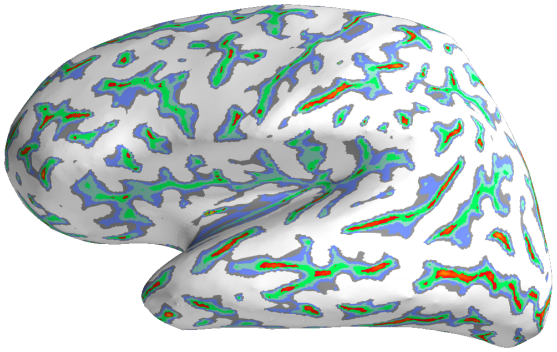
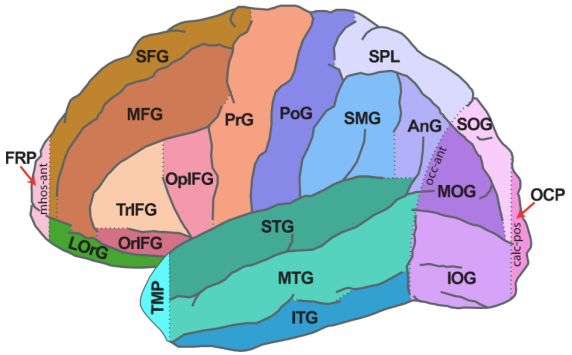
Mindboggle work in progress talk





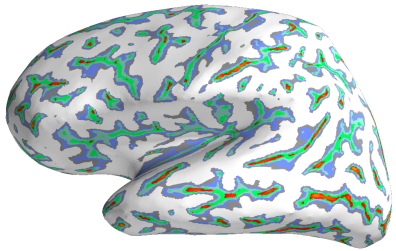
Arno Klein

arno@binarybottle.com
asst. professor of clinical neurobiology
columbia university

