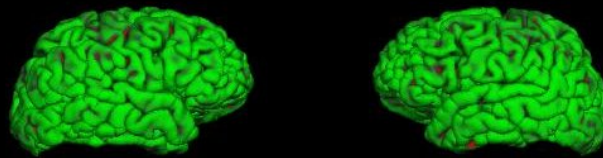
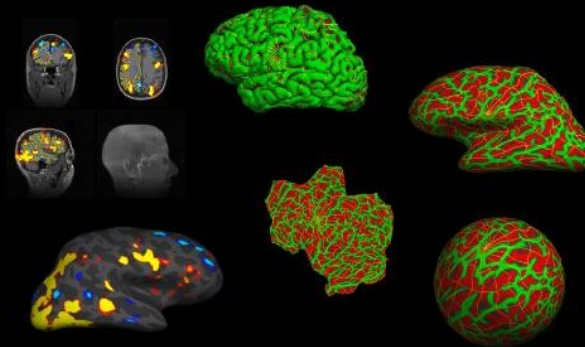


# Introduction to FreeSurfer

[surfer.nmr.mgh.harvard.edu](http://surfer.nmr.mgh.harvard.edu)



**FreeSurfer**



MASSACHUSETTS  
GENERAL HOSPITAL



# Post Your Questions!

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

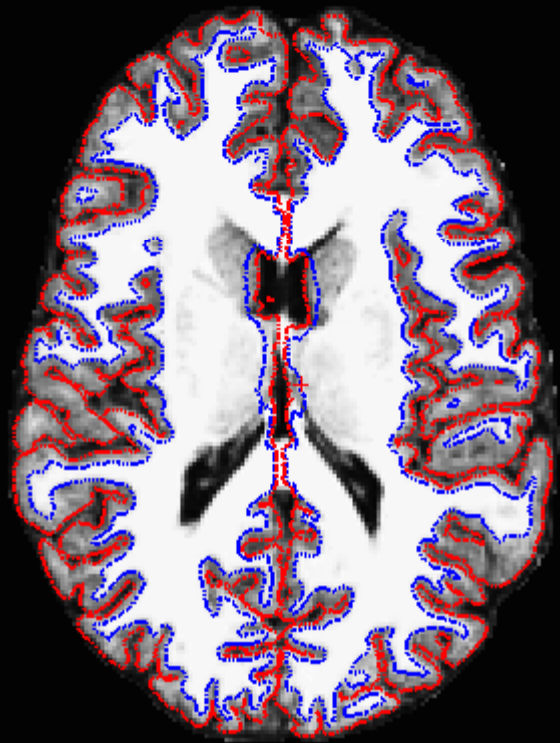
# To Caffeinate or not to Caffeinate?

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

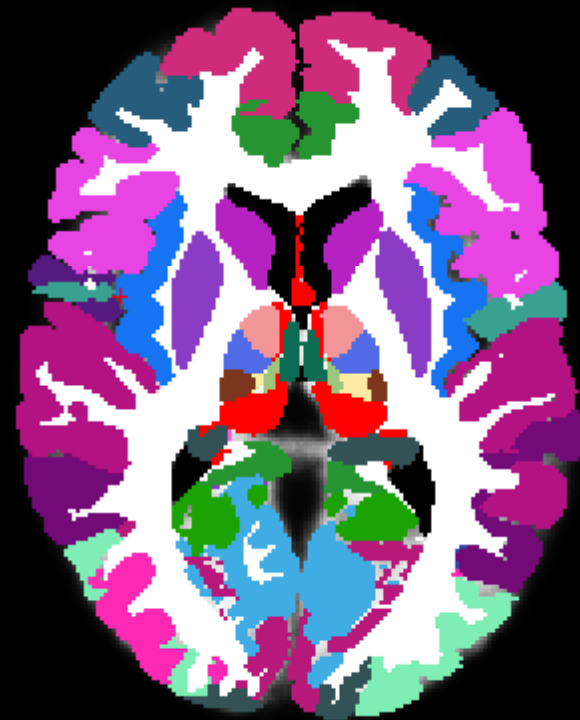
# Why FreeSurfer?

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?



