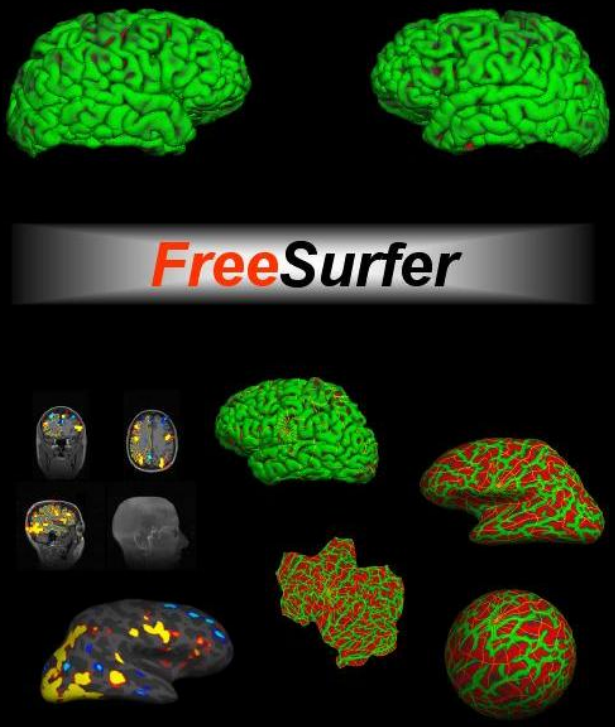
Introduction to FreeSurfer

surfer.nmr.mgh.harvard.edu



MASSACHUSETTS GENERAL HOSPITAL

Post Your Questions!

http://surfer.nmr.mgh.harvard.edu/cgi-bin/fsurfer/questions.cgi

To Caffeinate or not to Caffeinate?

Please don’t spill coffee (or anything else on the laptops), or if you feel you must, please be prepared to fund a replacement!

(we will have coffee this afternoon at the break)

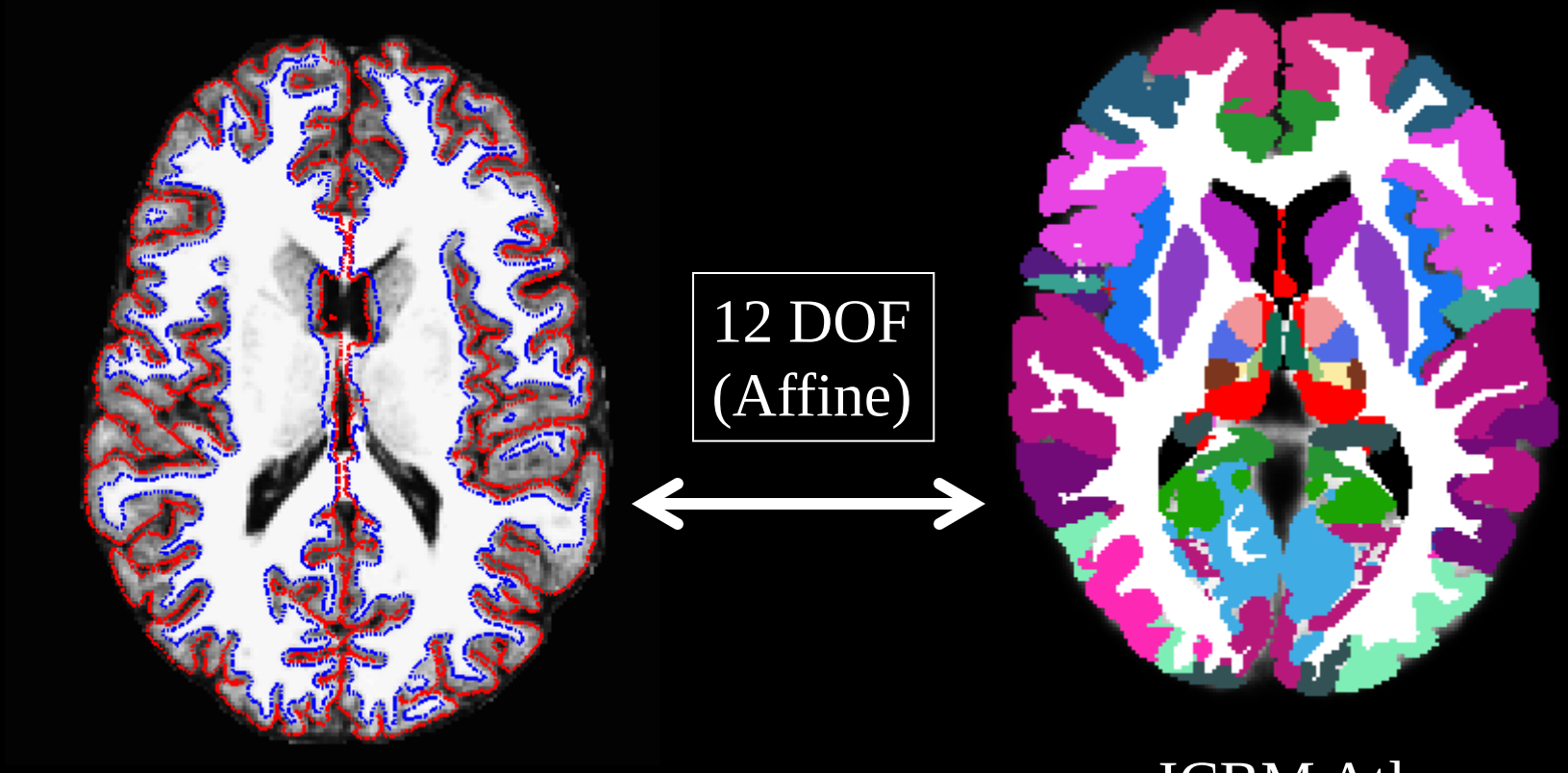
Why FreeSurfer?

1. Anatomical analysis is not like functional analysis – it is completely stereotyped.

2. Registration to a template (e.g. MNI/Talairach) doesn’t account for individual anatomy.

3. Even if you don’t care about the anatomy, anatomical models allow functional analysis not otherwise possible.

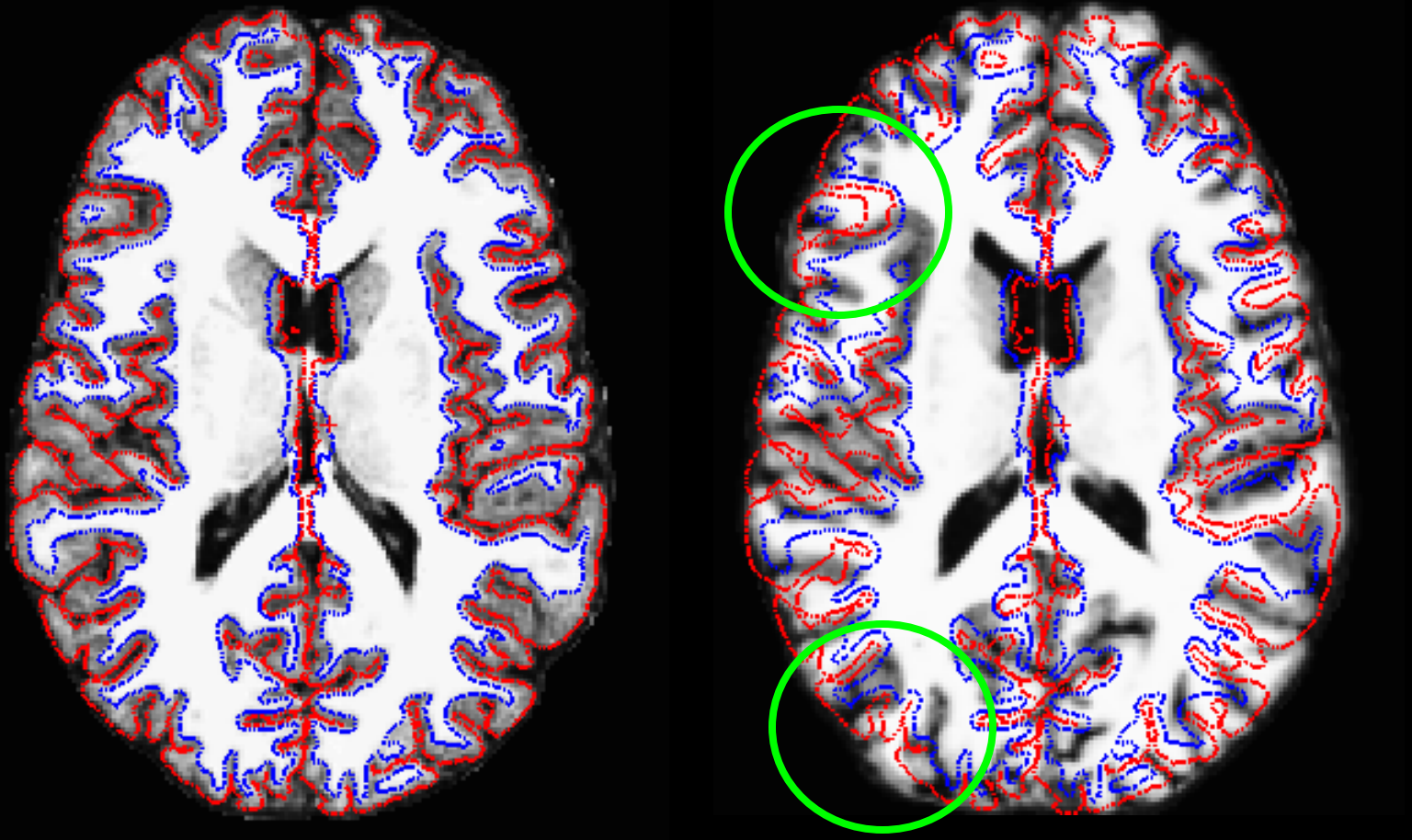
Why not just register to an ROI Atlas?