October 14, 2011
PICSL lab meeting
University of Pennsylvania

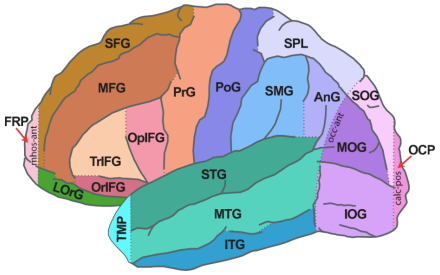
NIMH RO1 grant #MH084029-03

www.mindboggle.info/lectures

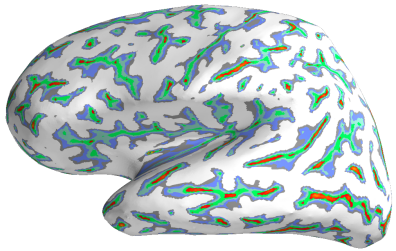


Shape analysis of brains

Informatics framework

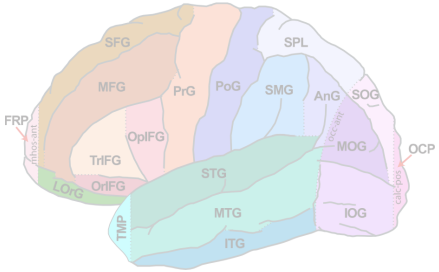


Automated brain labeling

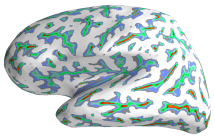


Shape analysis of brains

Informatics framework

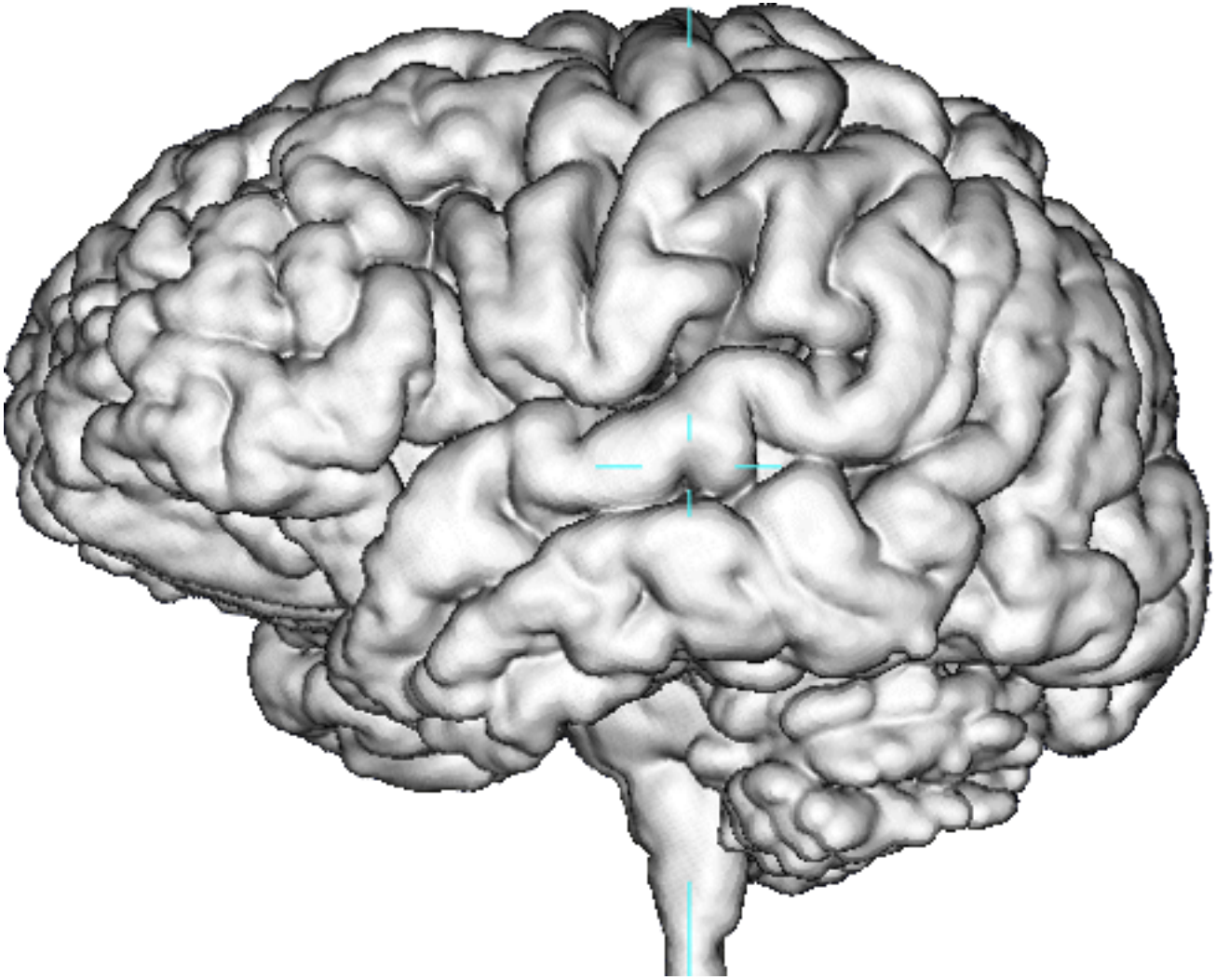


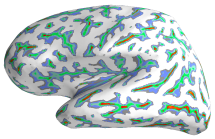
Automated brain labeling



Shape analysis

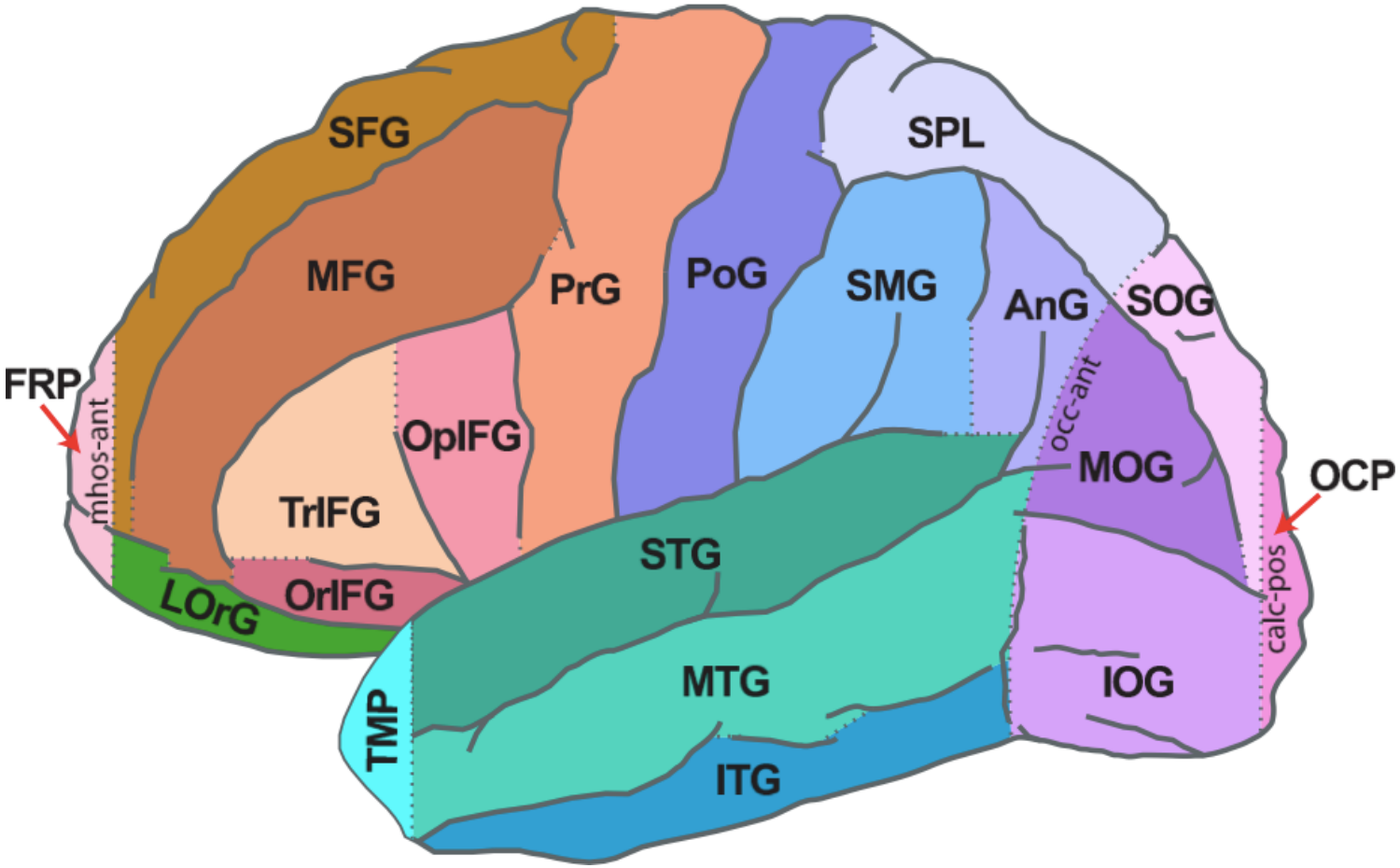
data: brain image

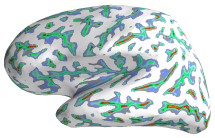




Shape analysis

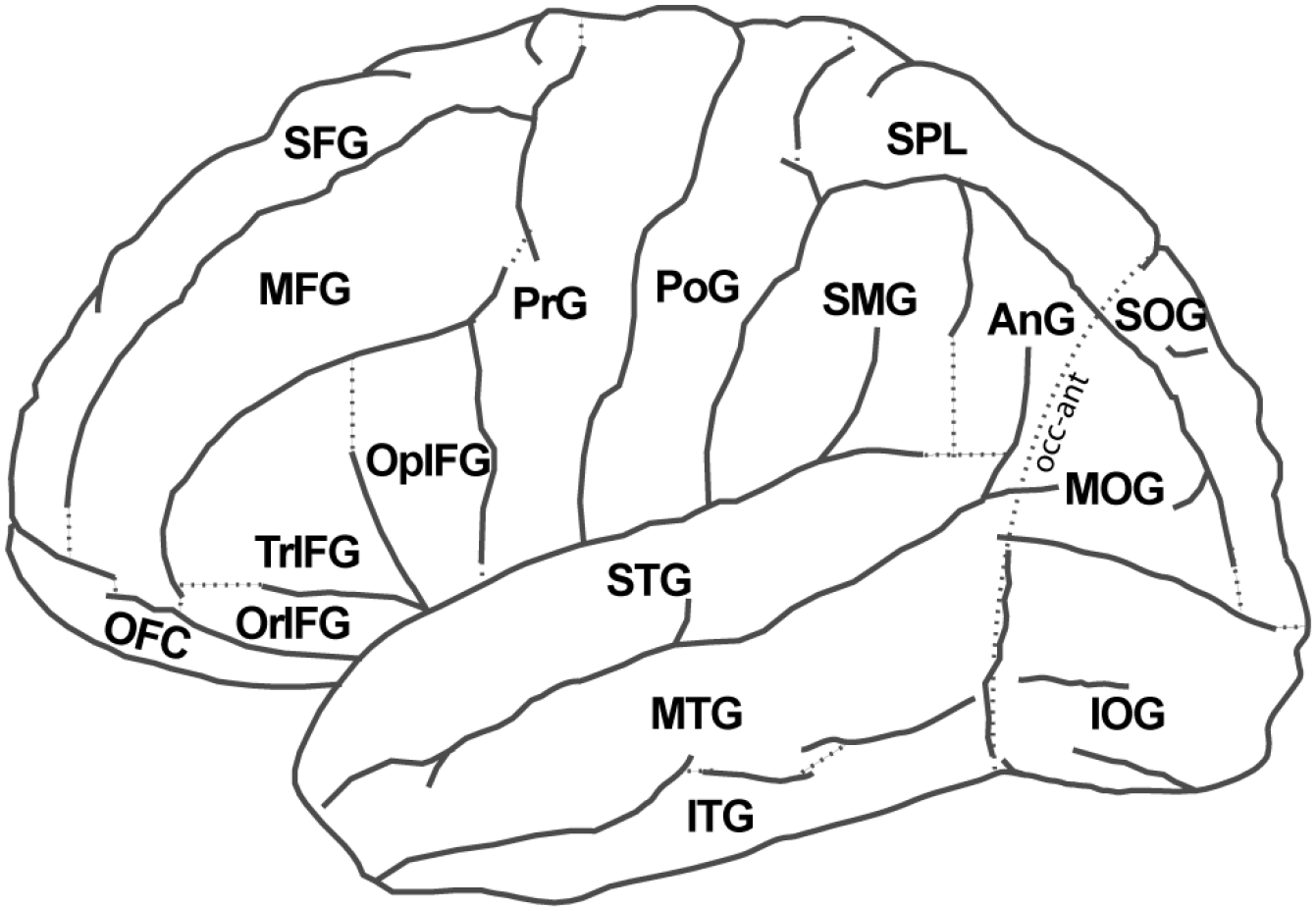
goal: label anatomy

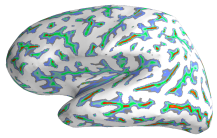




Shape analysis

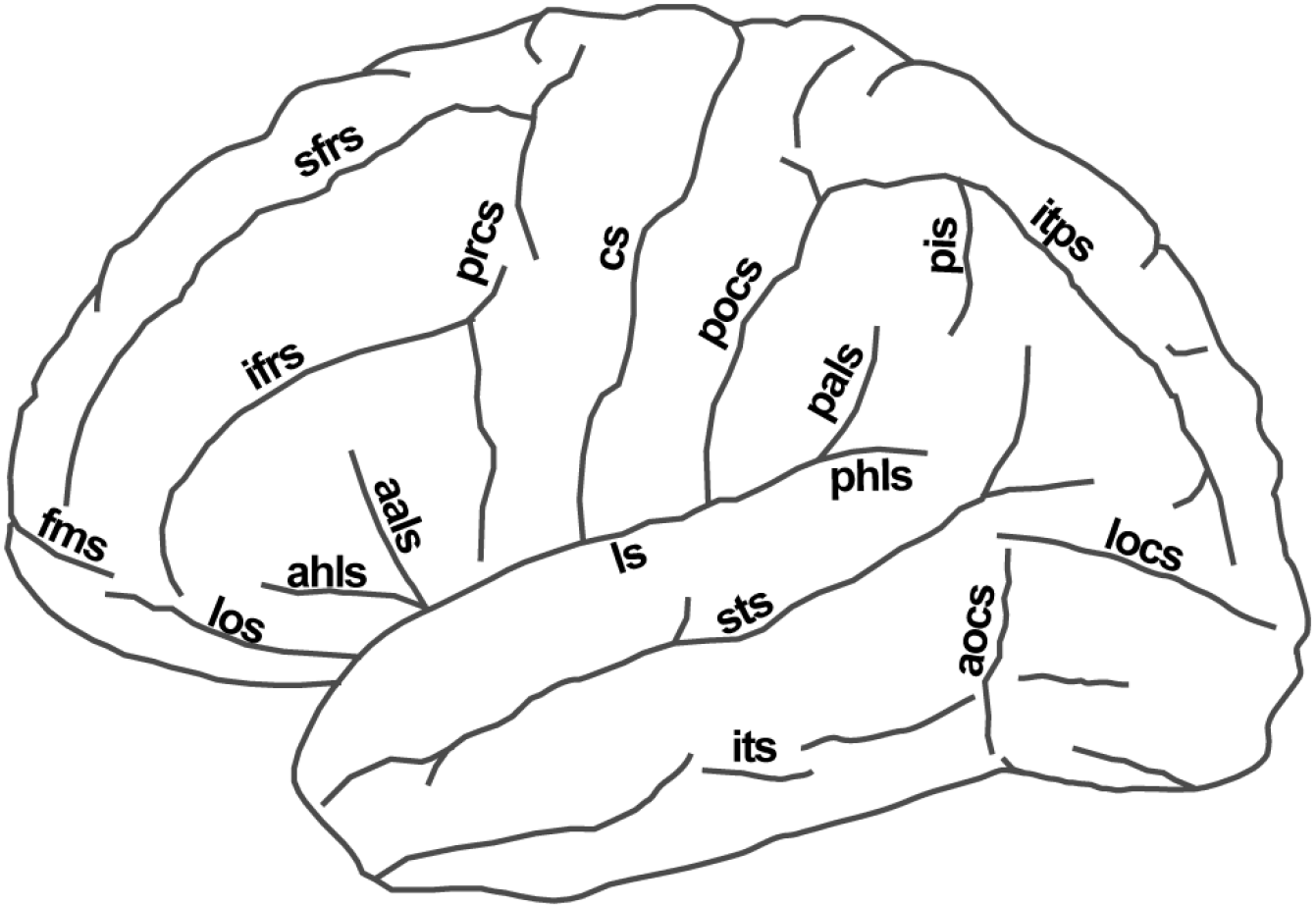
gyrus labels...

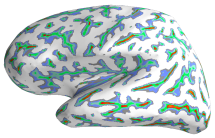




Shape analysis

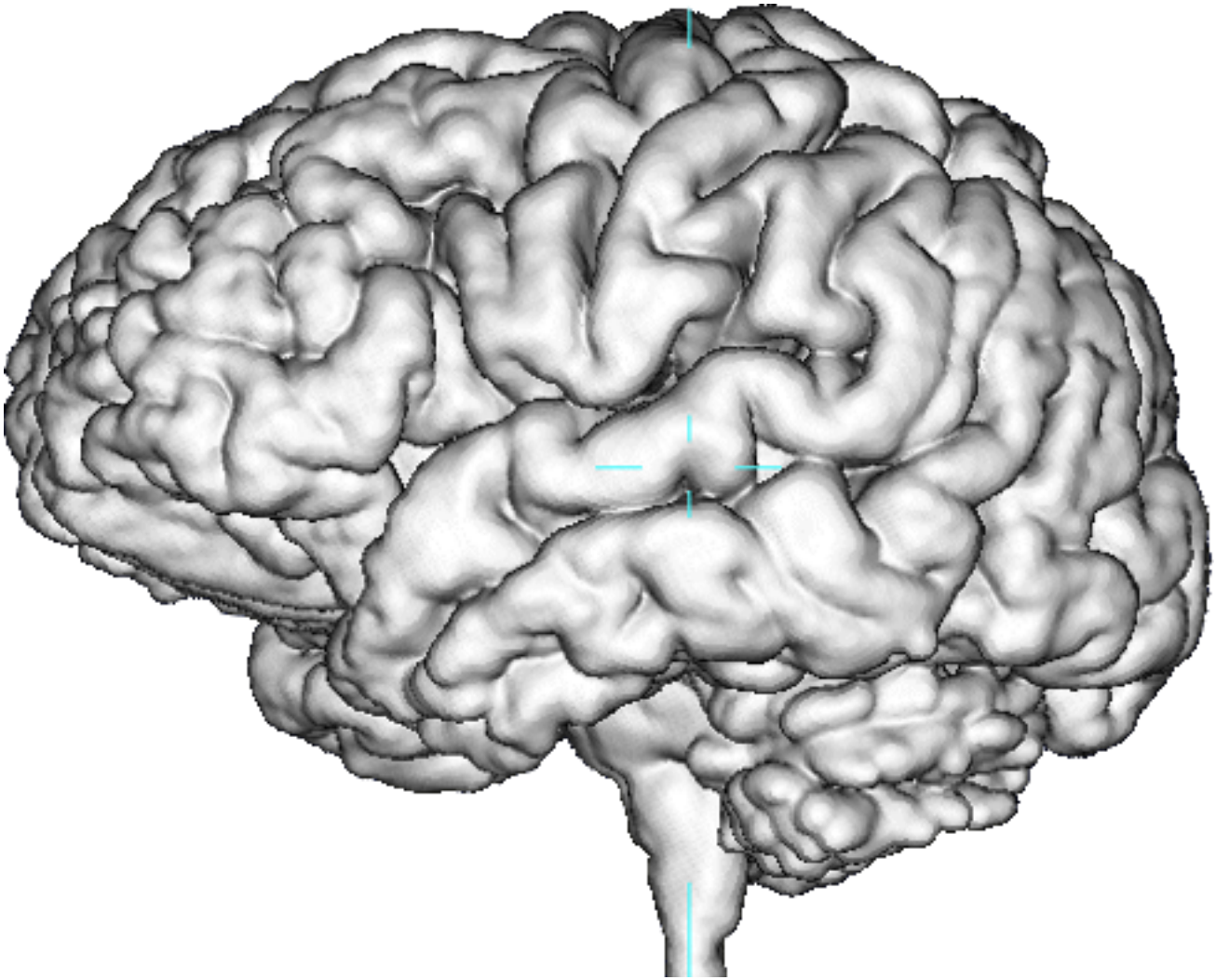
...are based on sulcus definitions

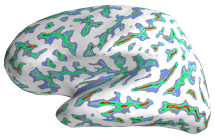




Shape analysis

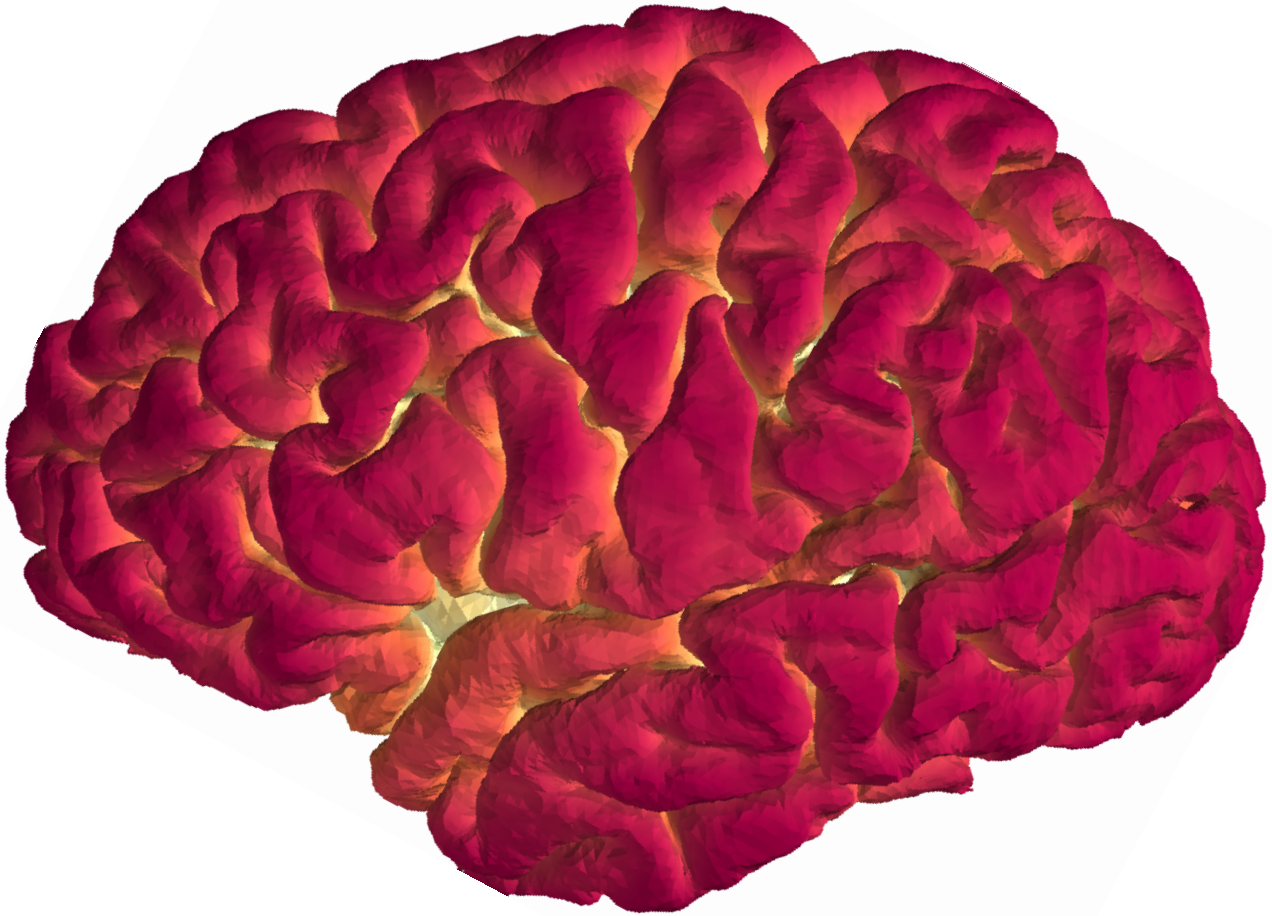
so identify the sulcus folds:

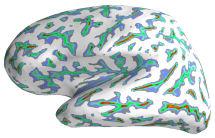




Shape analysis

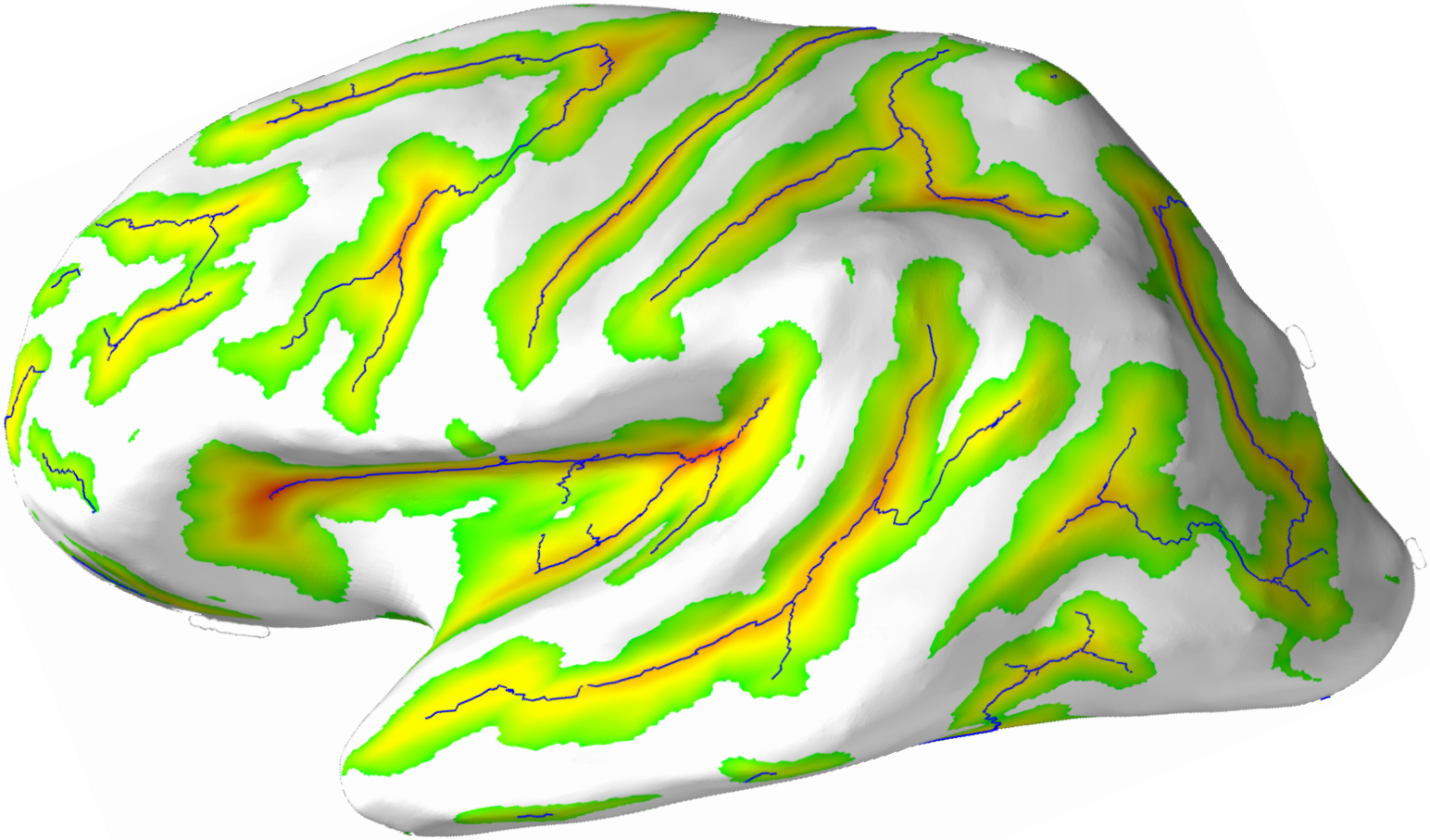
depth map



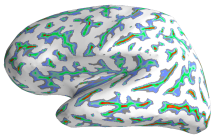


Shape analysis

basins containing fundi that run through pits

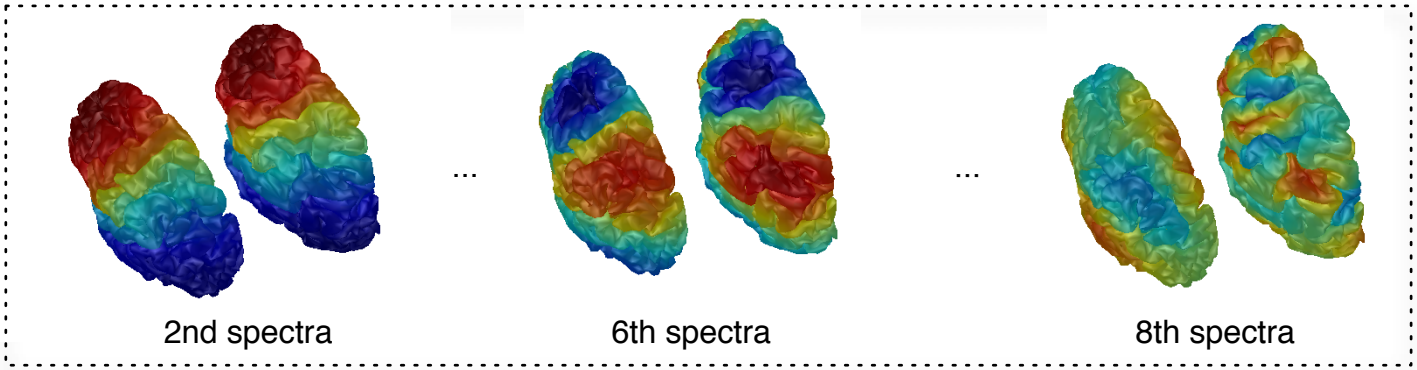


How should we extend fundi to basin edges?
How should we smooth them?

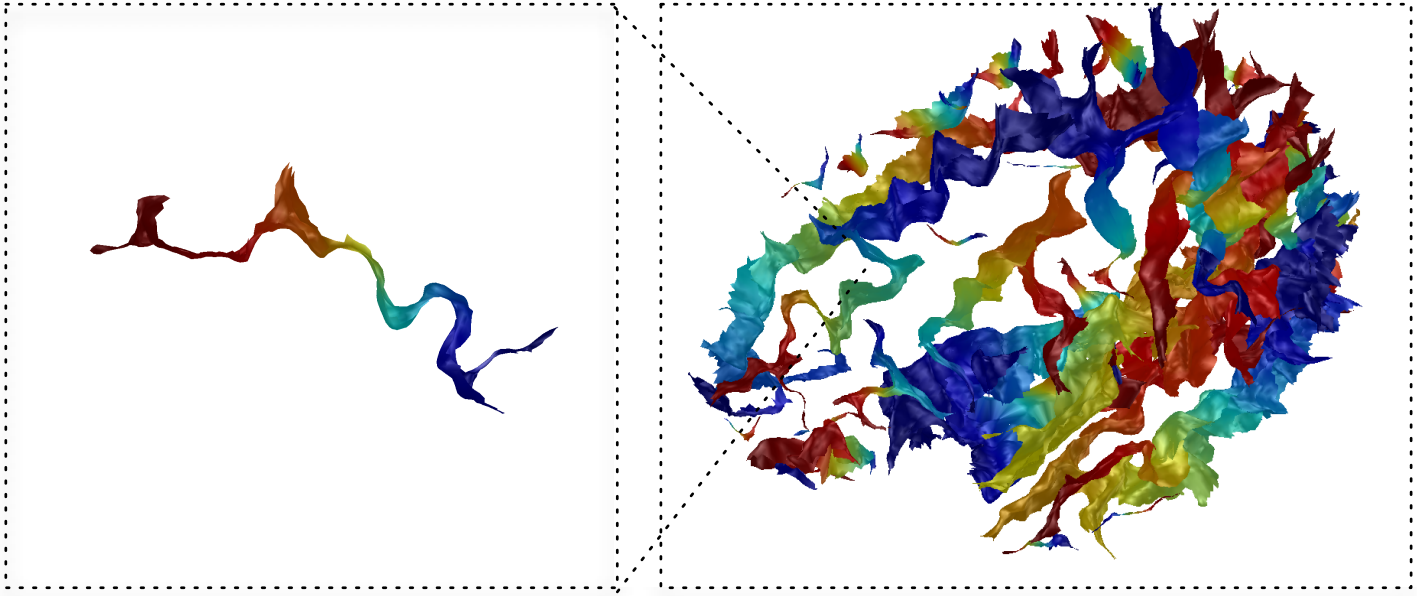


Shape analysis

spectral quantification: Laplace-Beltrami operator

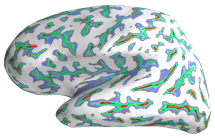


Global to local



LBO on sulcal basin

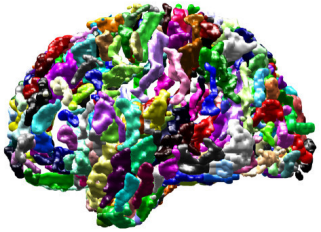
LBO on sulcal basins of left hemisphere

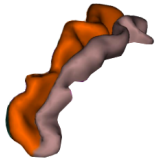


Shape analysis

geometric shape quantification of nested structures

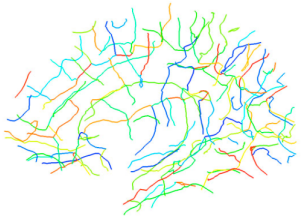
basins





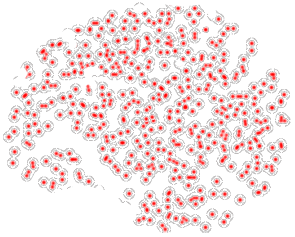
volume
surface area
cortical thickness / sulcal span
...

curves



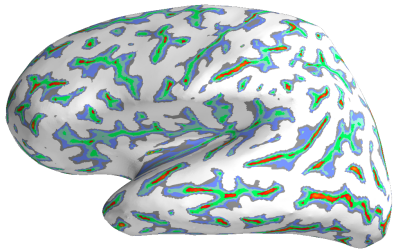
length / tortuosity
depth
curvature
convexity
spectral components
...

points



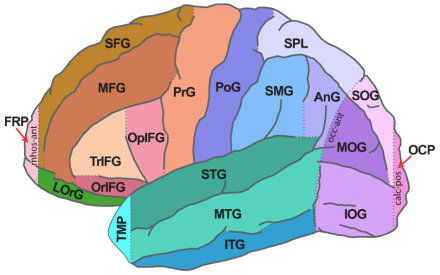
convex hull volume
sequence along a curve
...

What other shape measures should we use?