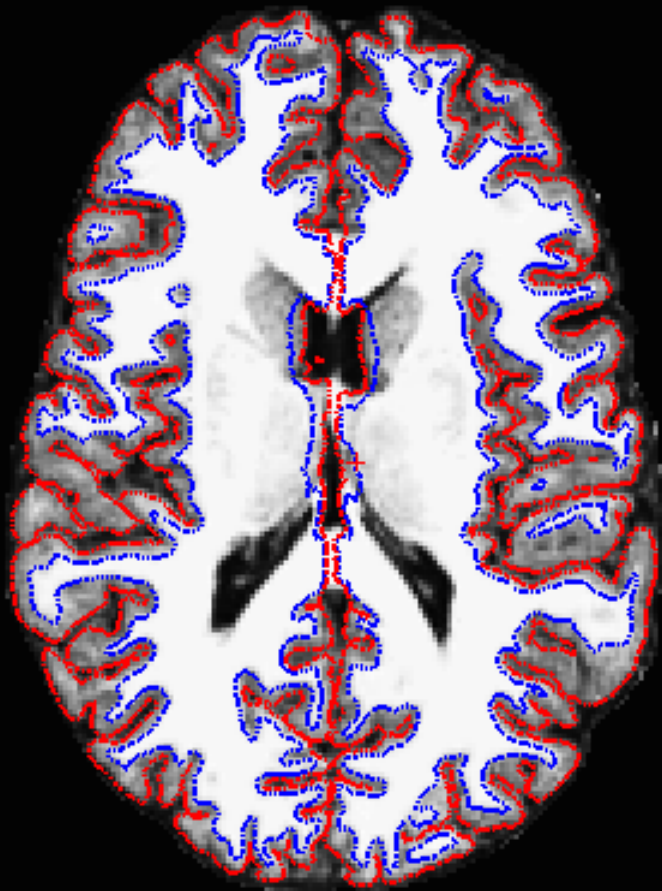
12 DOF  
(Affine)



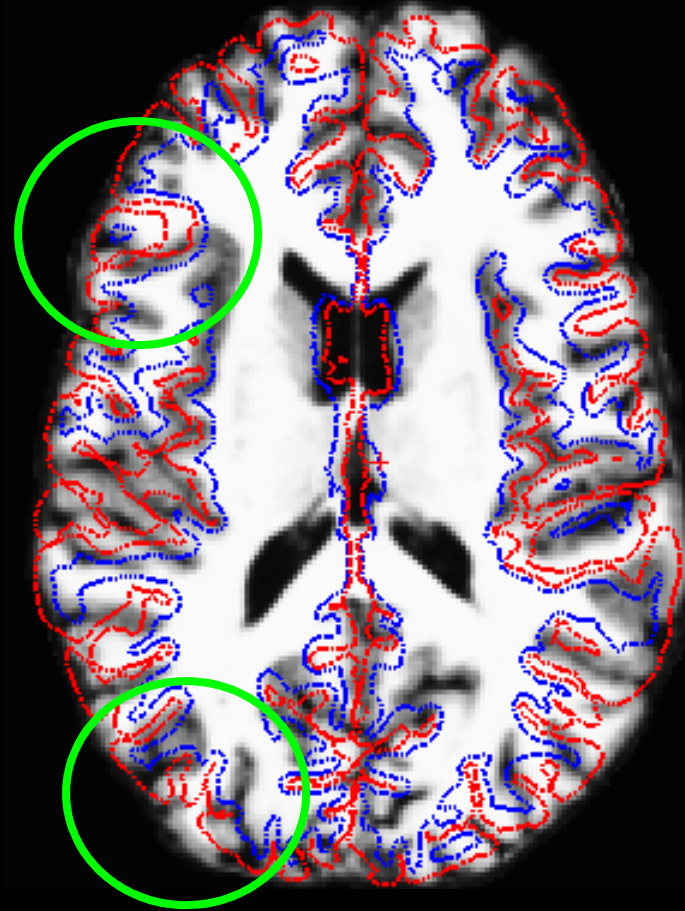
ICBM Atlas

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

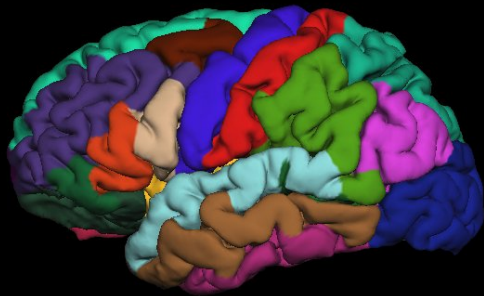
Subject 1



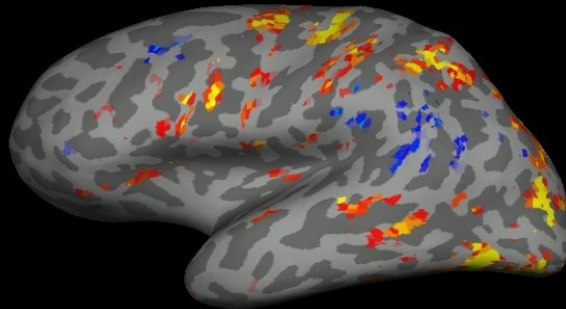
Subject 2 aligned with Subject 1  
(Subject 1's Surface)