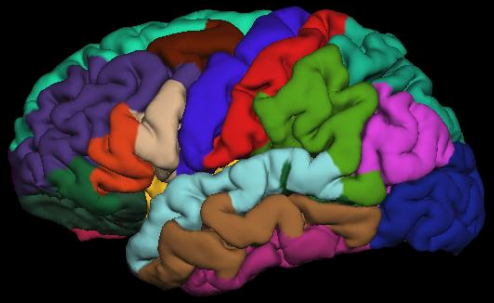
Problems with Affine (12 DOF) Registration (you will get sick of this slide)

Subject 1

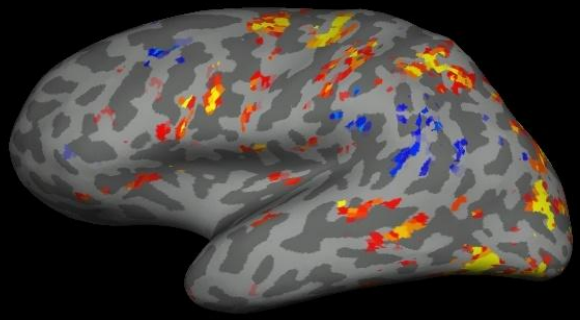
Subject 2 aligned with Subject 1
(Subject 1's Surface)



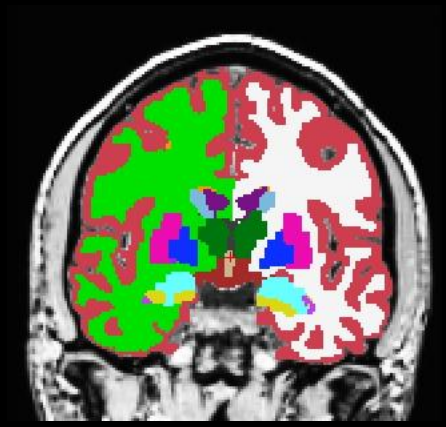
Surface and Volume Analysis



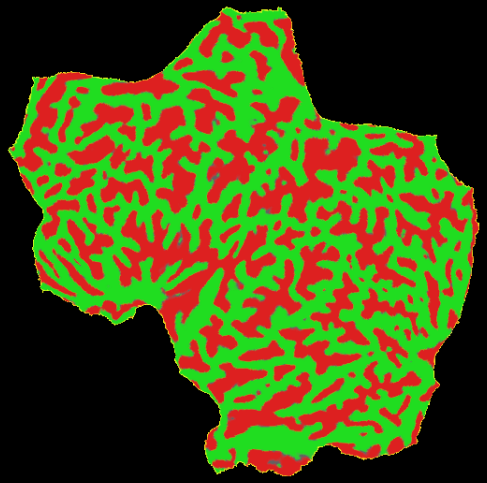
Cortical Reconstruction and Automatic Labeling



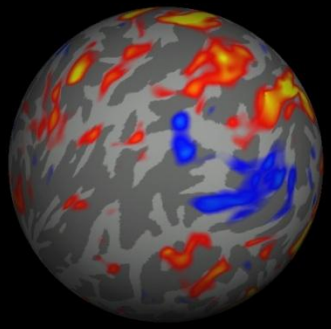
Inflation and Functional Mapping



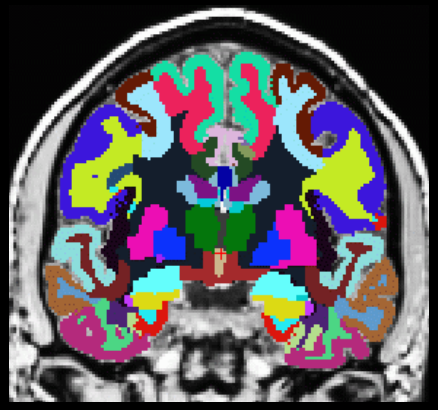
Automatic Subcortical Gray Matter Labeling



Surface Flattening



Surface-based Intersubject Alignment and Statistics



Automatic Gyral White Matter Labeling

Talk Outline

1. Cortical (surface-based) Analysis.
2. Volume Analysis.

Talk Outline

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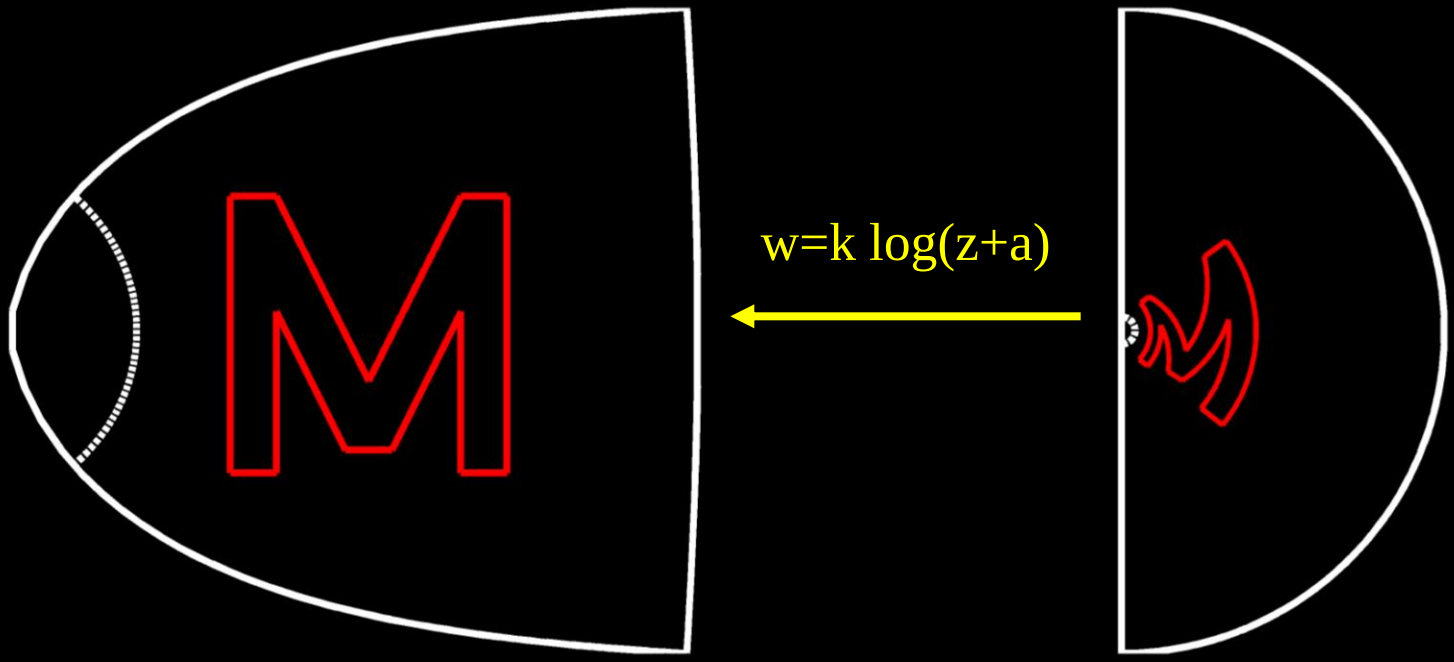
2. Volume Analysis.

What Can One Do With A Surface Model?

goal: use model to imposed desired activity pattern on V1

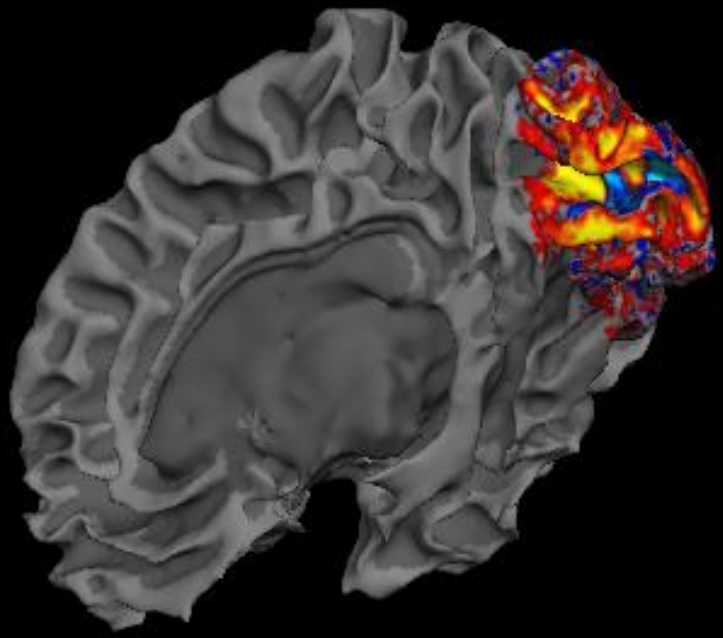
desired shape of activity pattern *required* shape of stimulus



left primary visual cortex right visual hemifield

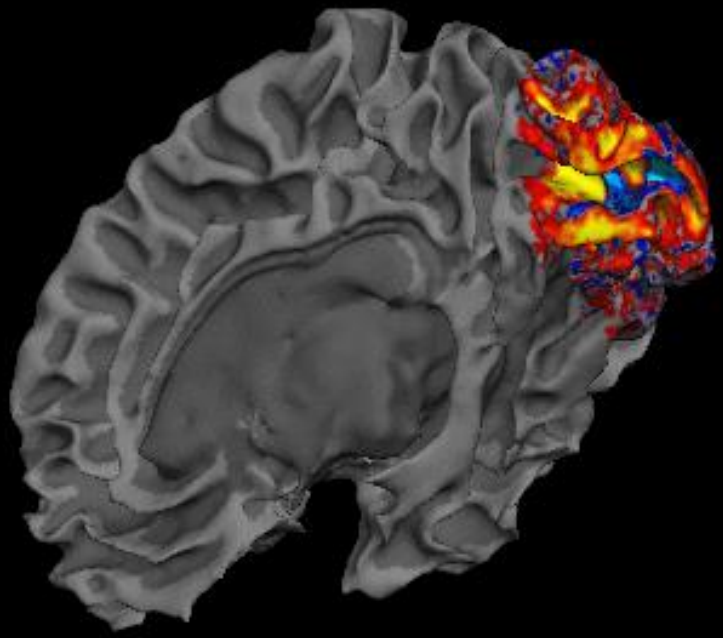
Collaboration with **Jon Polimeni** and Larry Wald.