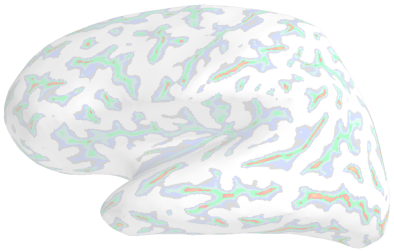


Shape analysis of brains

Informatics framework

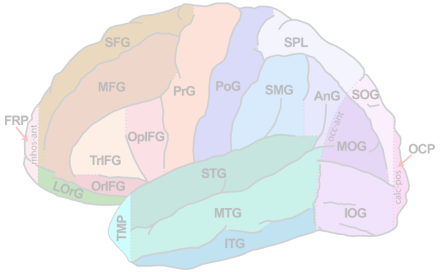


Automated brain labeling



Shape analysis of brains

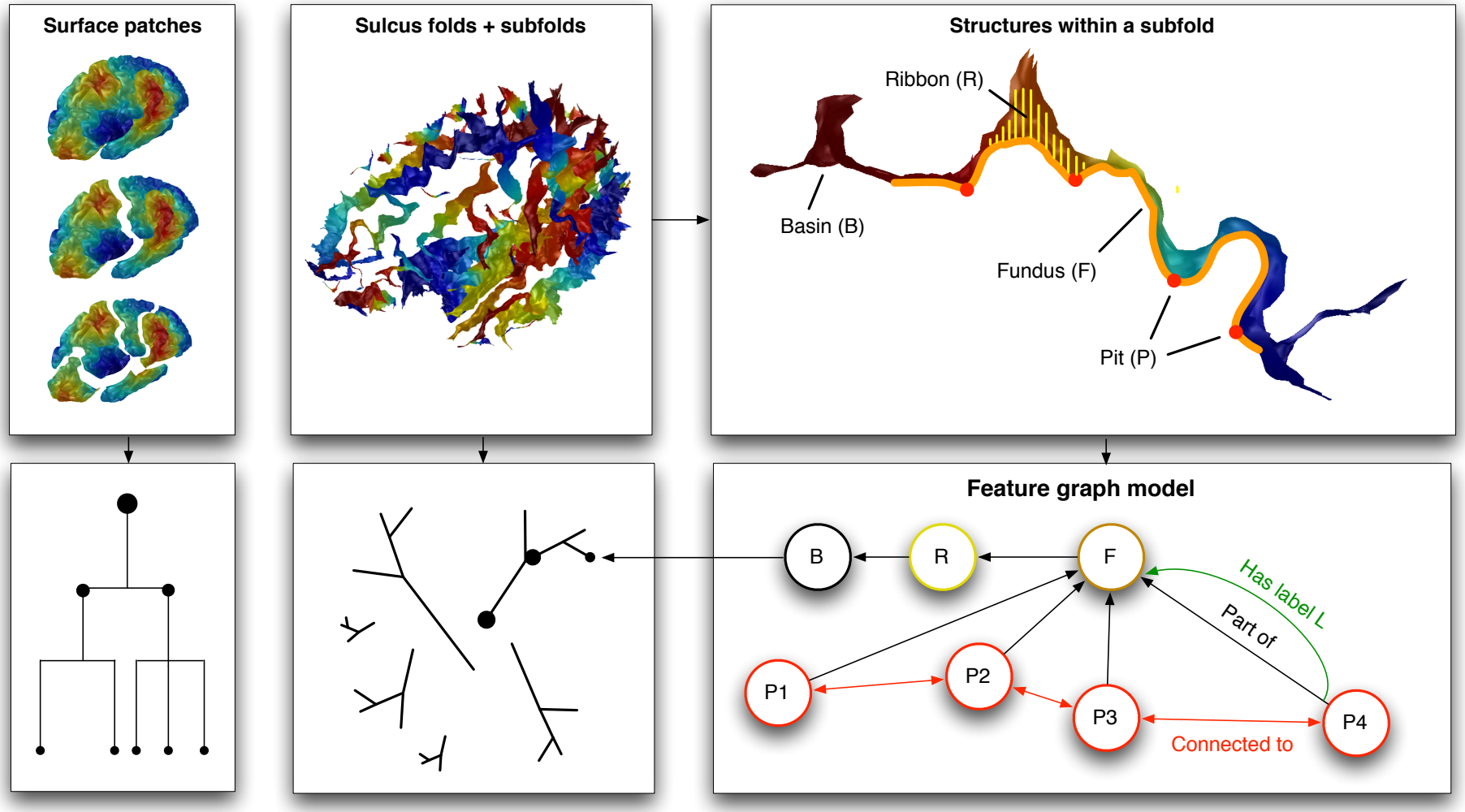
Informatics framework



Automated brain labeling

Informatics framework

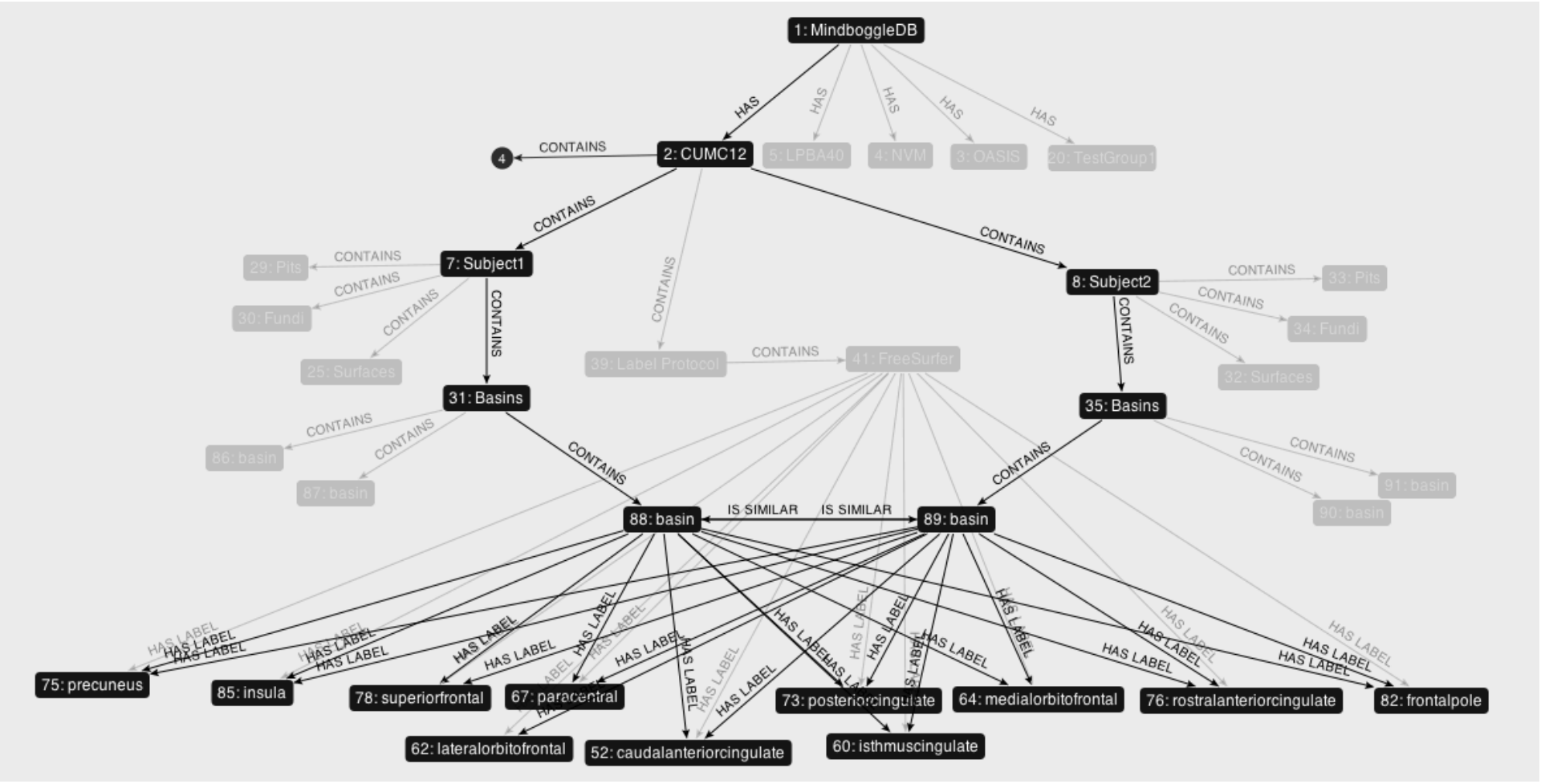
nested structures within a graph-based data model



What other node/edge properties should we include?

Informatics framework

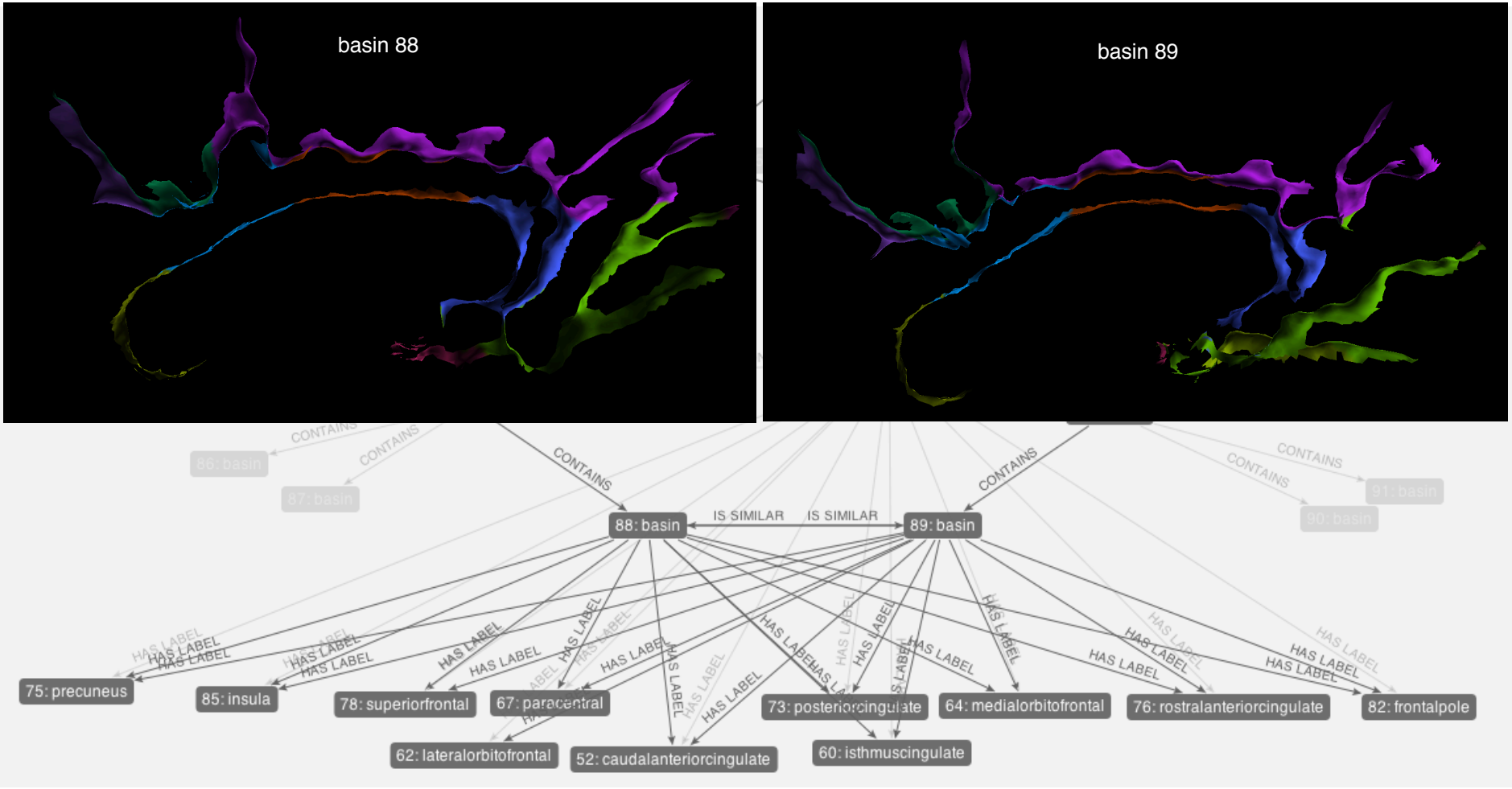
graph-based database of hierarchical brain features



This graph model shows an example of how relations between basins and their labeled regions are represented for two (CUMC12) subjects. Note that basin 88 and 89 share similar labels.

Informatics framework

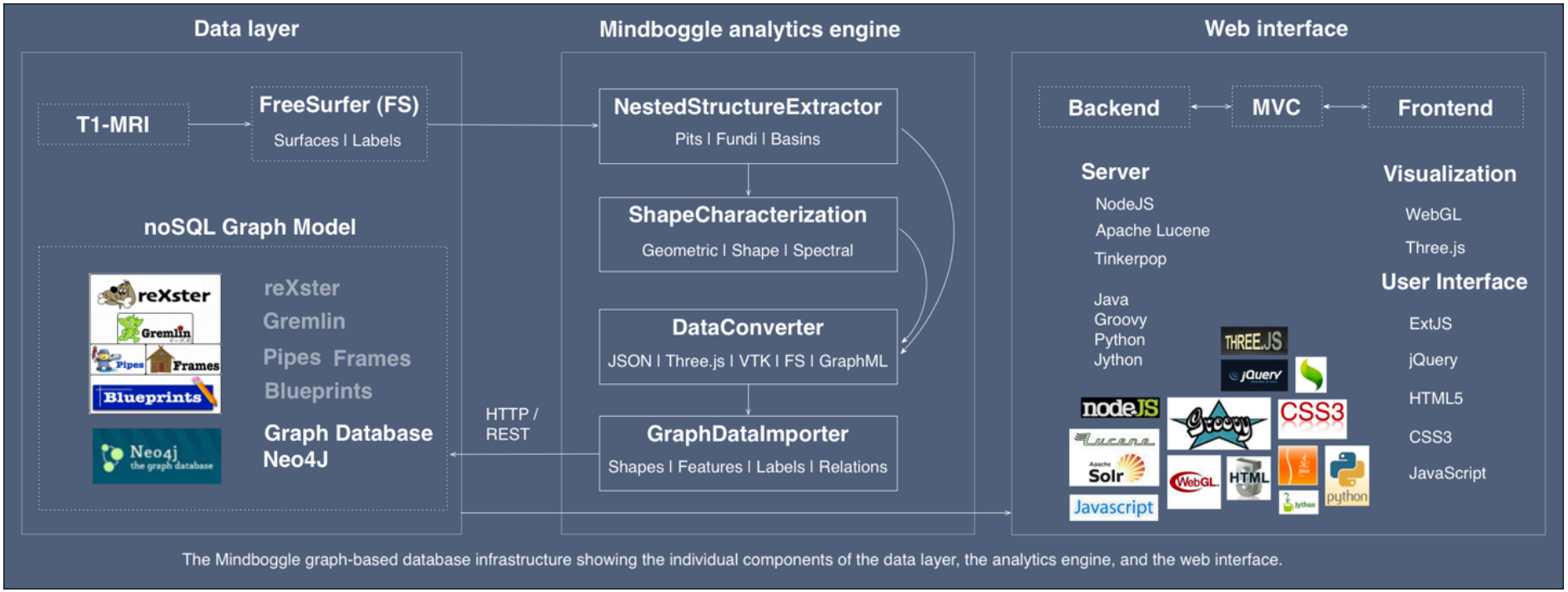
graph-based database: example query



What use cases should we expect?

Informatics framework

graph-based database: infrastructure and example query



The Mindboggle graph-based database infrastructure showing the individual components of the data layer, the analytics engine, and the web interface.

The graph model can be queried via REST, Cypher, reXster, or Gremlin.
This example shows how to query all outgoing relations from basin 88:

What surface format should we require as input? Gifti?

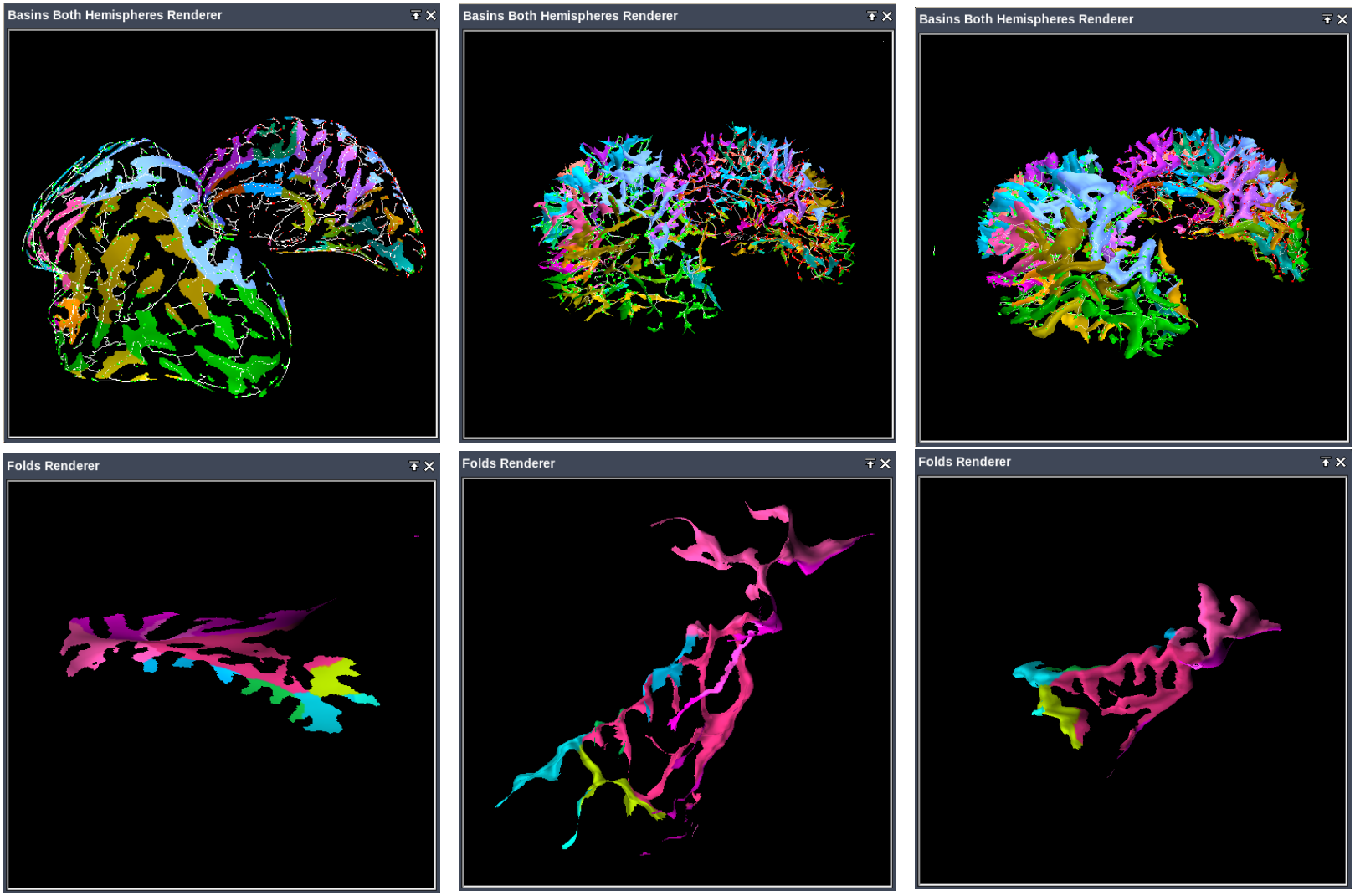
What gui should we consider aside from Paraview web?