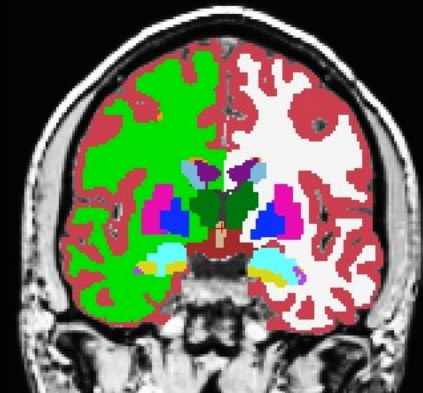
# Surface and Volume Analysis



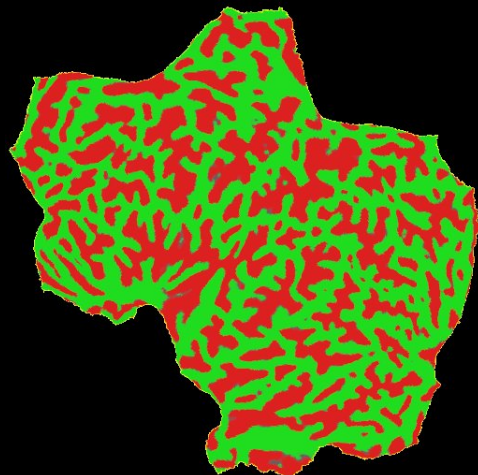
Cortical Reconstruction  
and Automatic Labeling



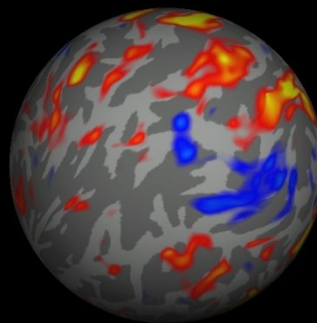
Inflation and Functional  
Mapping



Automatic Subcortical  
Gray Matter Labeling



Surface Flattening



Surface-based Intersubject  
Alignment and Statistics



Automatic Gyral White  
Matter Labeling

# Talk Outline

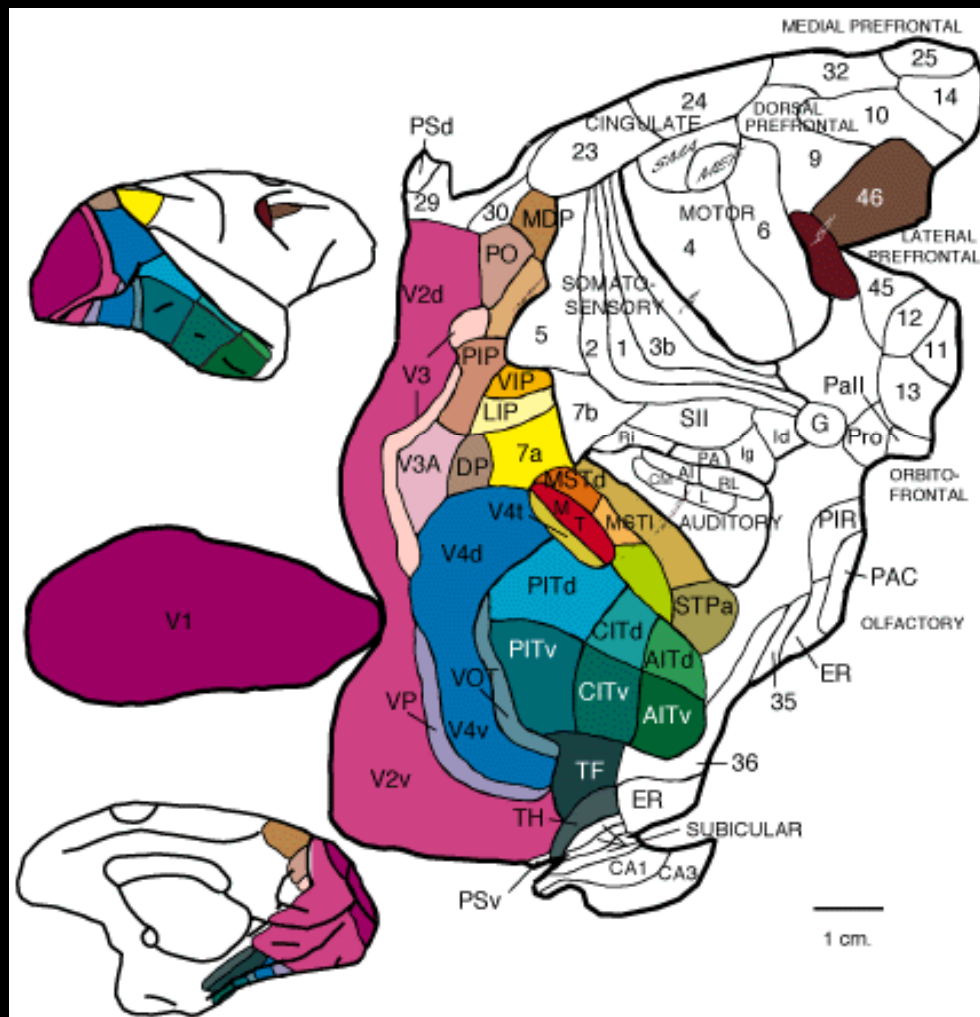
1. **Cortical (surface-based) Analysis.**
2. **Volume Analysis.**