Tangential Resolution Measured with Surface-based Analysis



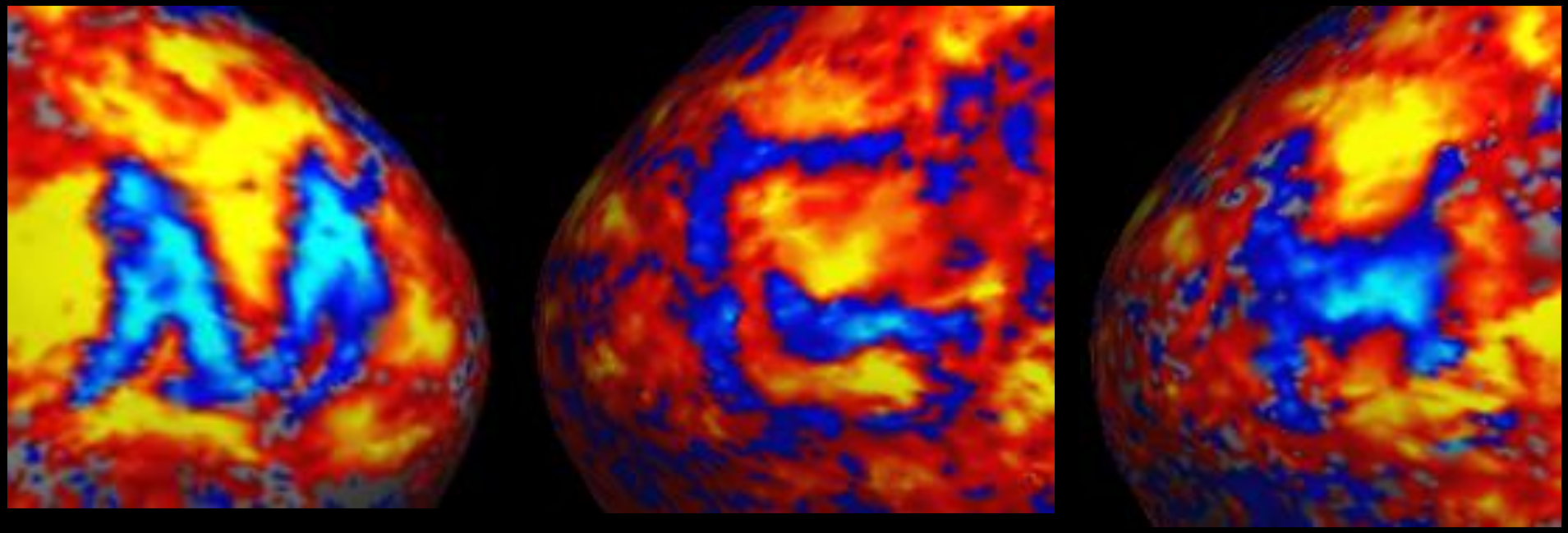
Collaboration with Jon Polimeni and Larry Wald.

Tangential Resolution Measured with Surface-based Analysis



Collaboration with Jon Polimeni and Larry Wald.

NeuroMarketing!



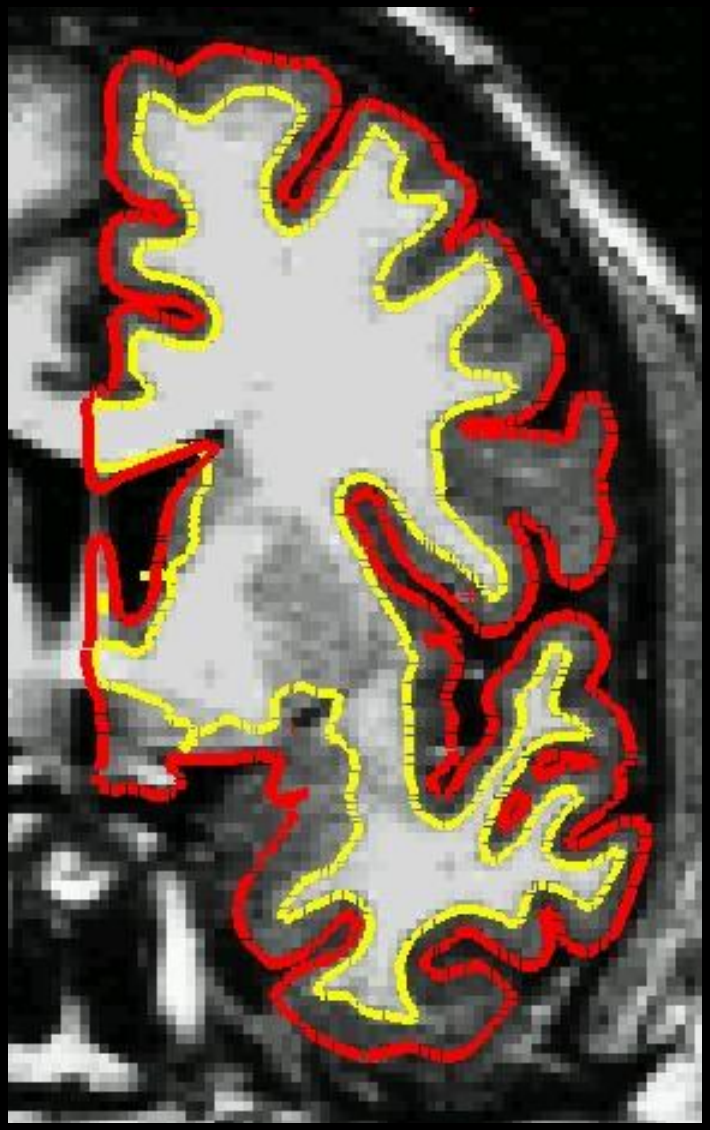
Aim 1 of our NCRR Center Grant, spelling:

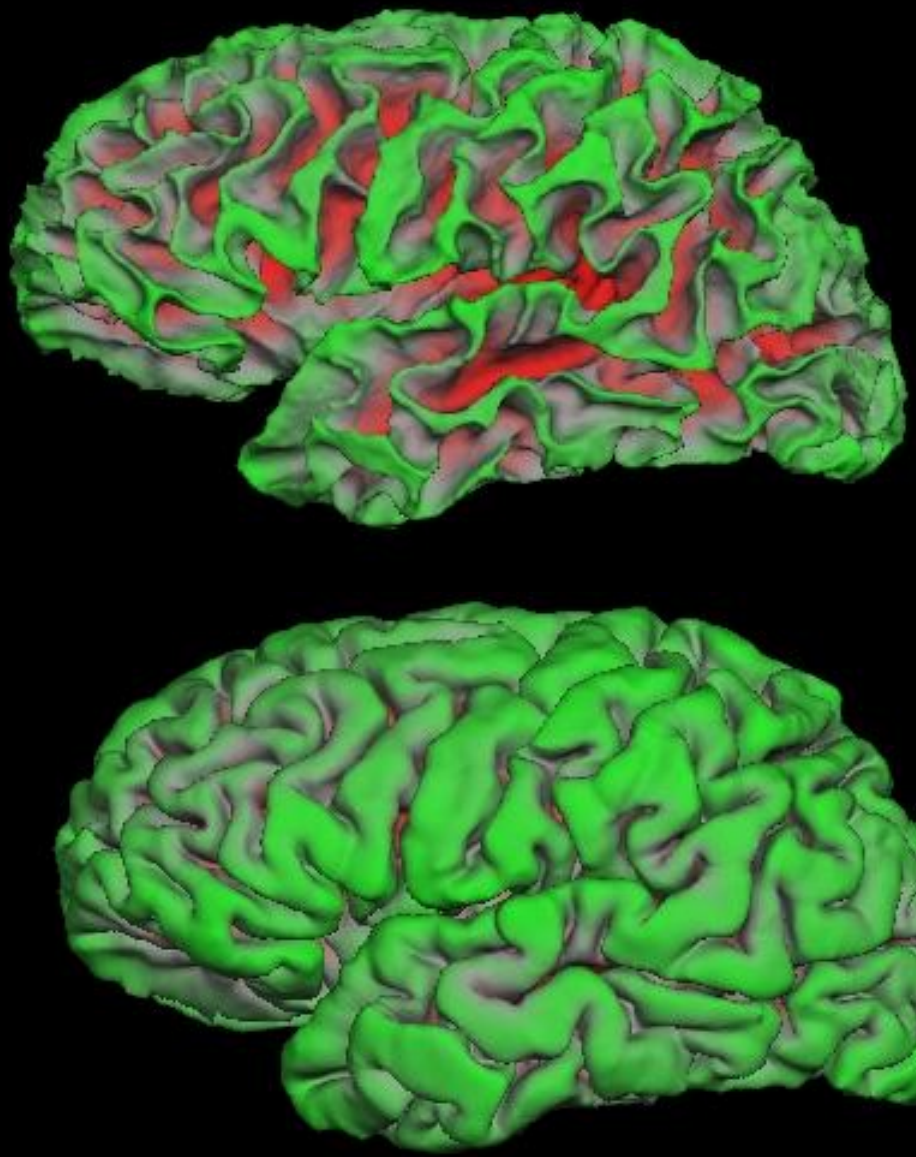
"MGH Center for Functional Neuroimaging Technologies; an NCRR Center for Research Resources."

(just kidding)

