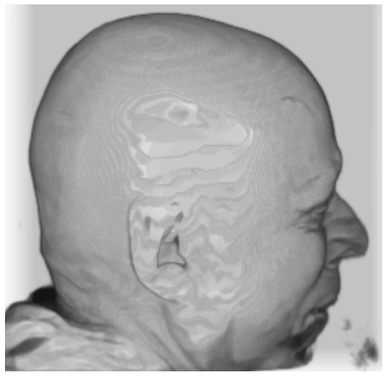
Relatively Thinner — Relatively Thicker

Mean Thickness: rat=1.7mm dog=2.0mm, monkey=3.0mm, chimp=3.5mm, adol=3.4mm, mid-age=3.0mm, ndgen=2.6mm

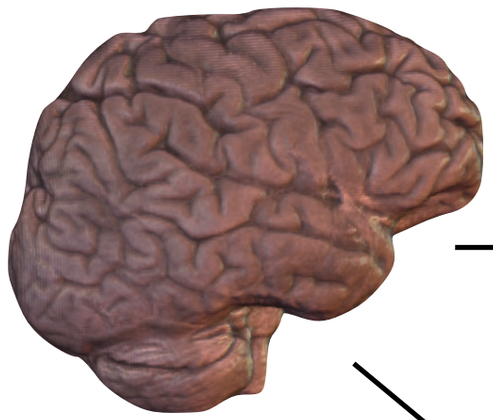
Badea, et al. Shamy, et al. Hallam Hurt Martha Farah Avants, Tustison Grossman, et al.

Datta, et al. Avants, Hoffman

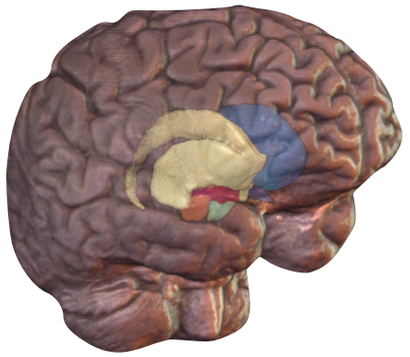
Structural IDPs from T1w using ANTsPyT1w