# Talk Outline

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

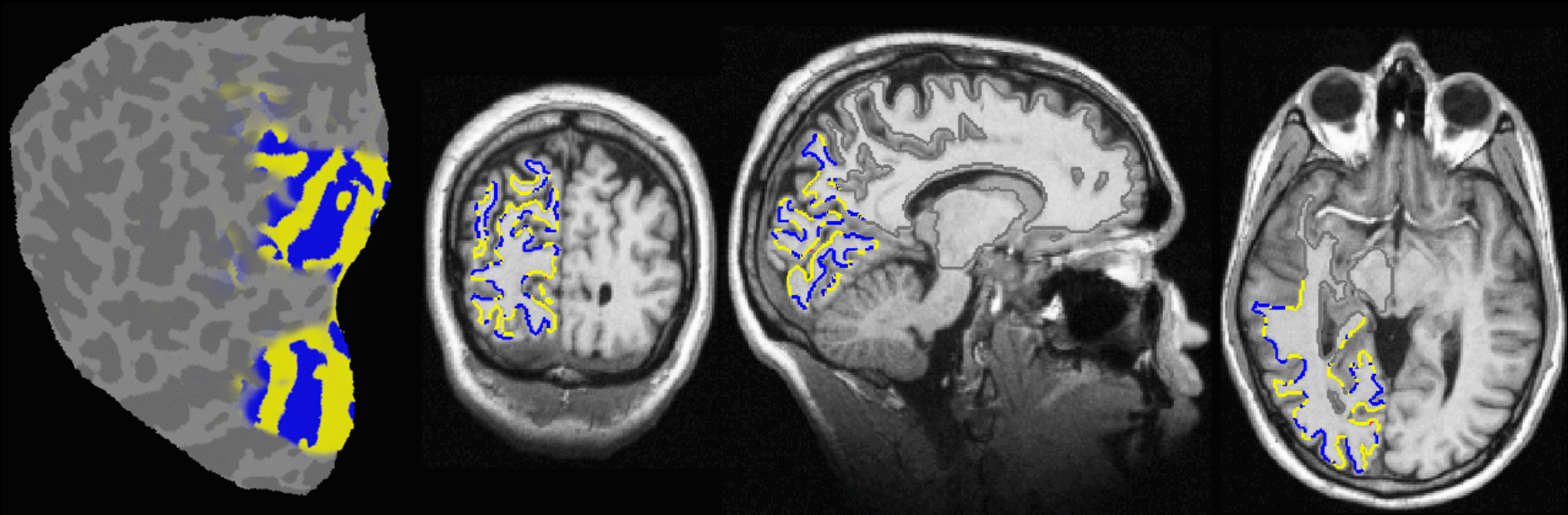
# Flat Map of Monkey Visual Areas



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