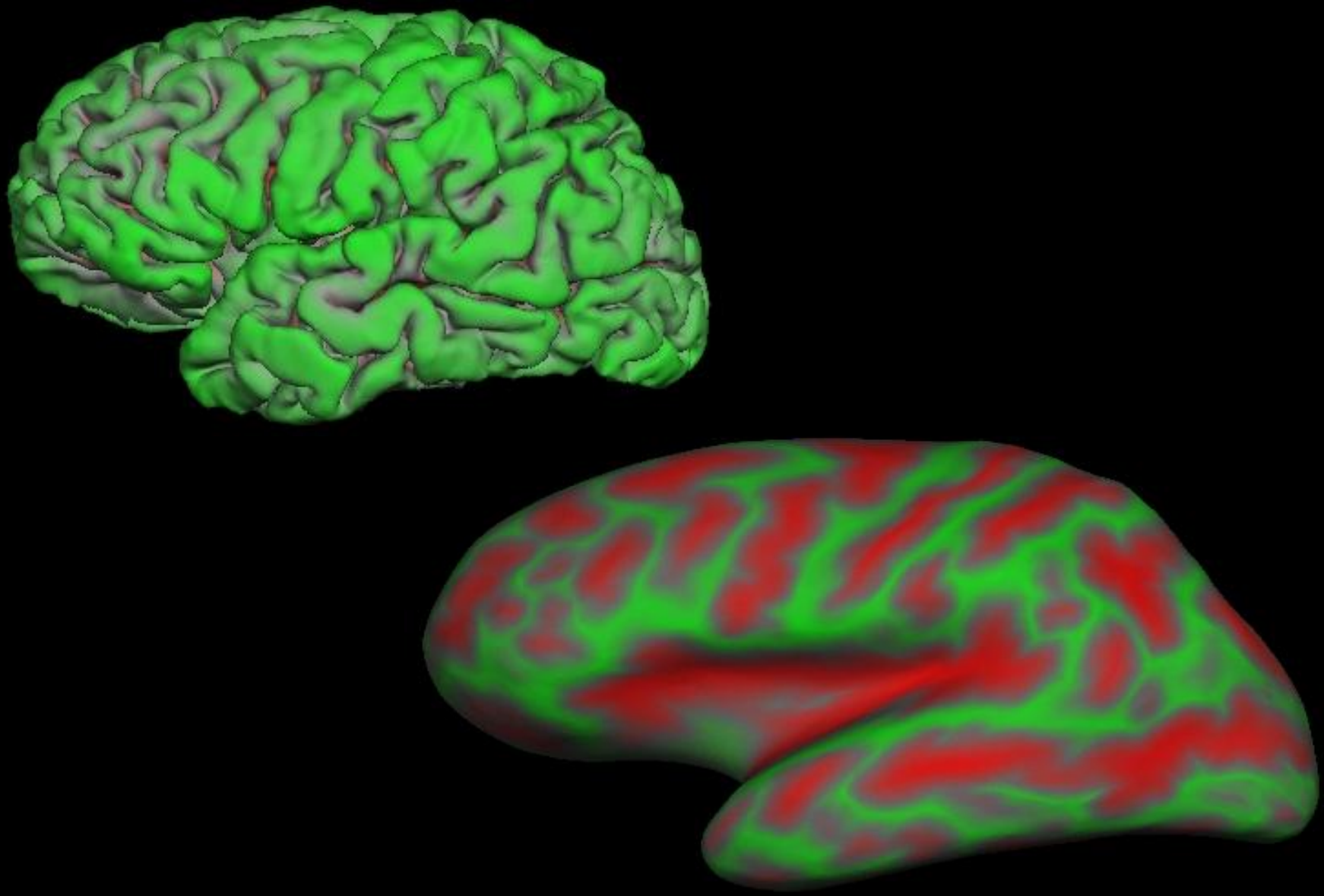
Thanks to Larry Wald for this slide.