Informatics framework

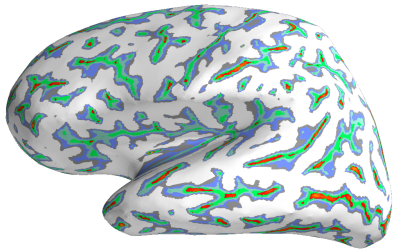
graph-based database: hierarchical structures view

whole brain

single folds

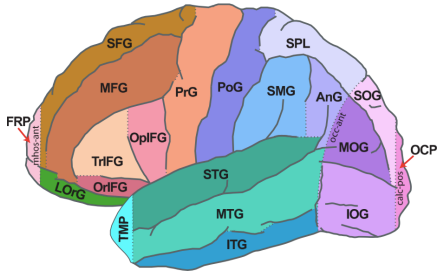


What other visualizations should we consider?

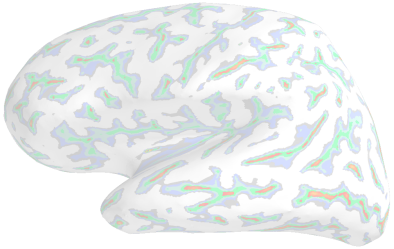


Shape analysis of brains

Informatics framework

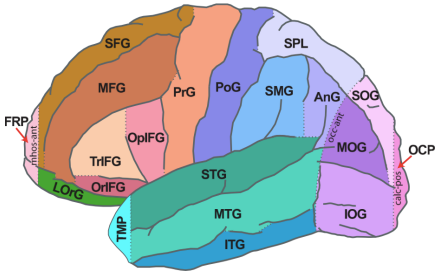


Automated brain labeling

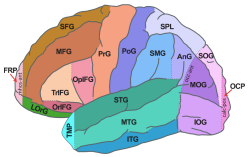


Shape analysis of brains

Informatics framework



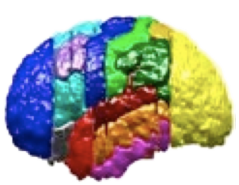
Automated brain labeling

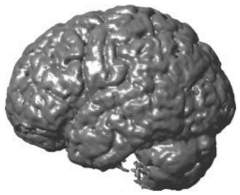


Automated brain labeling

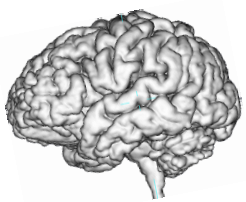
atlas + unlabeled target brain

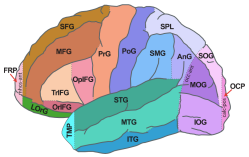
atlas





target



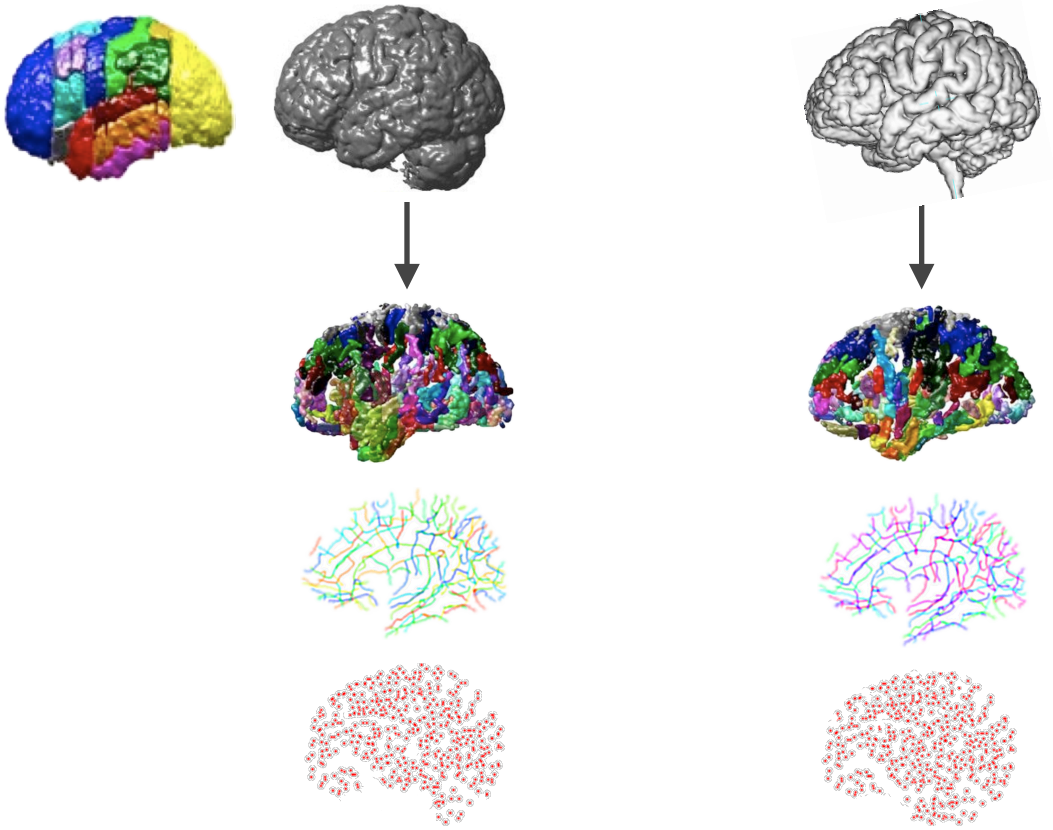


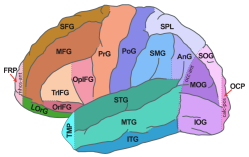
Automated brain labeling

step 1: extract structures, compute their features

atlas

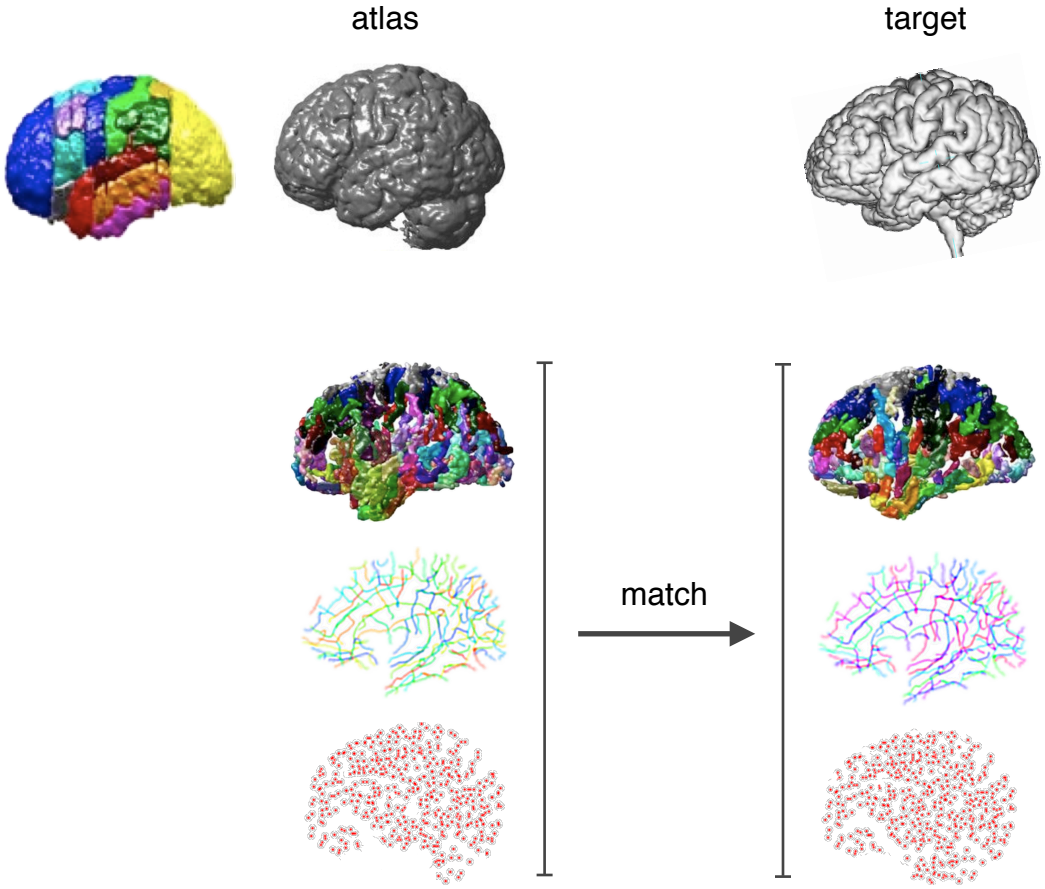
target





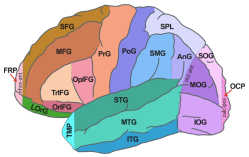
Automated brain labeling

step 2: match atlas and target features



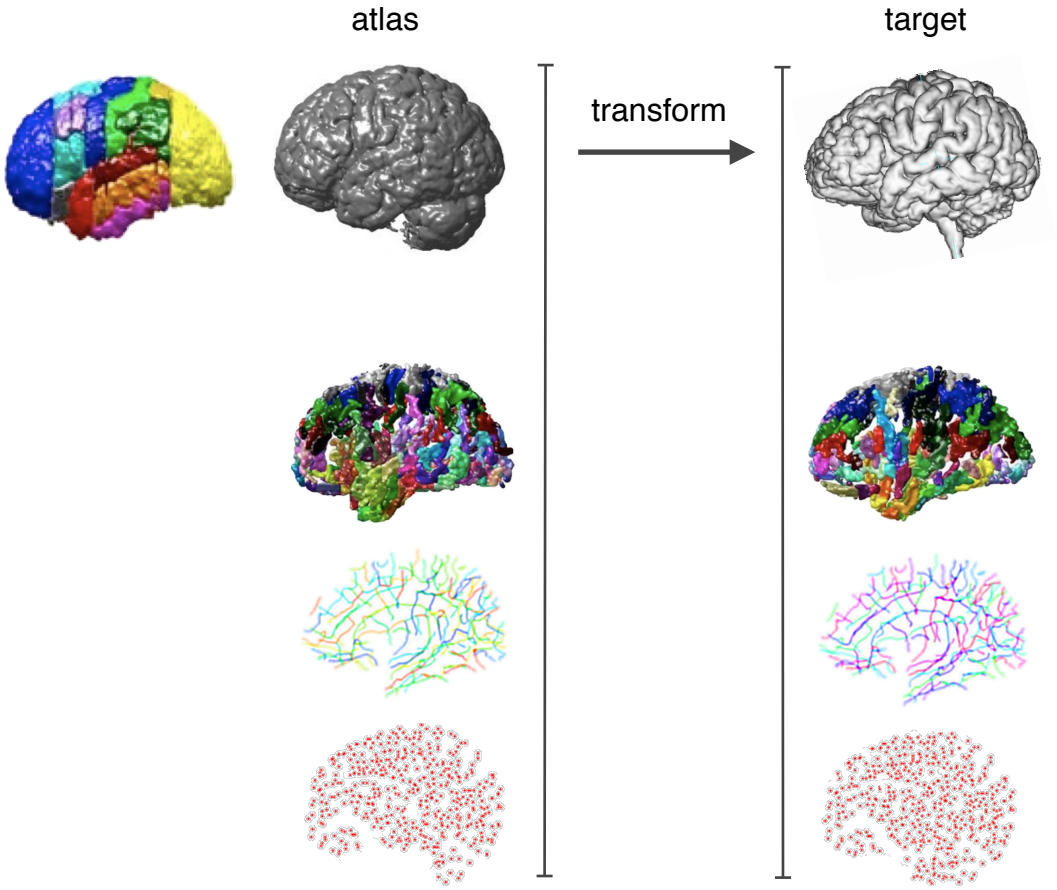
Is there a better way to compare curves than dynamic time warping?

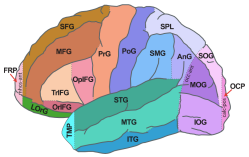
What is the best way to compare two trees (branching fundi)?