# Why Is a Model of the Cortical Surface Useful?

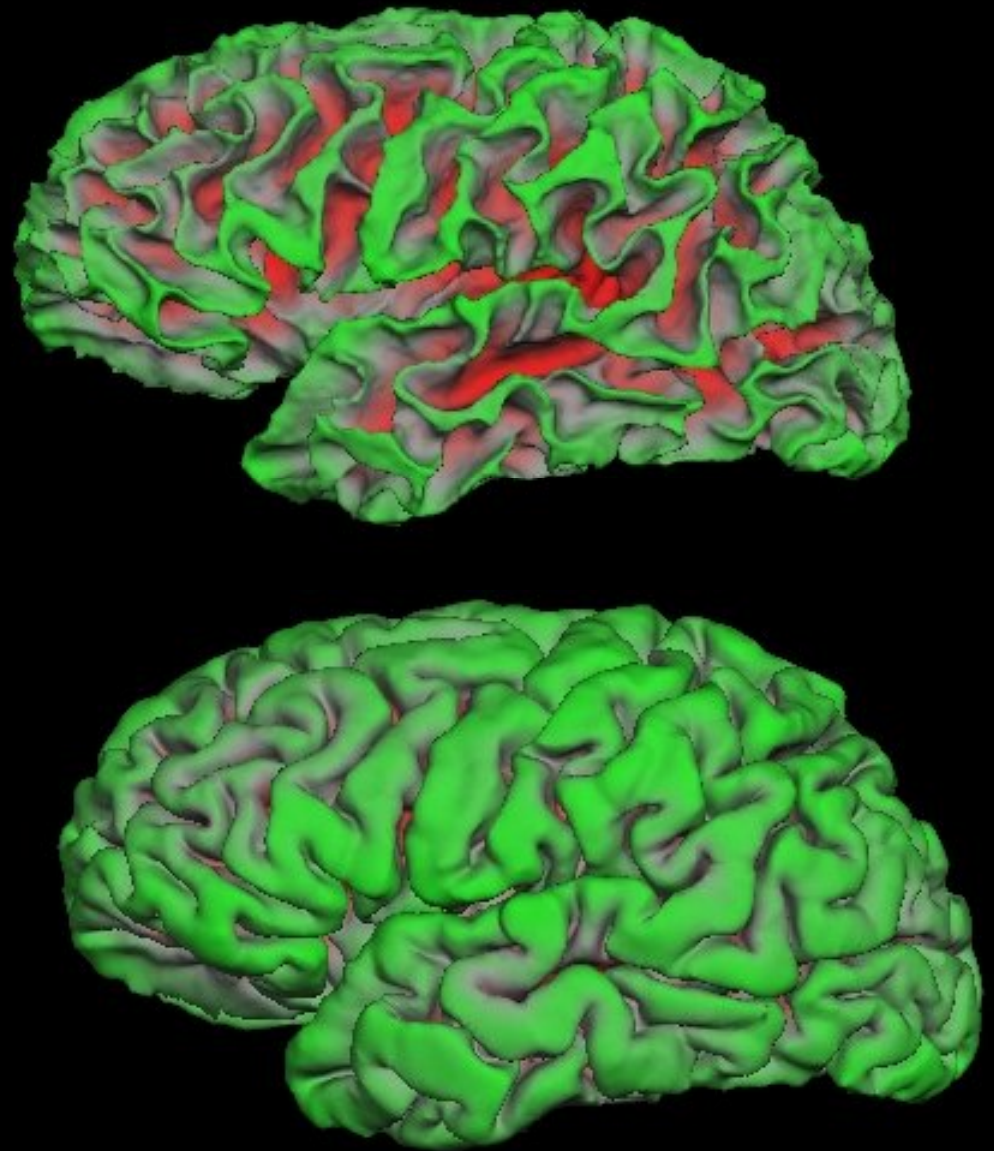
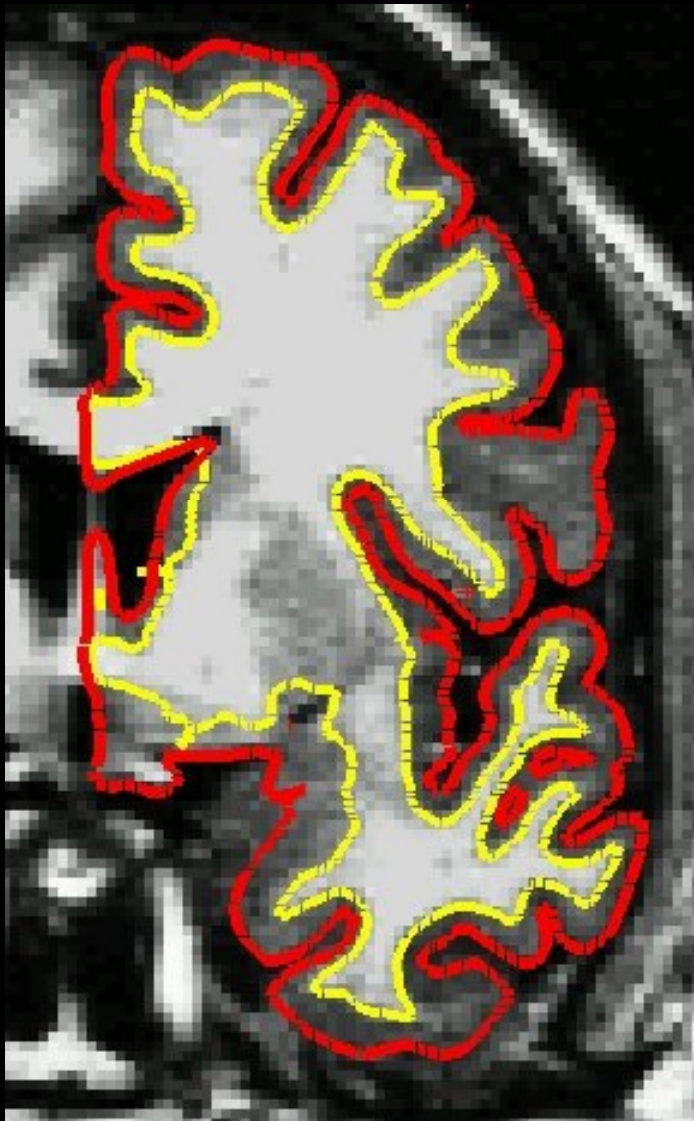
Local functional organization of cortex is largely 2-dimensional! Eg, functional mapping of primary visual areas:



From (Sereno et al, 1995, Science).

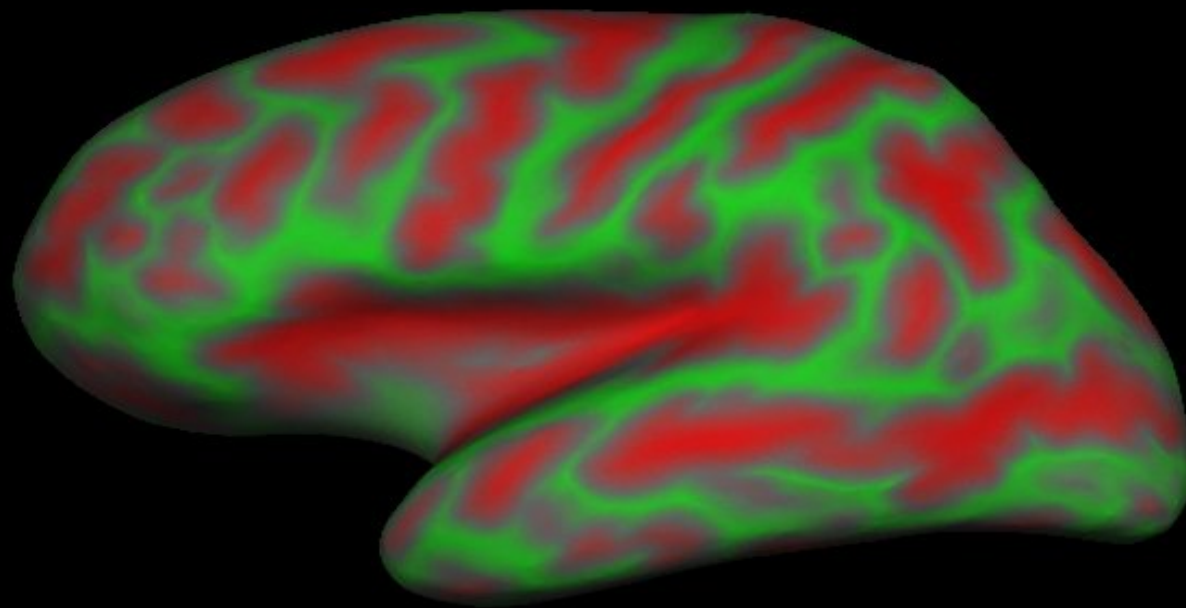
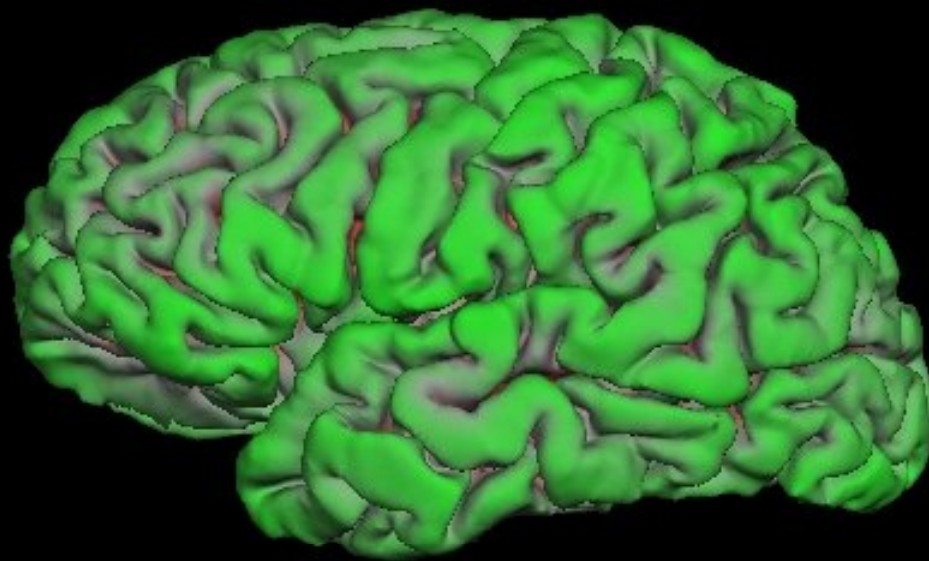
Also, smooth along surface