Surfaces: White and Pial

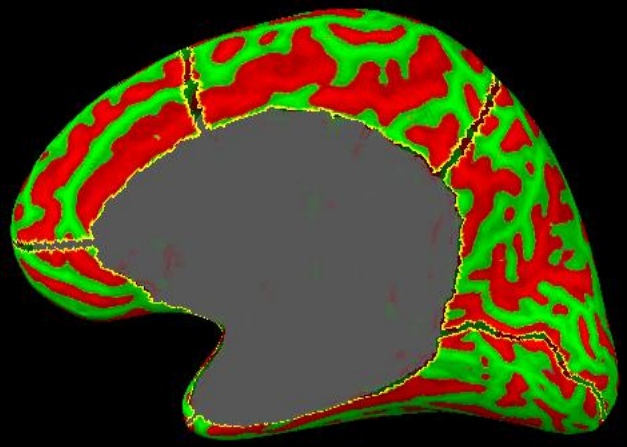




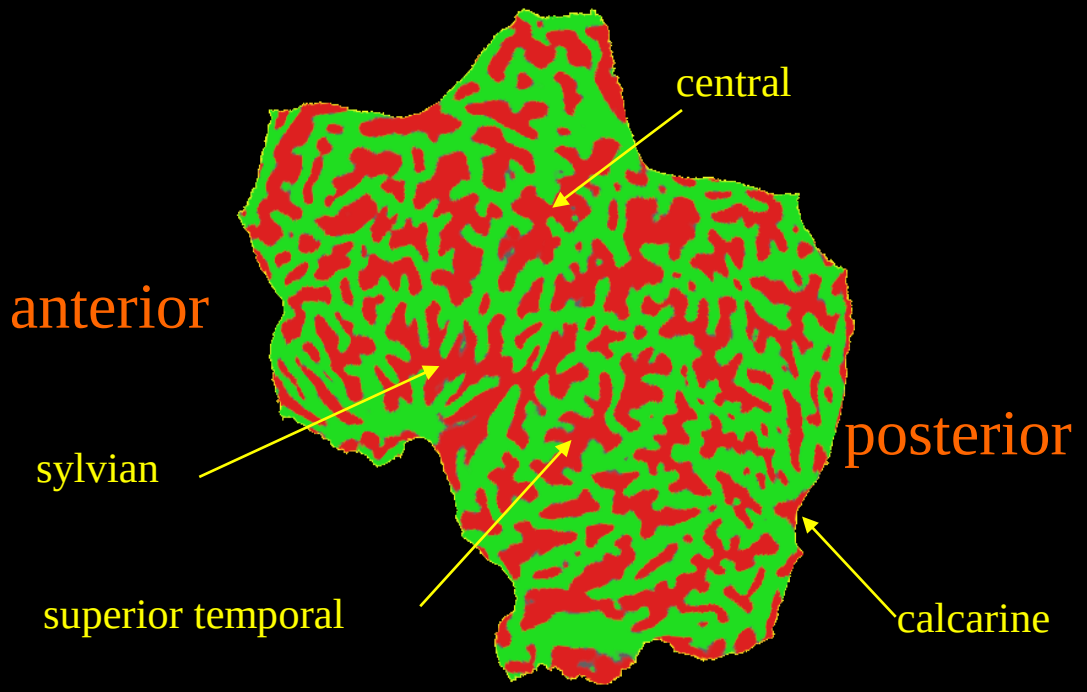
Inflation



Surface Flattening – Whole Hemisphere



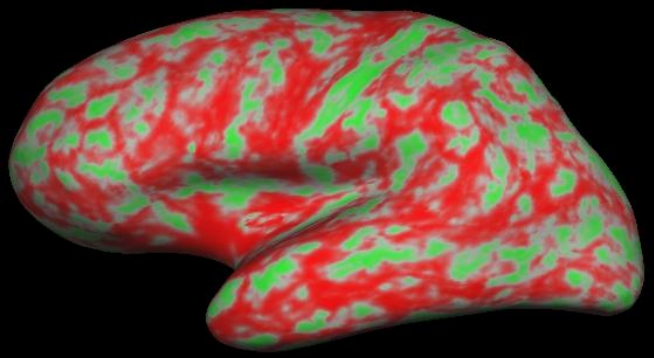
Inflated surface with cuts



Metrically optimal flat map

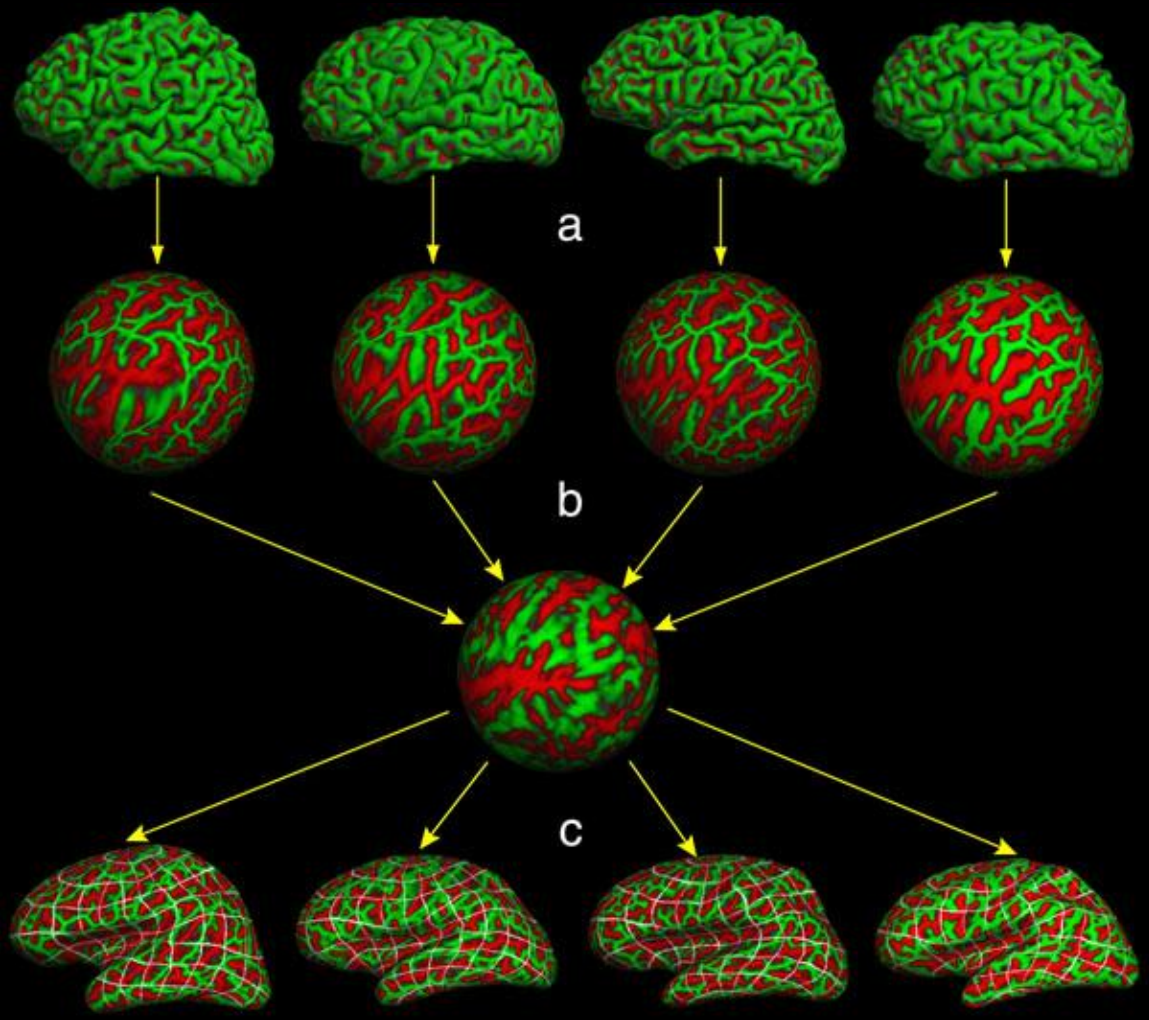
Cortical Thickness

- Distance between white and pial surfaces
- One value per vertex

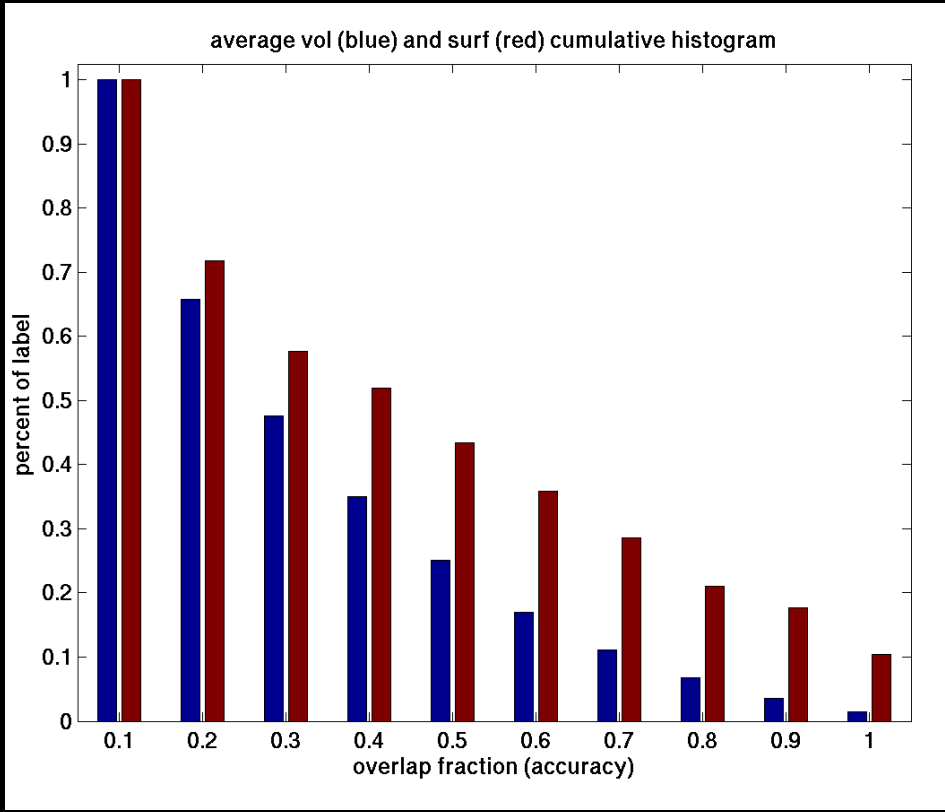


lh.thickness, rh.thickness

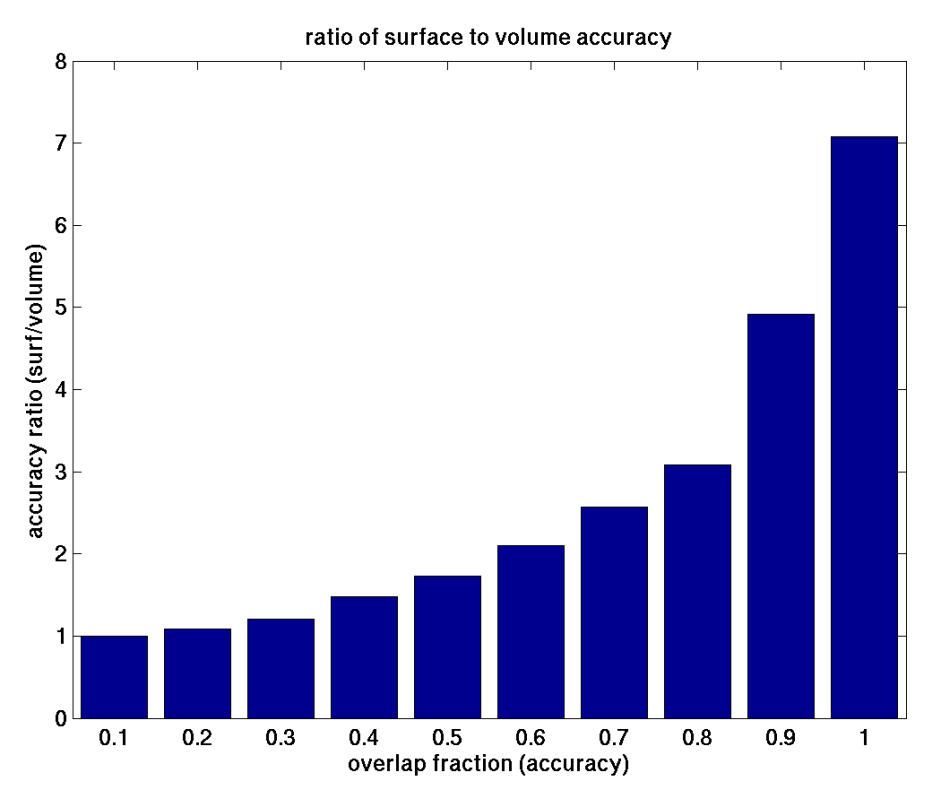
A Surface-Based Coordinate System



Comparing Coordinate Systems and Brodmann Areas

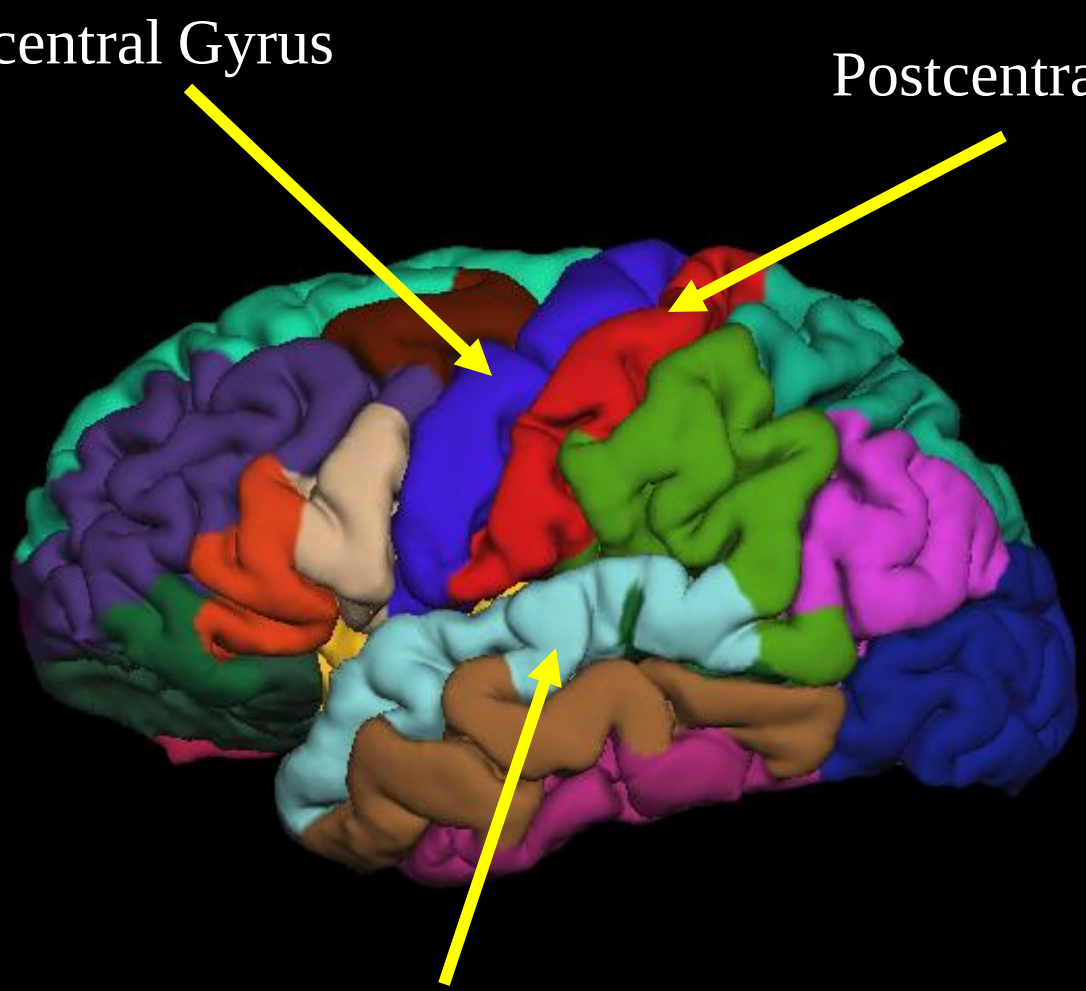


Cumulative histogram (red=surface, blue=nonlinear Talairach)