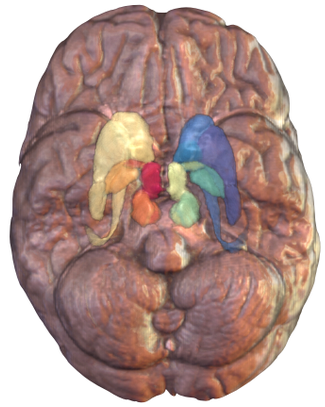


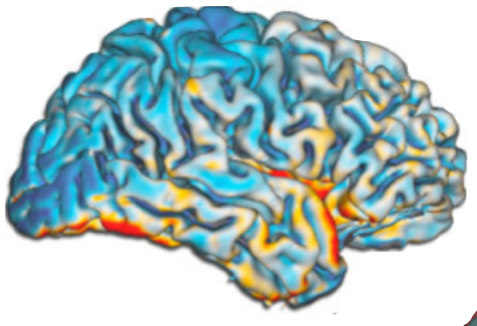
brain extraction



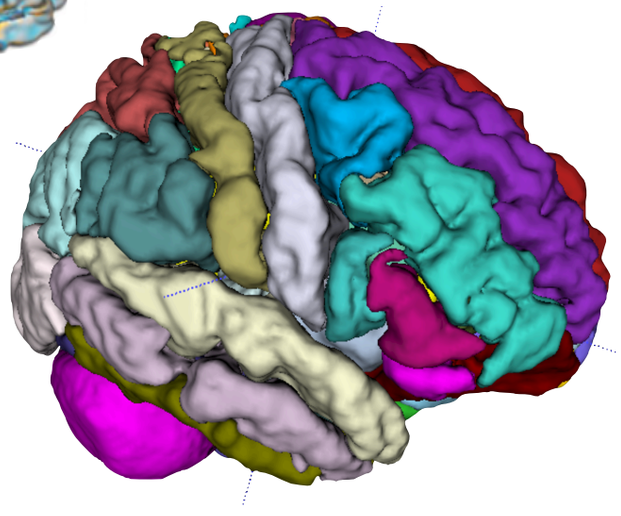
deep brain parcellation



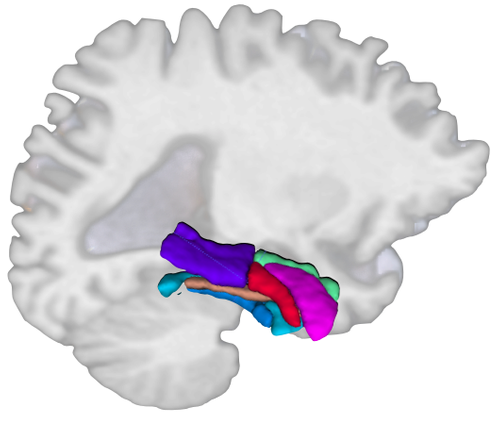




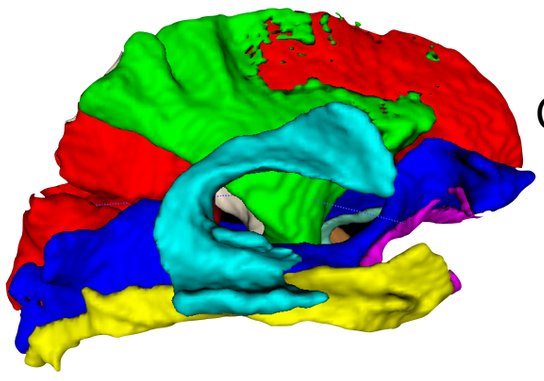
DiReCT



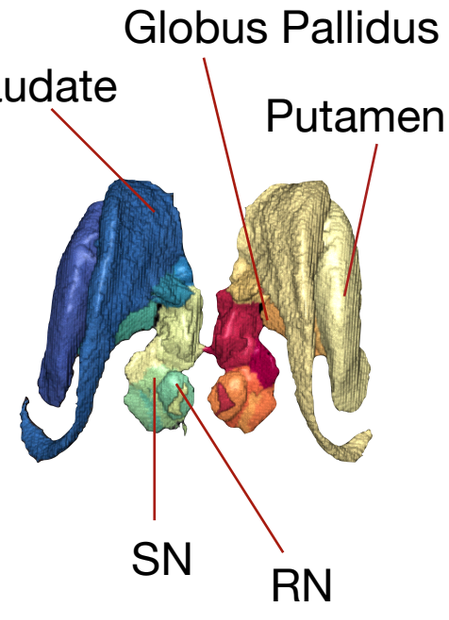
deep cortical parcellation



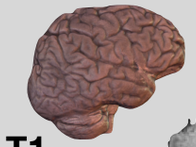
MTL parcellation

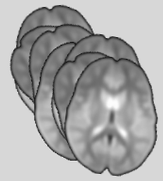


White matter parcellation



Raw M3RI


T1

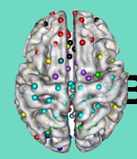
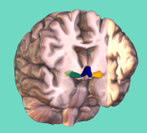

BOLD


NM

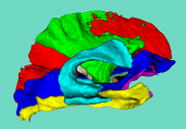

FLAIR

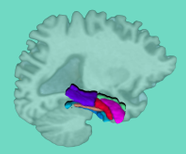
DWI

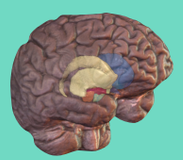
Anatomical priors

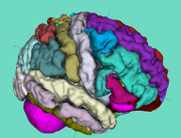


Basal Forebrain

P/P nodes

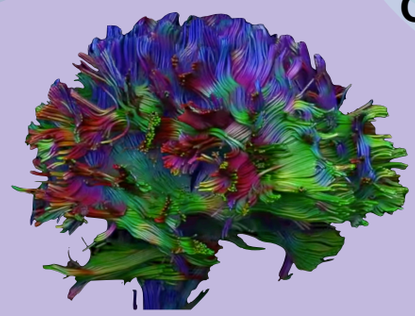

JHU


Yassa MTL


CIT 168

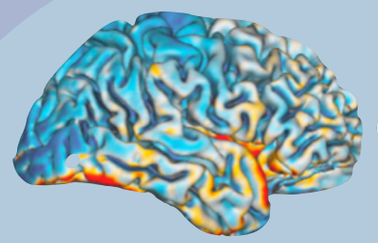

DKT

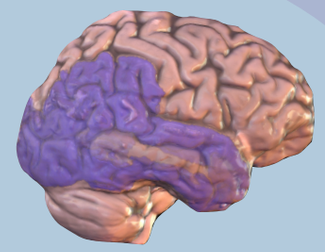

DTI/DWI


Whole-brain tractography

>10k outputs

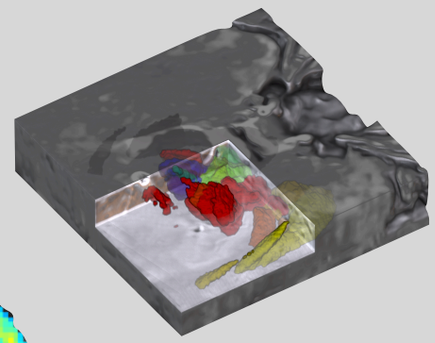
Structural Quantification


Cortical thickness

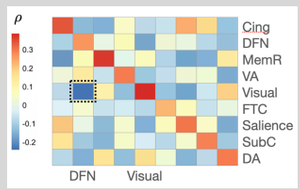

Volumetrics

> 800 outputs

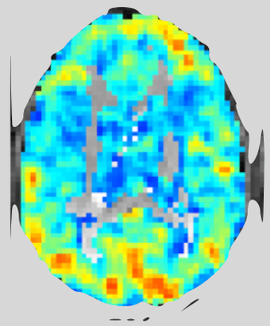
Functional Quantification

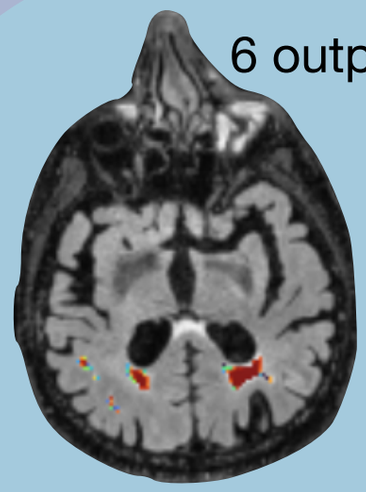

Neuromelanin

40 outputs



621 outputs


fMRI


6 outputs

FLAIR WMH

ANTs

Full integration of “hard-core” C++ with R, Python and Keras (deep learning)

ANTsR & ANTsPy