# Surfaces: White and Pial

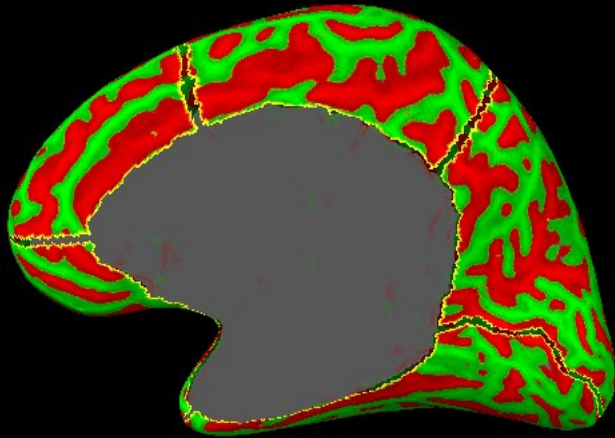




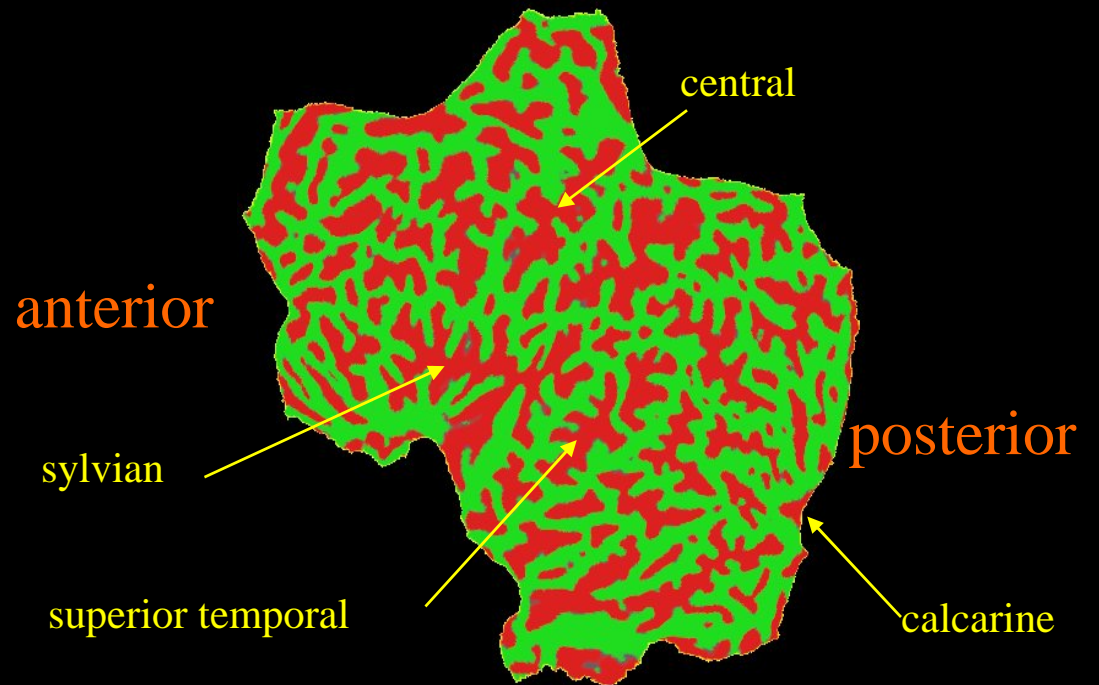
# Inflation



# Surface Flattening – Whole Hemisphere



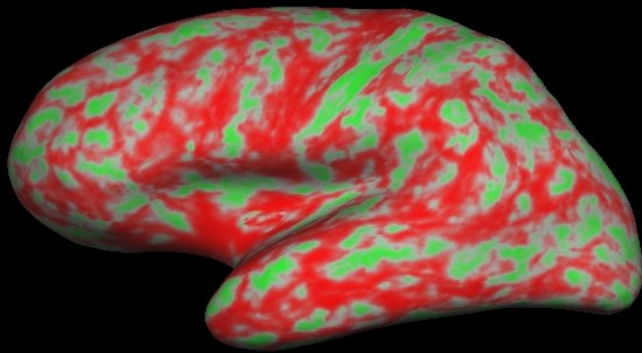