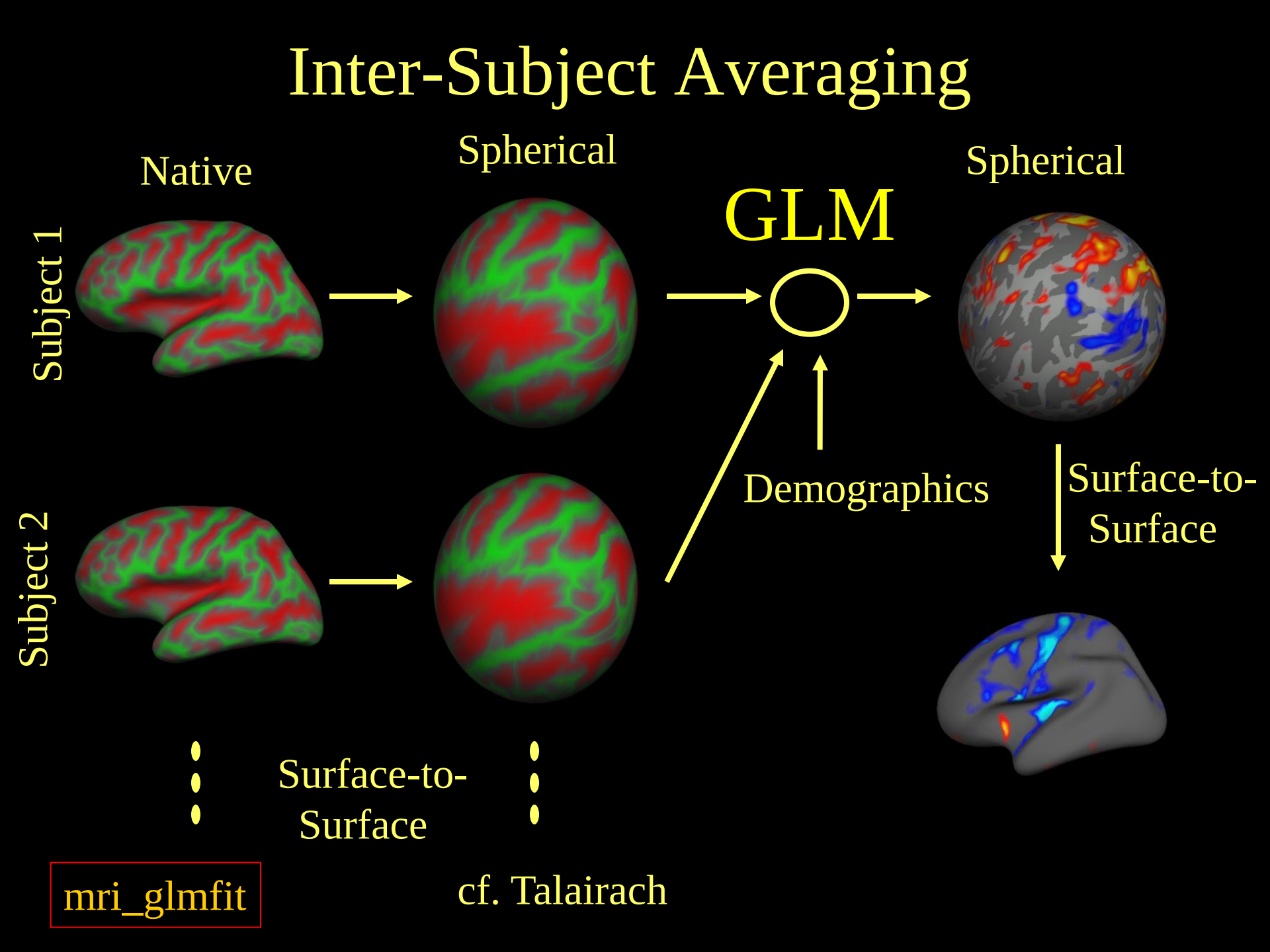
Ratio of surface accuracy to volume accuracy

Automatic Surface Segmentation

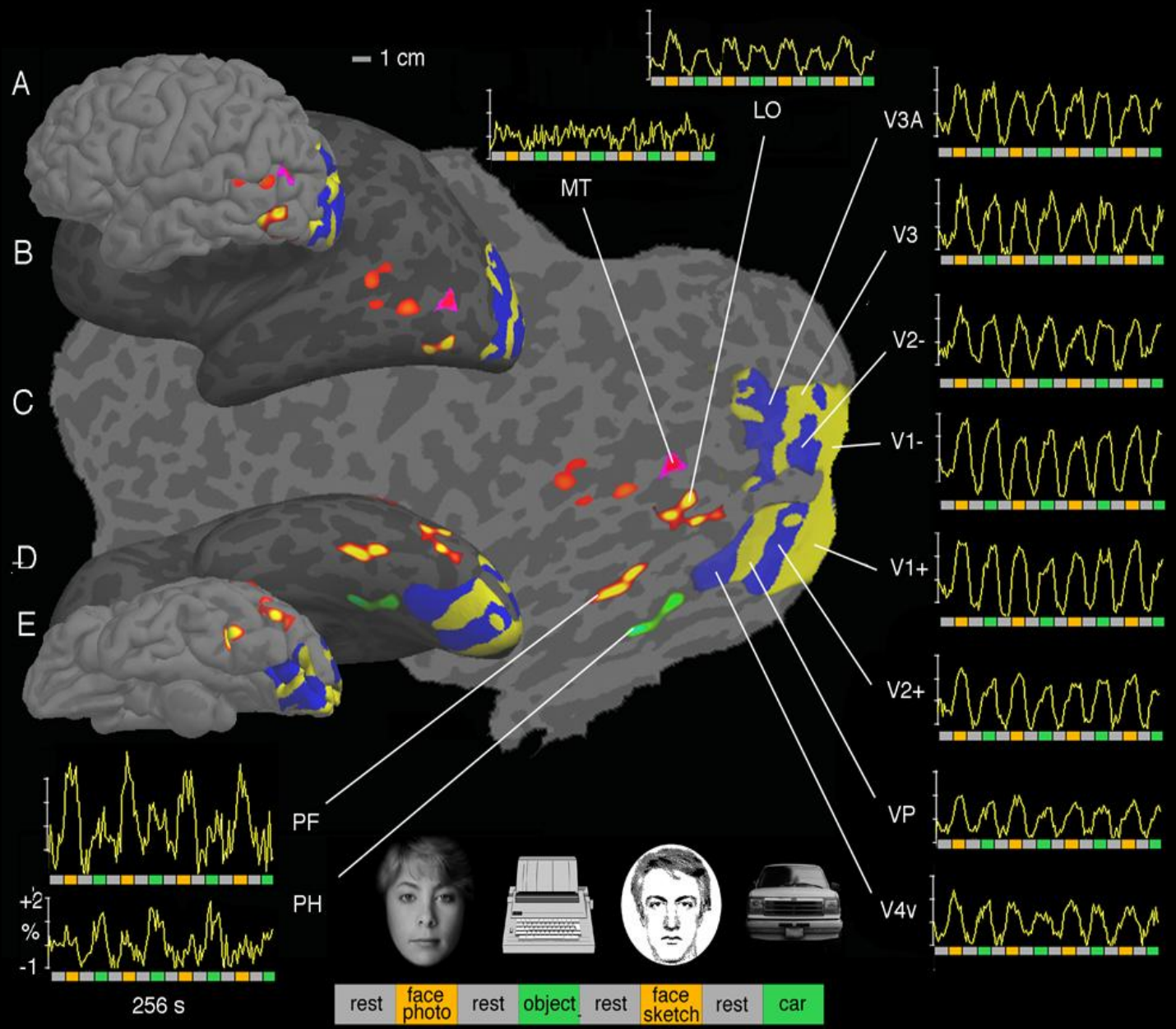


Based on individual's folding pattern

Inter-Subject Averaging

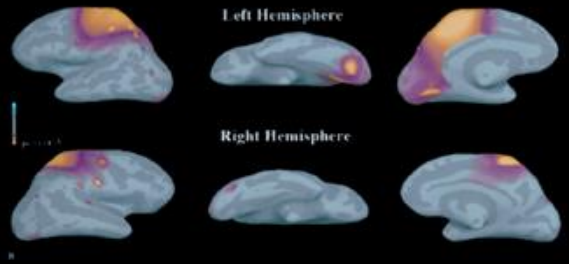


Visualization



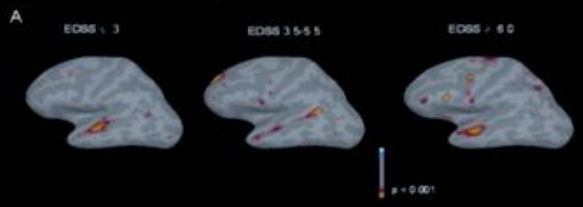
Borrowed from (Halgren et al., 1999)