Automated brain labeling

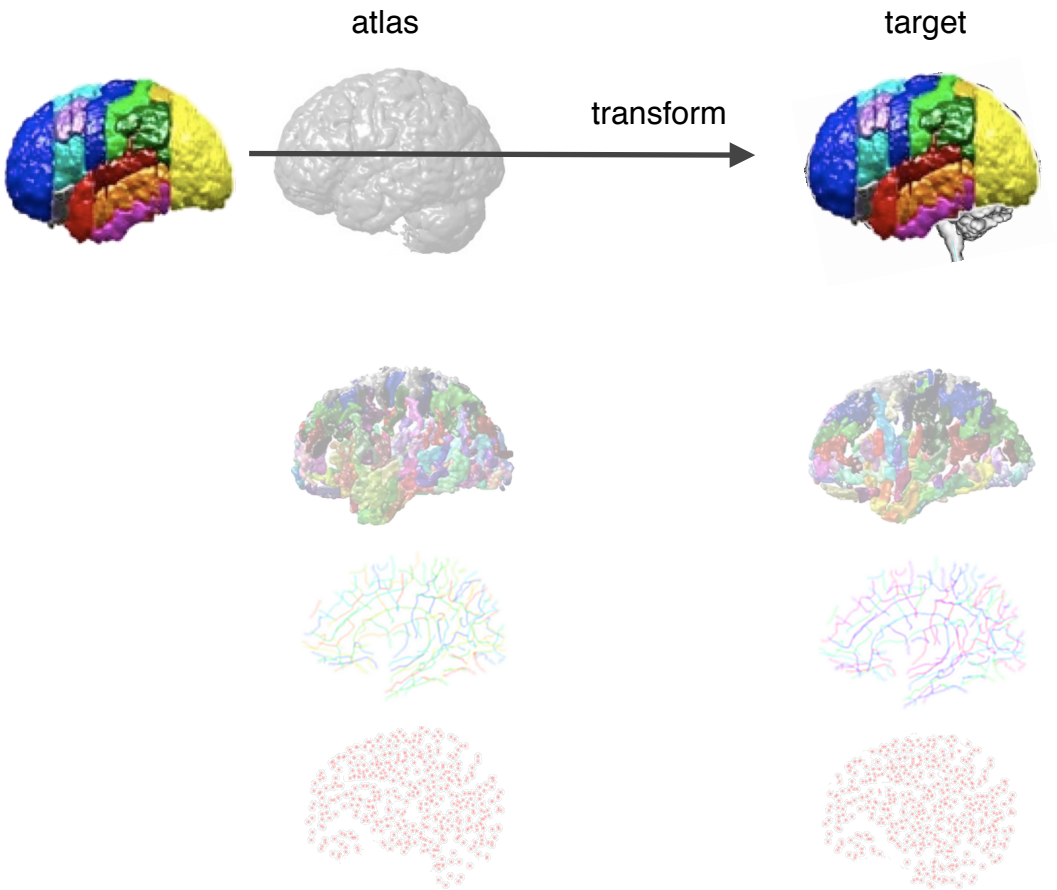
step 3: compute transforms from atlas to target



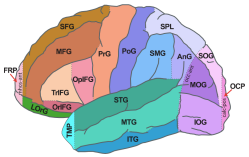


Automated brain labeling

step 3: apply transforms to atlas

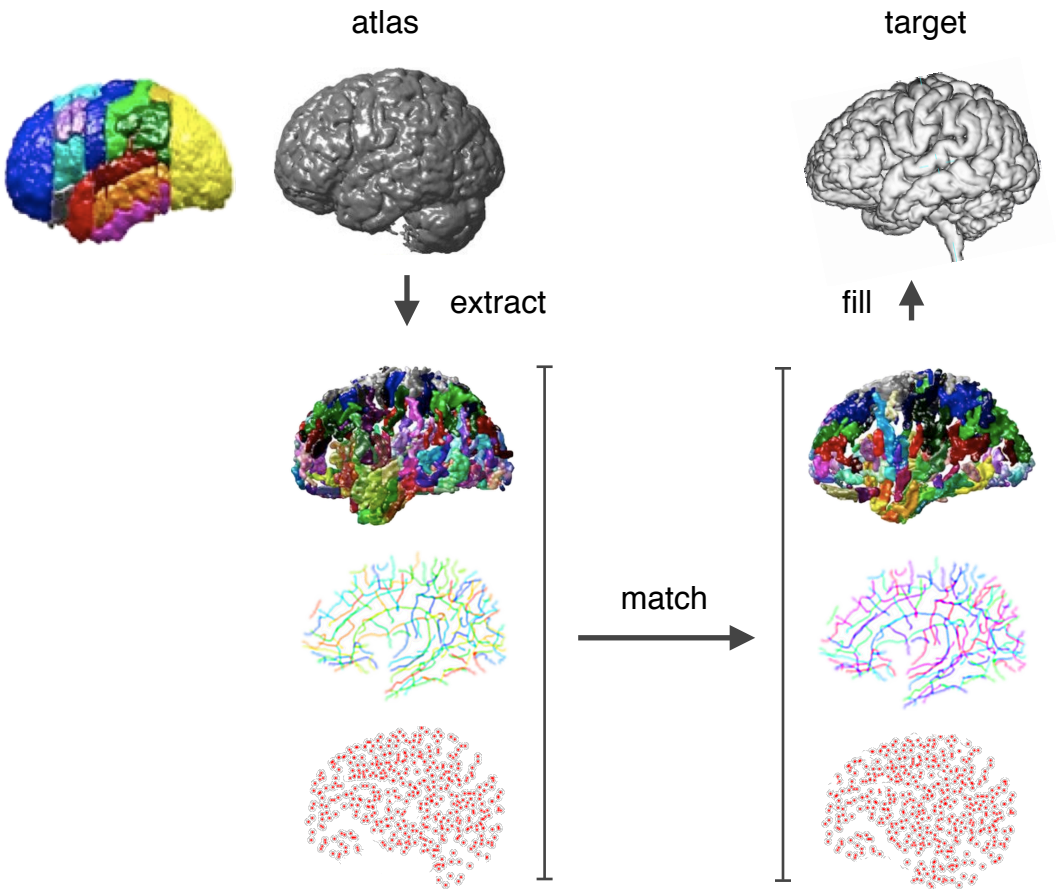


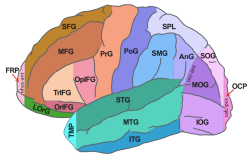
What is the best way to drive these features into register?



Automated brain labeling

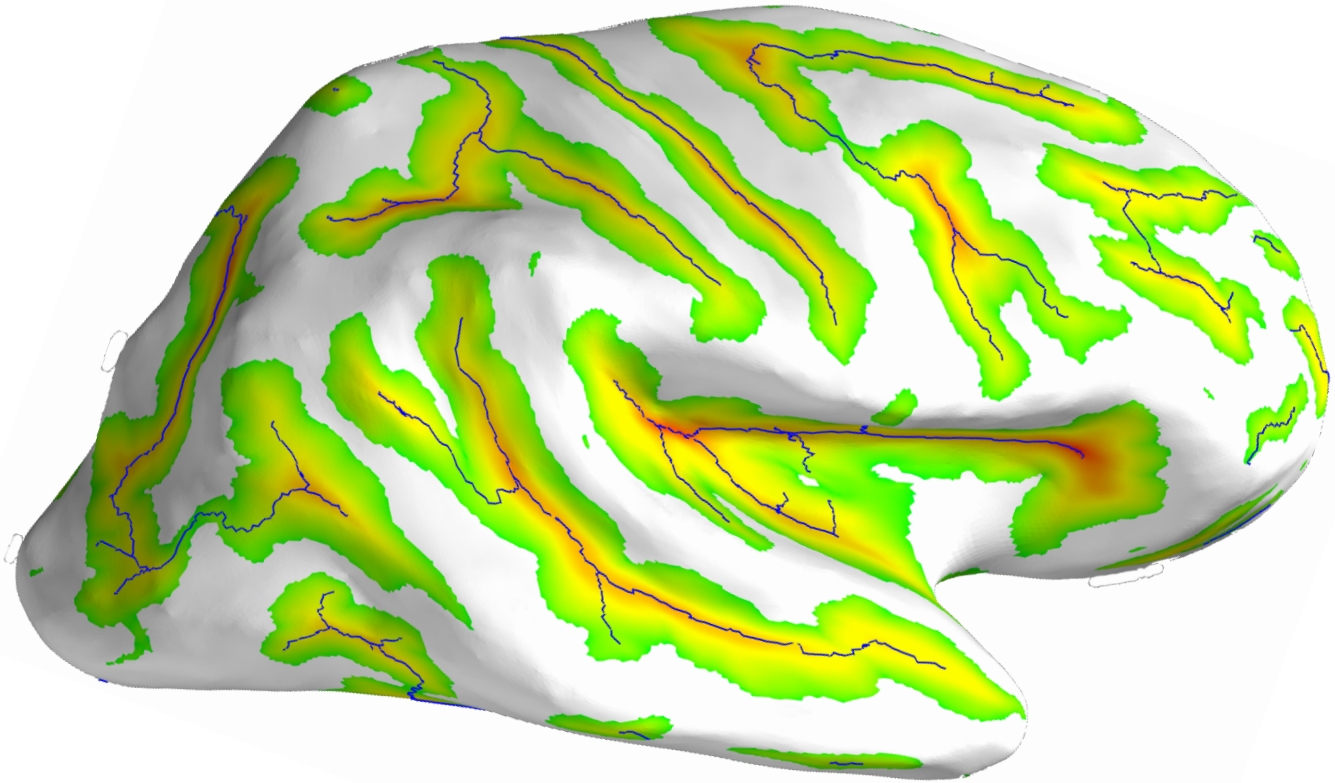
OR extract, match, and fill labels without registration!