Huntington's Disease



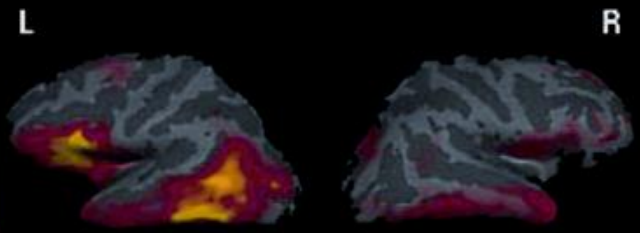
Rosas et al., 2002

Multiple Sclerosis

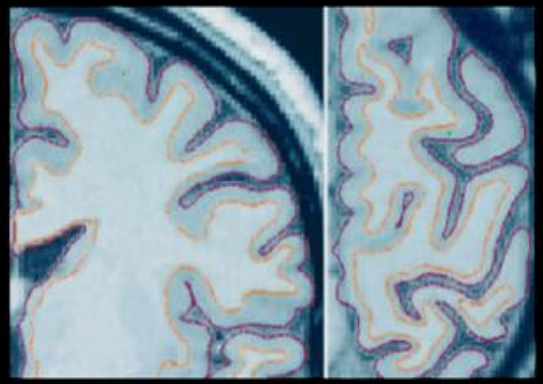


Sailer et al., 2003

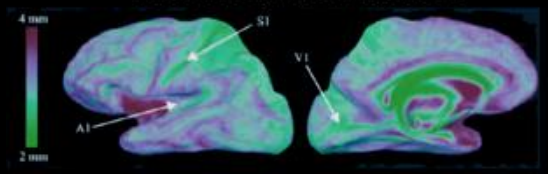
Schizophrenia



Kuperberg et al., 2003

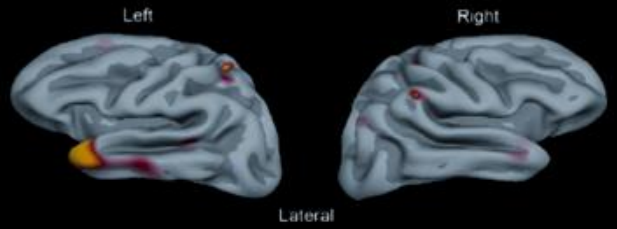


Normal Variation



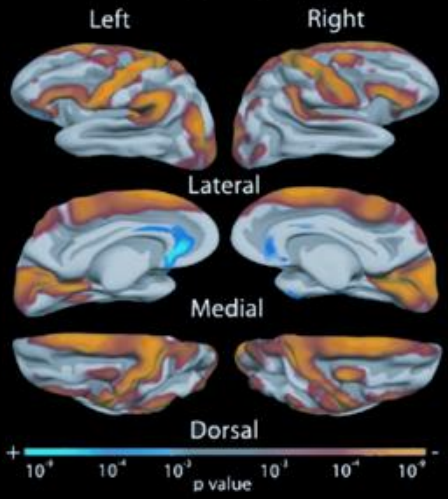
Fischl et al., 2000

Semantic Dementia



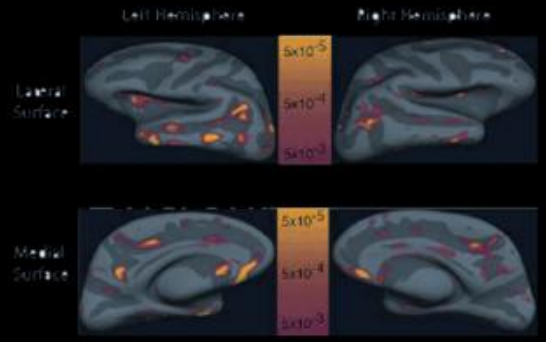
Gold et al., 2005

Aging



Salat et al., 2004

Animal Phobia



Rauch et al., 2004

Talk Outline

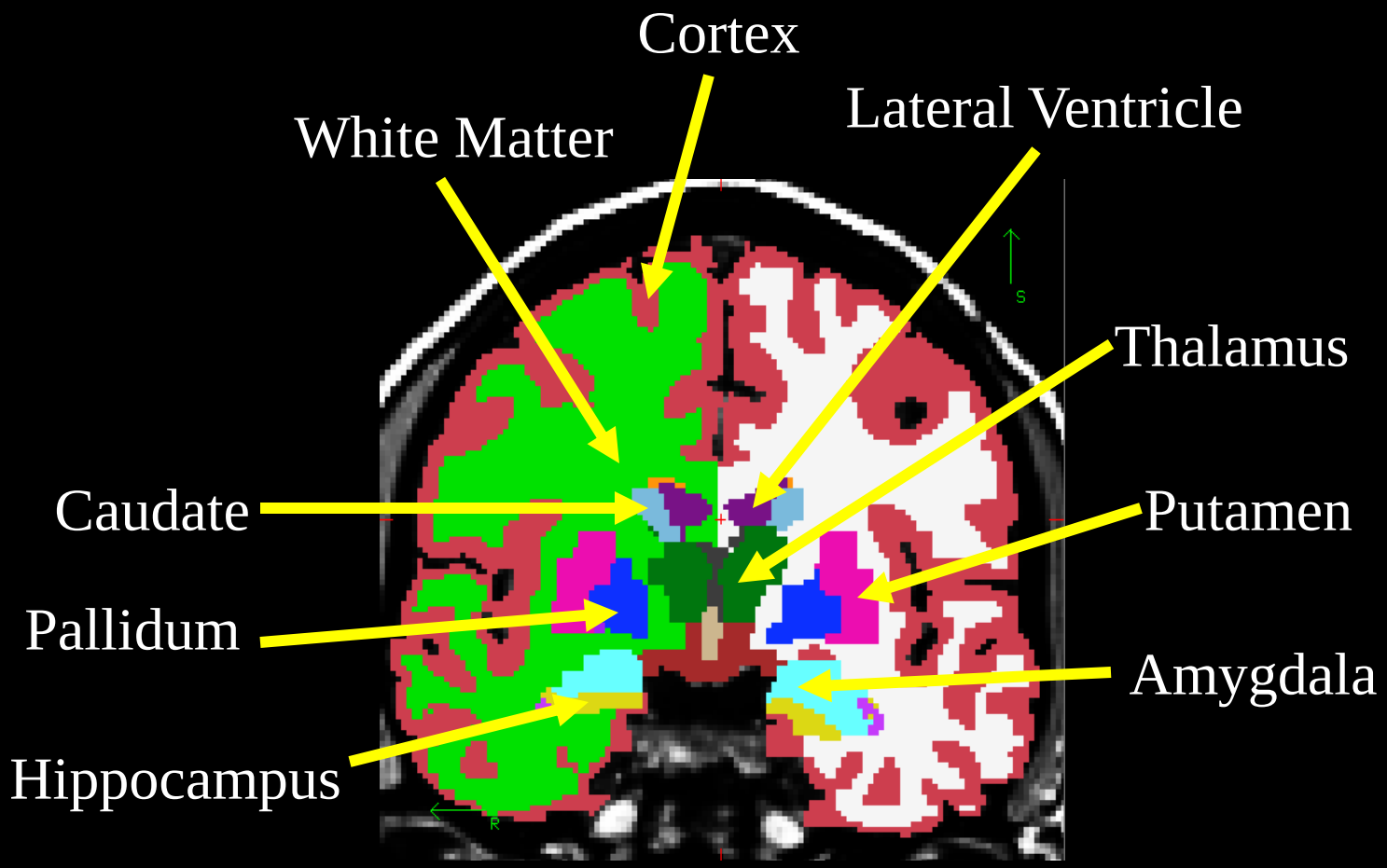
1. Cortical (surface-based) Analysis.
2. Volume Analysis.

Volume Analysis: Automatic Individualized Segmentation

Surface-based coordinate system/registration appropriate for cortex but not for thalamus, ventricular system, basal ganglia, etc…

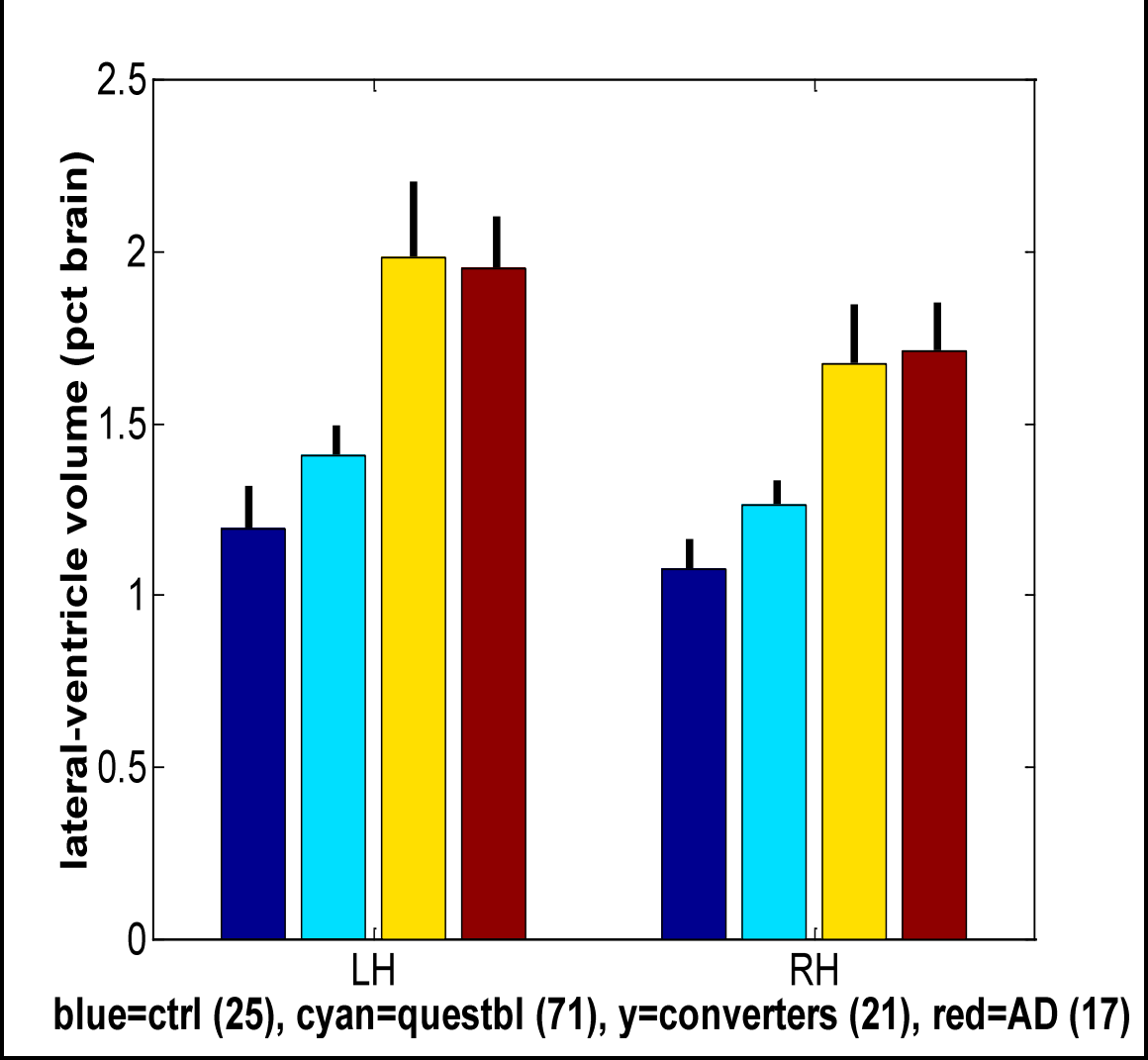
Anatomy is extremely variable – measuring the variance and accounting for it is critical (more in the individual subject talk)!

Volumetric Segmentation (aseg)



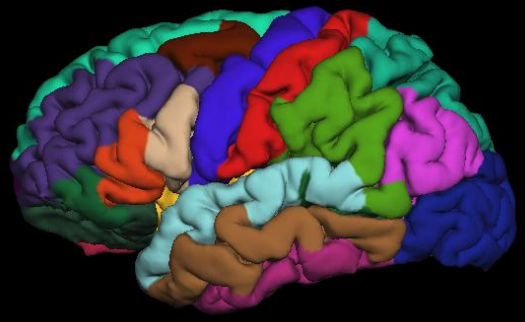
Not Shown:
Nucleus Accumbens
Cerebellum

Volume Differences Predictive of AD

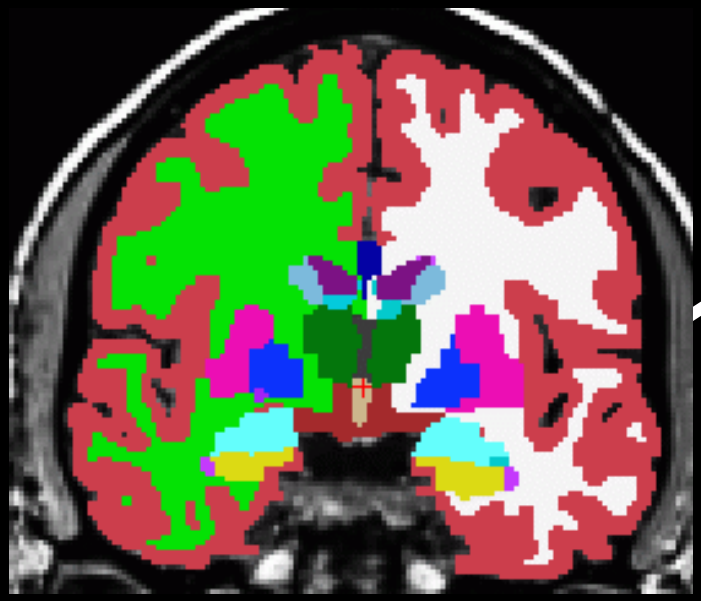


Data courtesy of Drs Marilyn Albert and Ron Killiany

Combined Segmentation



aparc

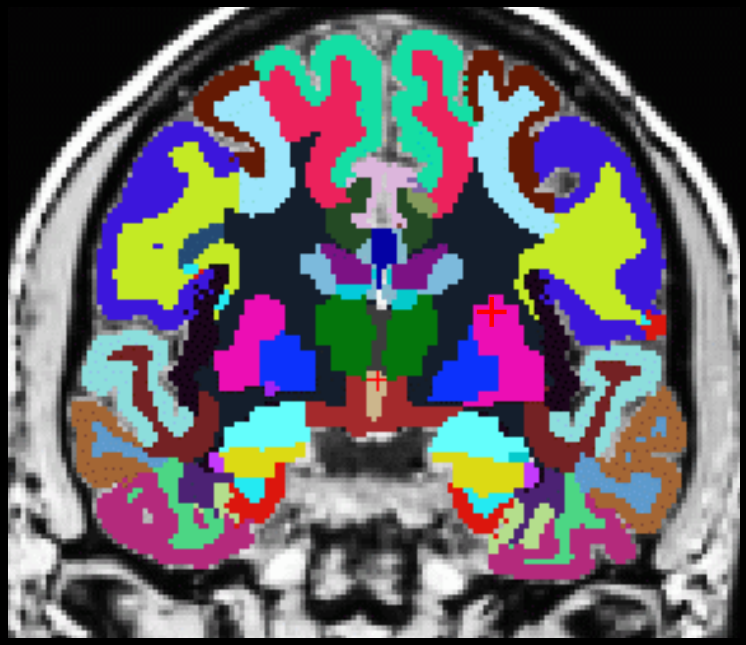


aseg

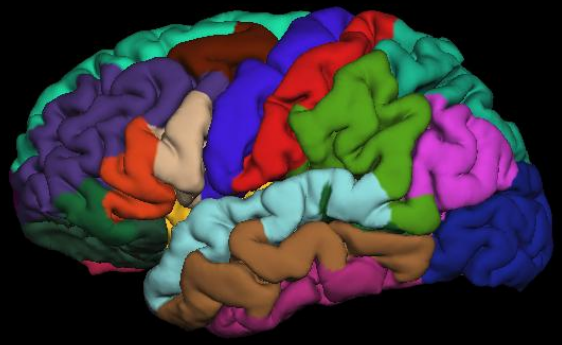
aparc+aseg

Gyral White Matter Segmentation

aparc+aseg



wmparc



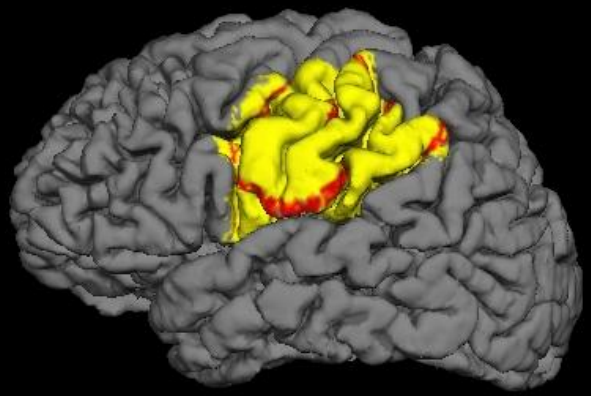
aparc

Nearest Cortical Label
to point in White Matter

Summary

- Why Surface-based Analysis?
  - Function has surface-based organization
  - Visualization: Inflation/Flattening
  - Cortical Morphometric Measures
  - Inter-subject registration
- Automatically generated ROI tuned to each subject individually

Use FreeSurfer



Be Happy

Acknowledgements

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Mert Sabuncu
Florent Segonne
Peng Yu
Ramesh Sridharan

UC San Diego

Anders Dale

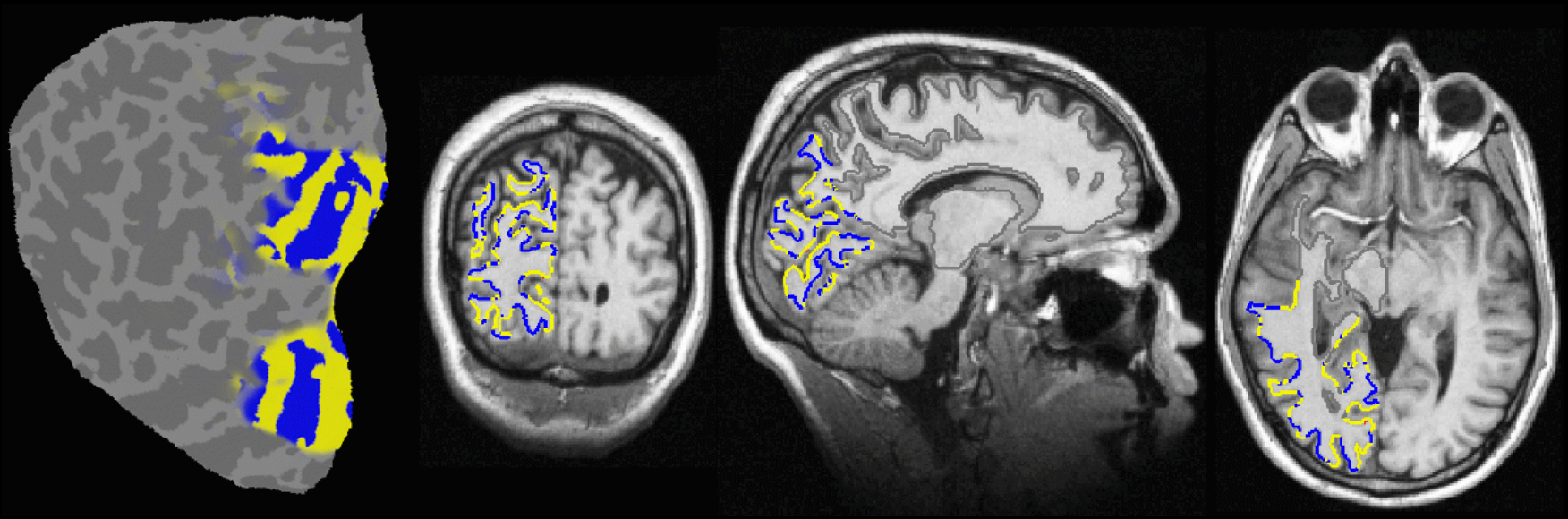
UCL

Marty Sereno

NINDS

Why Is a Model of the Cortical Surface Useful?

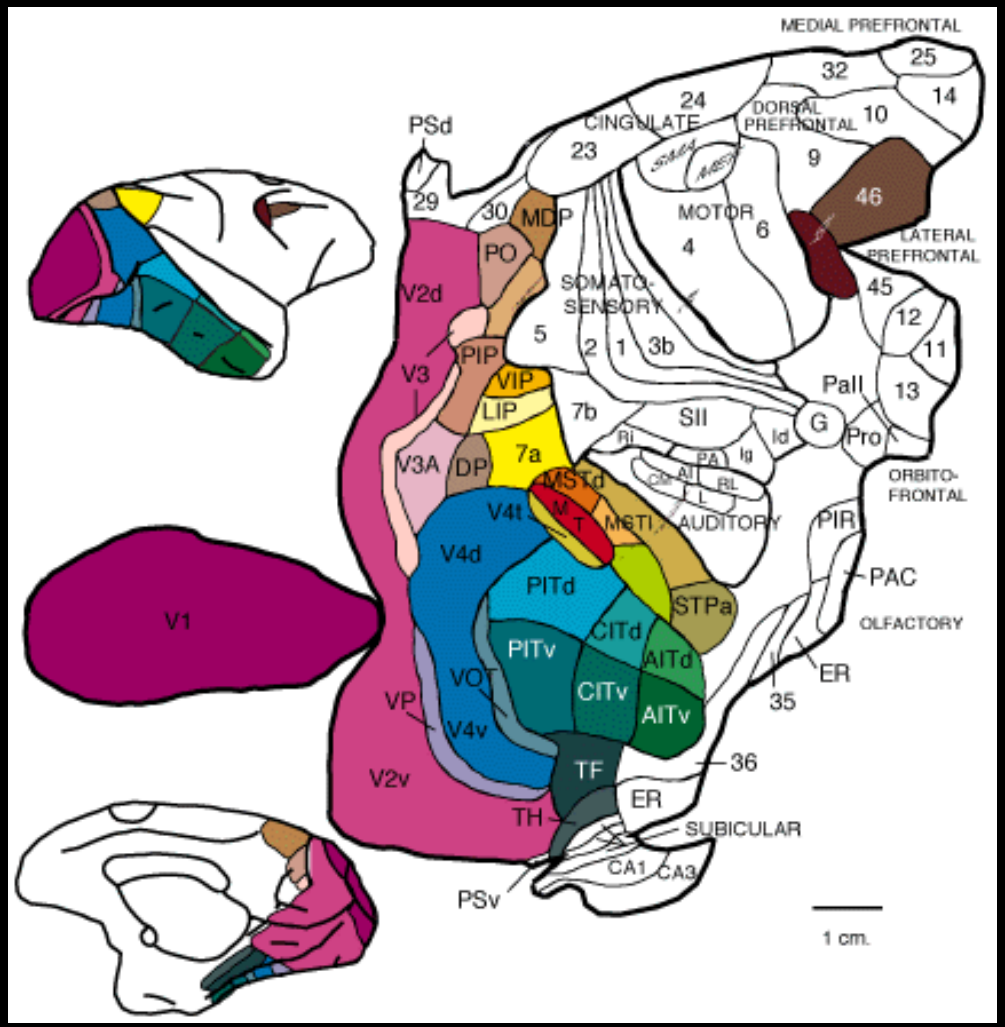
Local functional organization of cortex is largely 2-dimensional! Eg, functional mapping of primary visual areas:



From (Sereno et al, 1995, Science).

Also, smooth along surface

Flat Map of Monkey Visual Areas



D.J. Felleman and D.C. Van Essen, CC, 1991