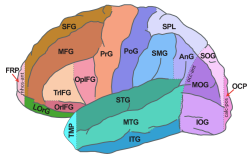




Automated brain labeling

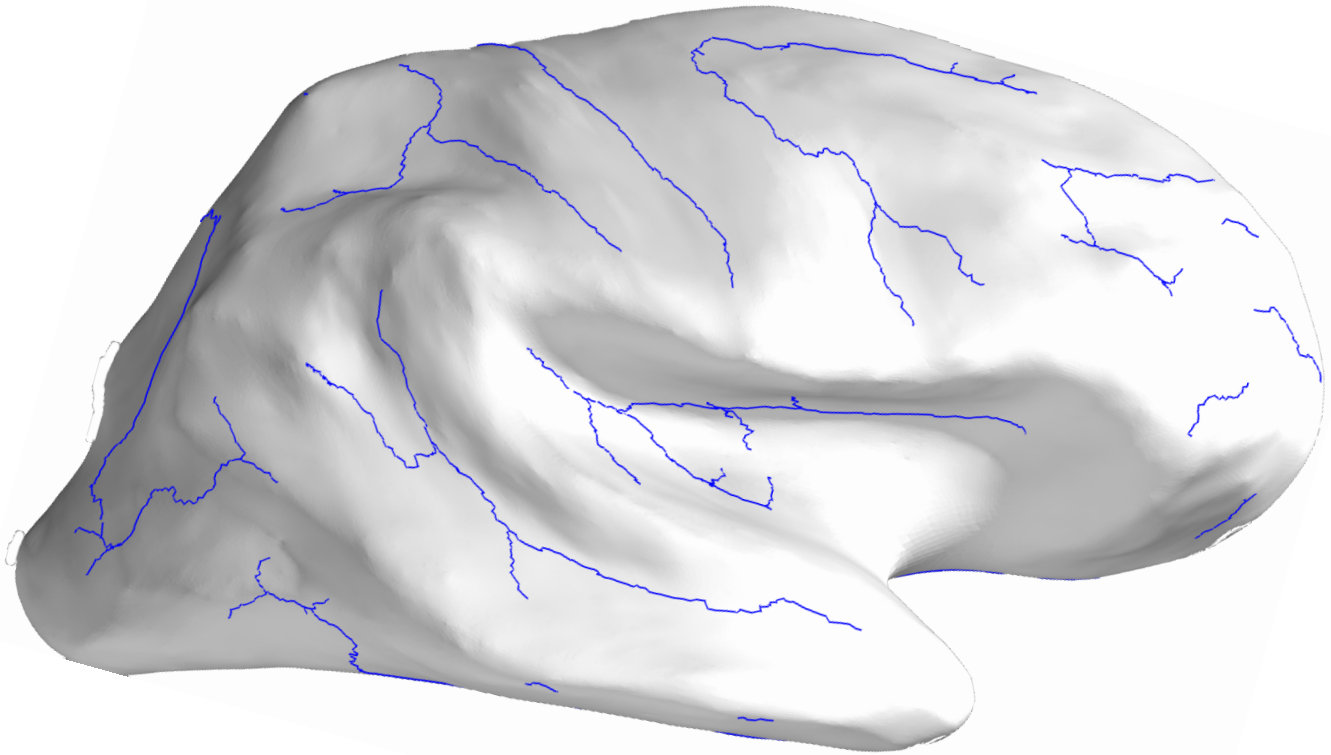
extract basins + fundi

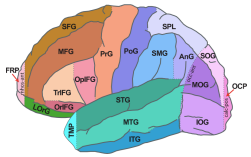




Automated brain labeling

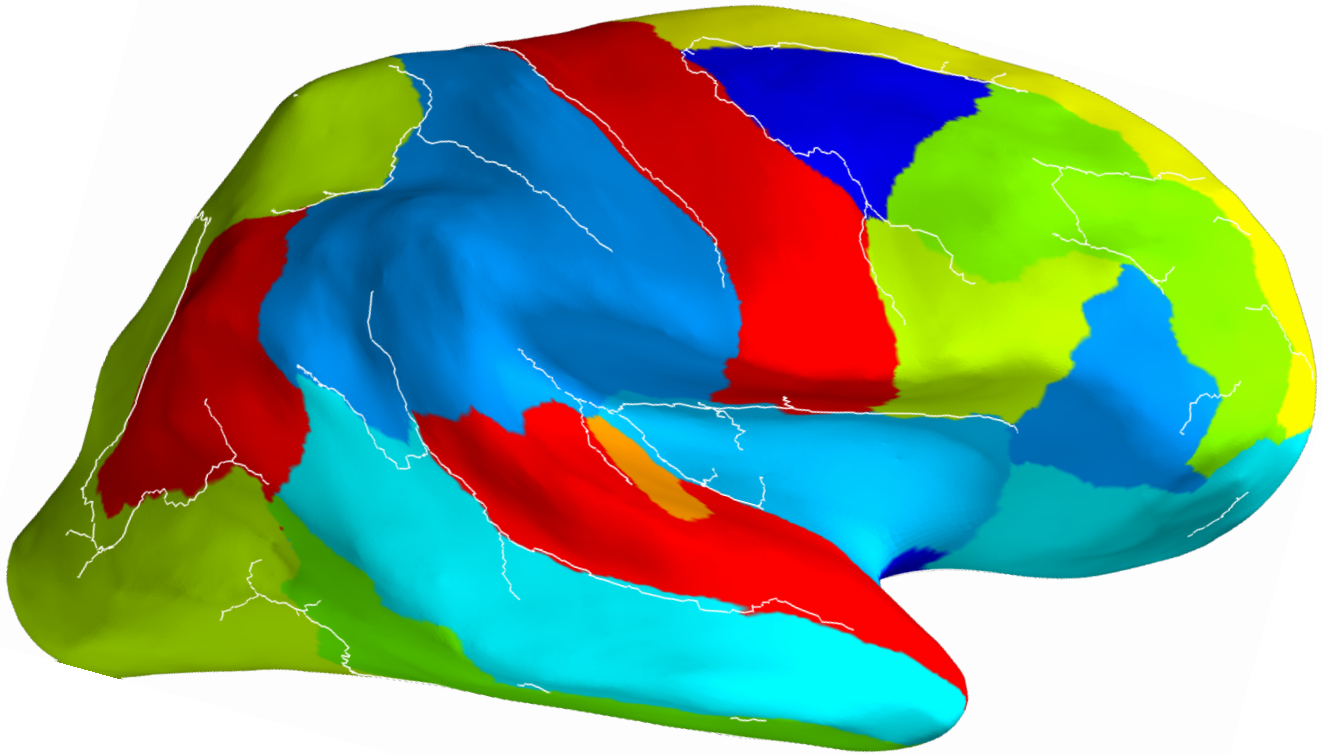
fundi

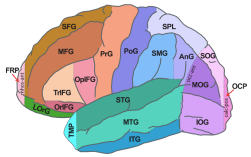




Automated brain labeling

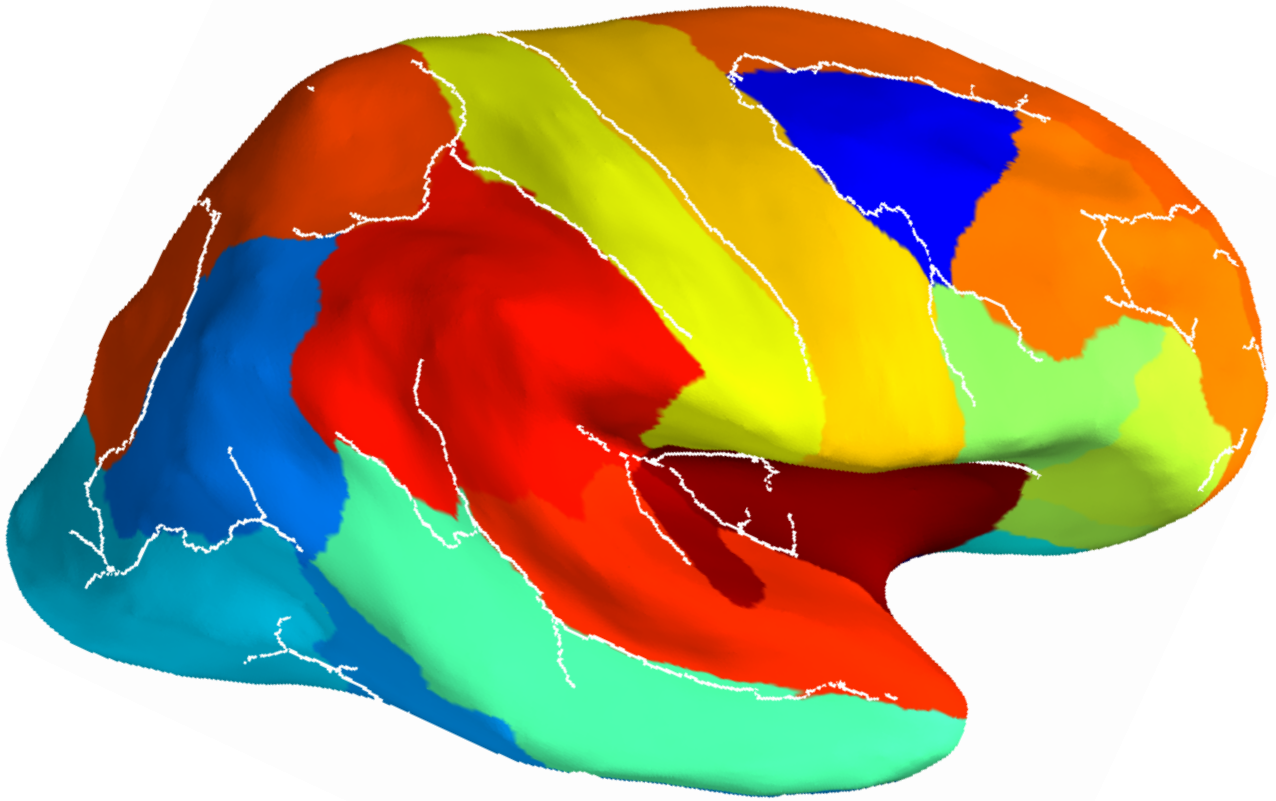
fundi + manual labels

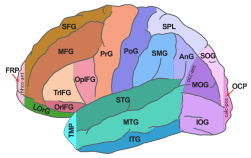




Automated brain labeling

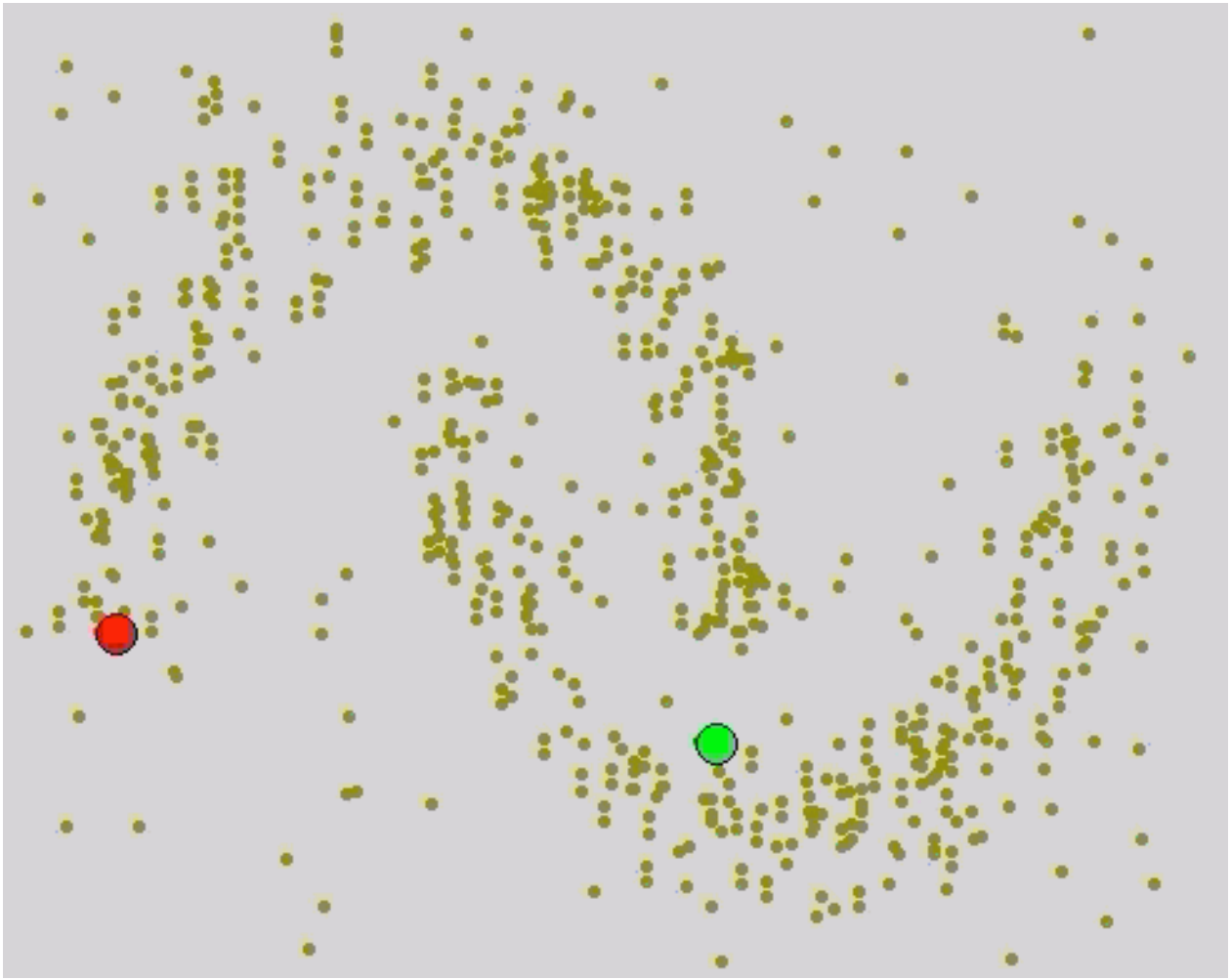
fundi + manual labels



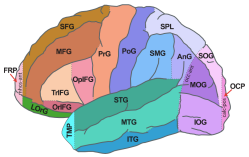


Automated brain labeling

label propagation (graph transduction)



What other label propagation algorithms should we consider?

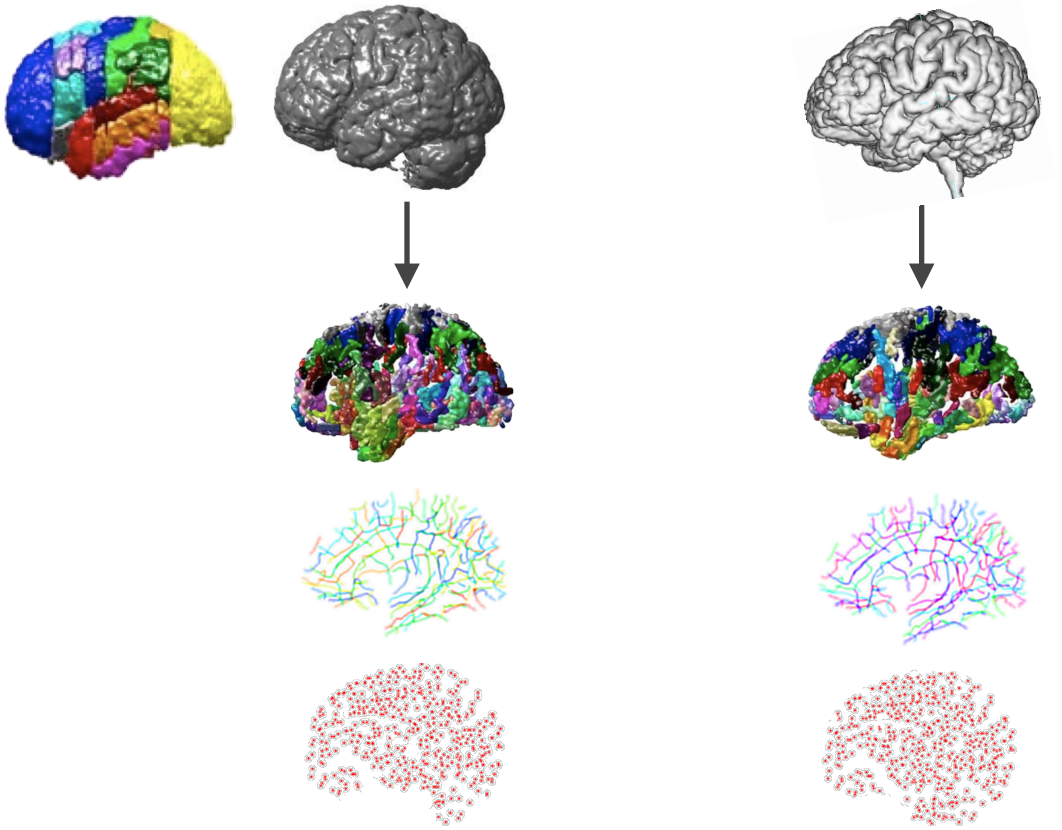


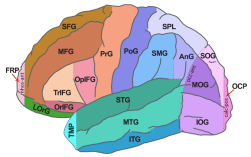
Automated brain labeling

consider features from other modalities

atlas

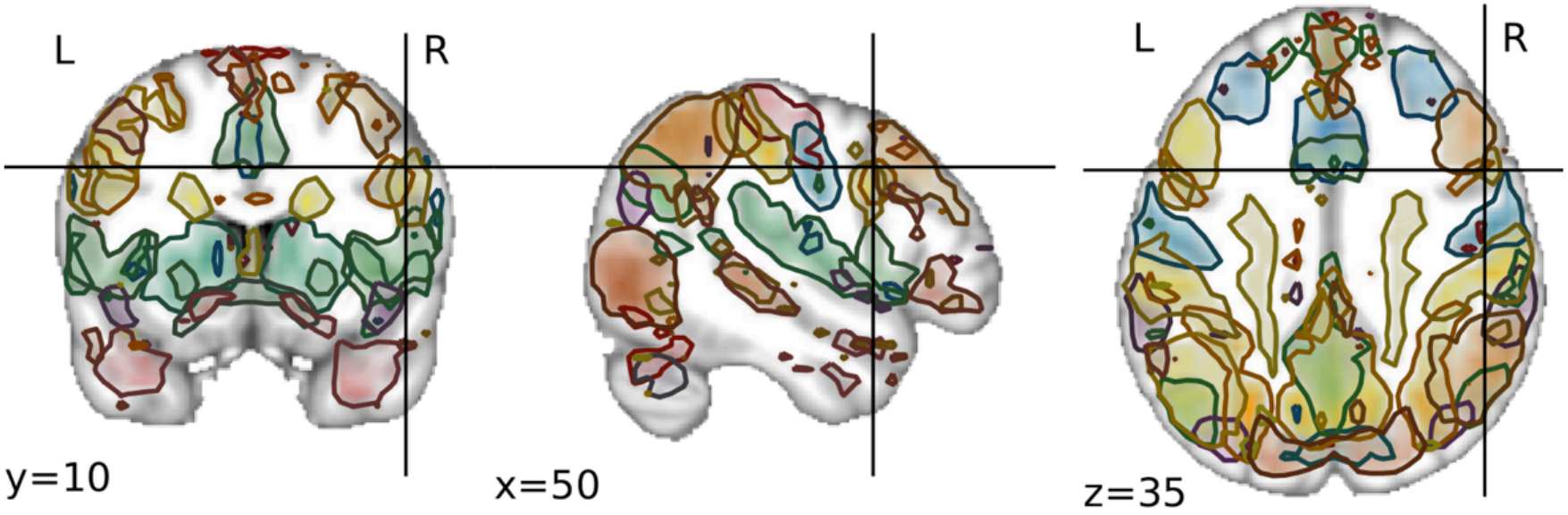
target



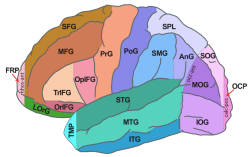


Automated brain labeling

fMRI networks as features

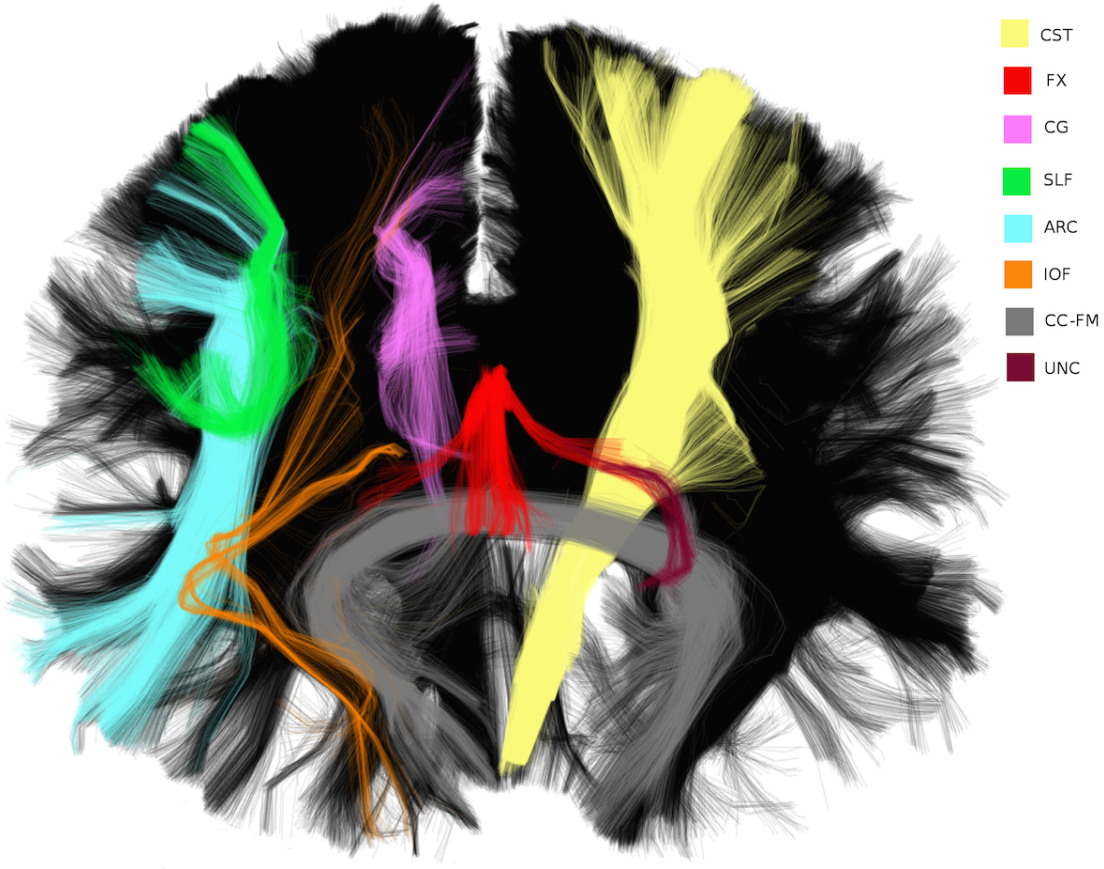


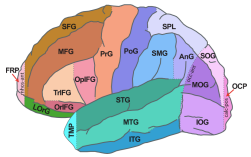
What other fMRI features should we extract?



Automated brain labeling

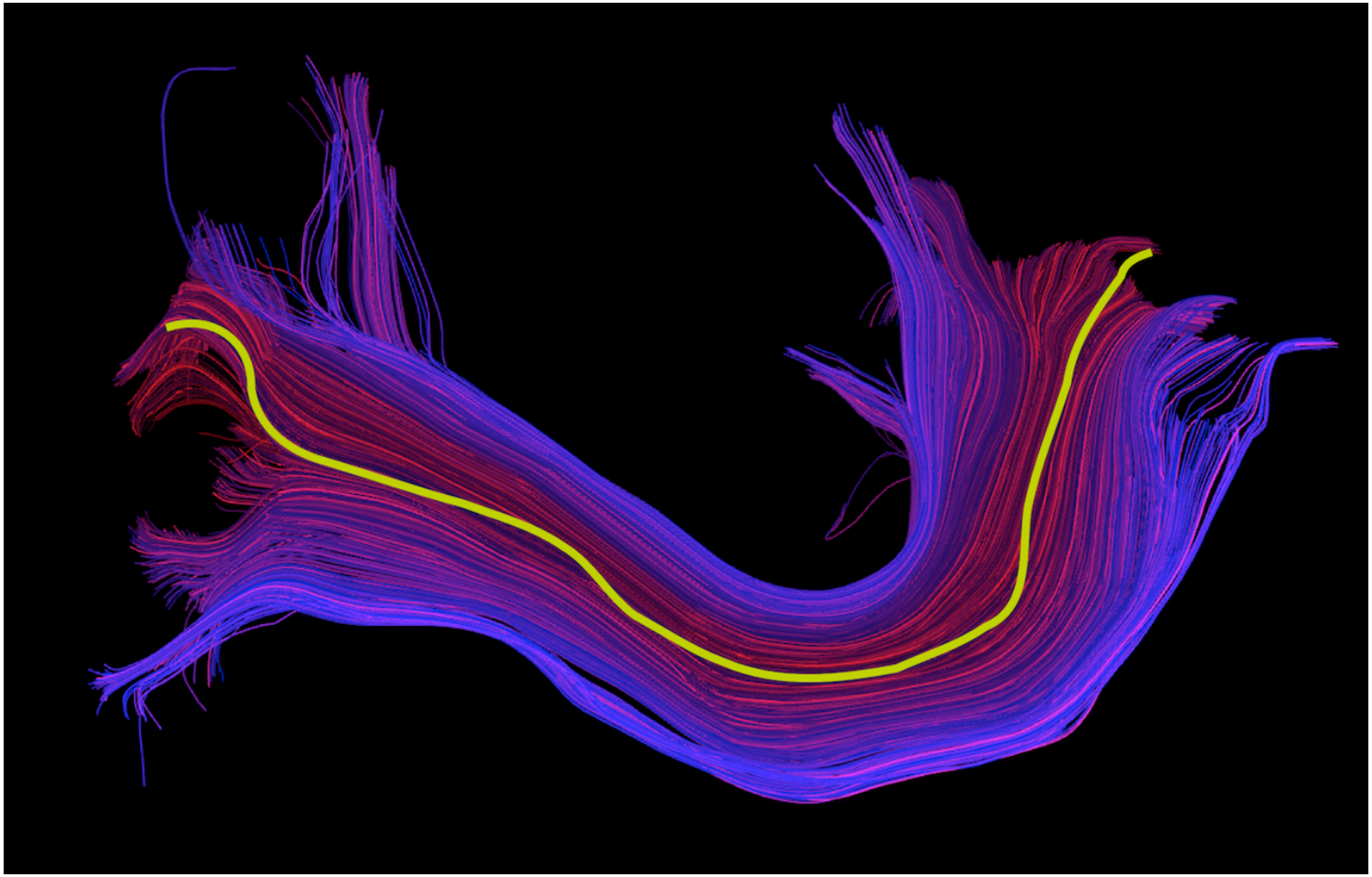
diffusion tractography clusters as features

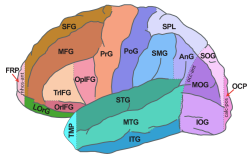




Automated brain labeling

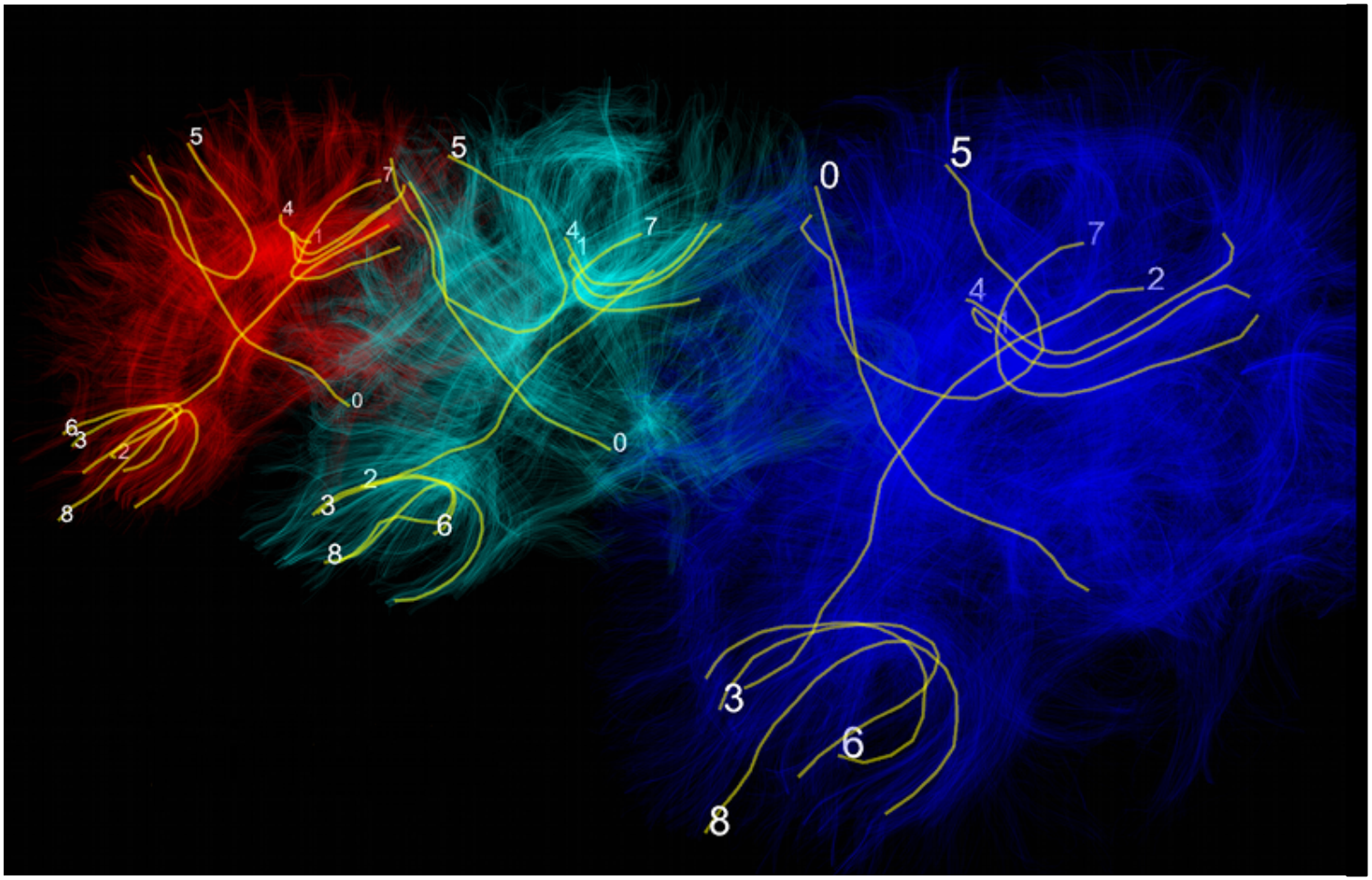
diffusion tractography clusters as features



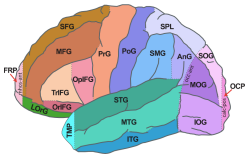


Automated brain labeling

diffusion tractography clusters as features

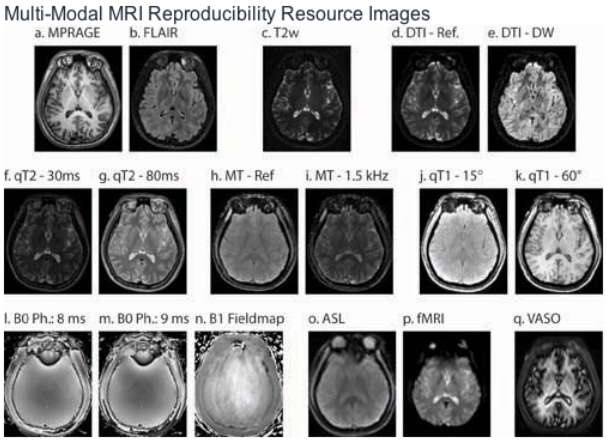


What other diffusion features should we extract?



Automated brain labeling

multimodal data



OASIS

http://www.oasis-brains.org/ T1

MRI Multimodal Reproducibility Resource

http://www.nitrc.org/projects/multimodal/

MPRAGE T1, FLAIR, resting state fMRI,
B0 and B1 field maps, ASL, VASO, DTI,
quantitative T1 and T2 mapping,
magnetization transfer imaging
MMRR2 includes a 7T T1-weighted scan

PLoS 12

http://www.plosone.org/article/info:doi%2F10.1371%2Fjournal.pone.0006660

MPRAGE T1, fMRI, resting state fMRI

Nathan Kline Institute / Rockland Sample

http://fcon_1000.projects.nitrc.org/indi/pro/nki.html

MPRAGE T1, T2, resting state fMRI, DSI,...

EMBARC

http://grants.nih.gov/grants/guide/rfa-files/RFA-MH-10-040.html

T1, fMRI and resting state fMRI, DTI, ASL, EEG

What other modalities should we extract features from?

aMRI features

Forrest Bao
Graduate student, Texas Tech

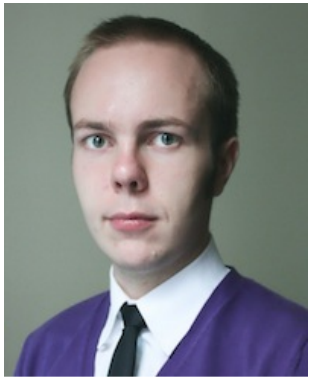
fMRI features

Gael Varoquaux
NeuroSpin, France

dMRI features

Eleftherios Garyfallidis
Cambridge University

Feature matching



Yrjö Häme
Graduate student

Database & visualization

Noah Lee
Postdoctoral research scientist

Registration

Brian Avants
Asst. Professor, UPenn