Inflated surface with cuts



Metrically optimal flat map

# Cortical Thickness

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

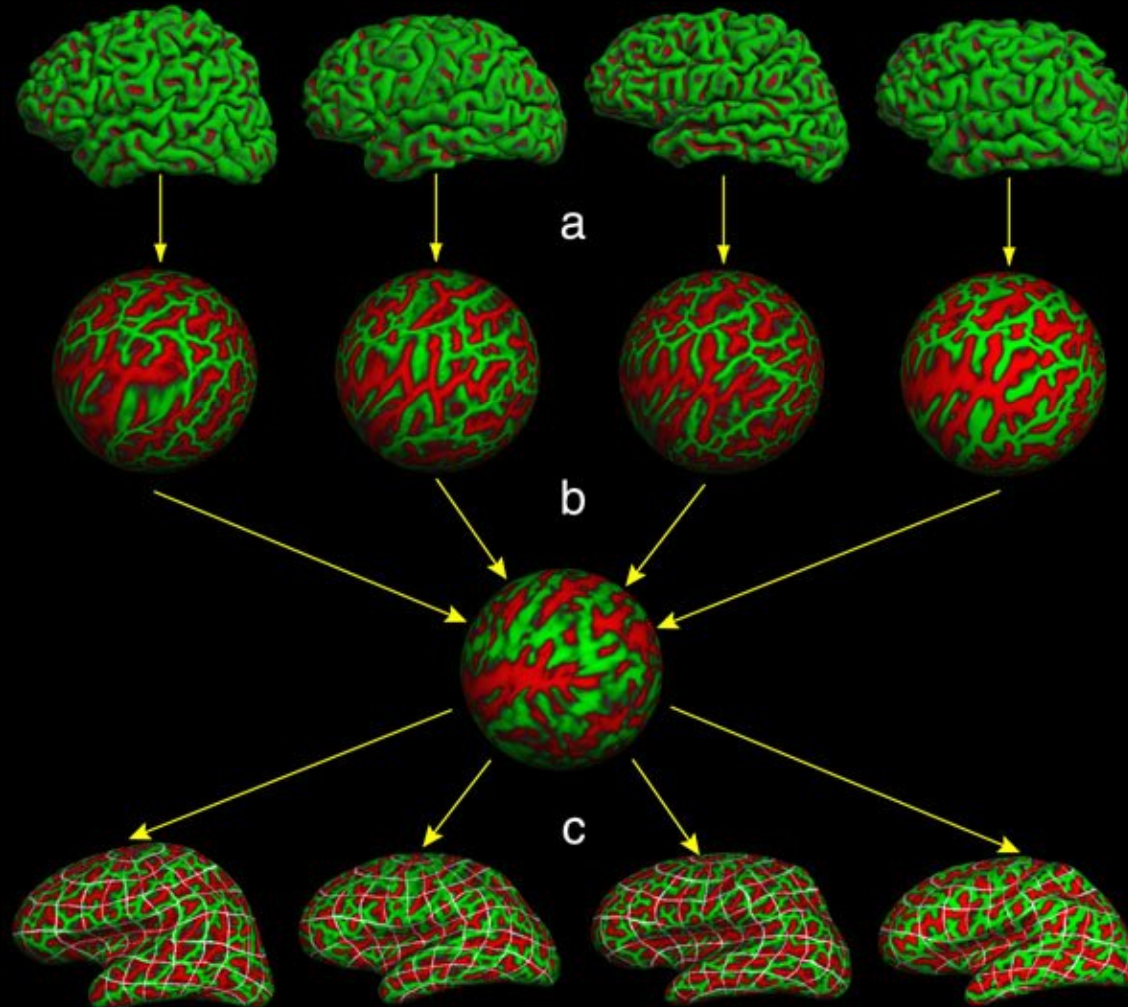


white/gray surface

lh.thickness, rh.thickness

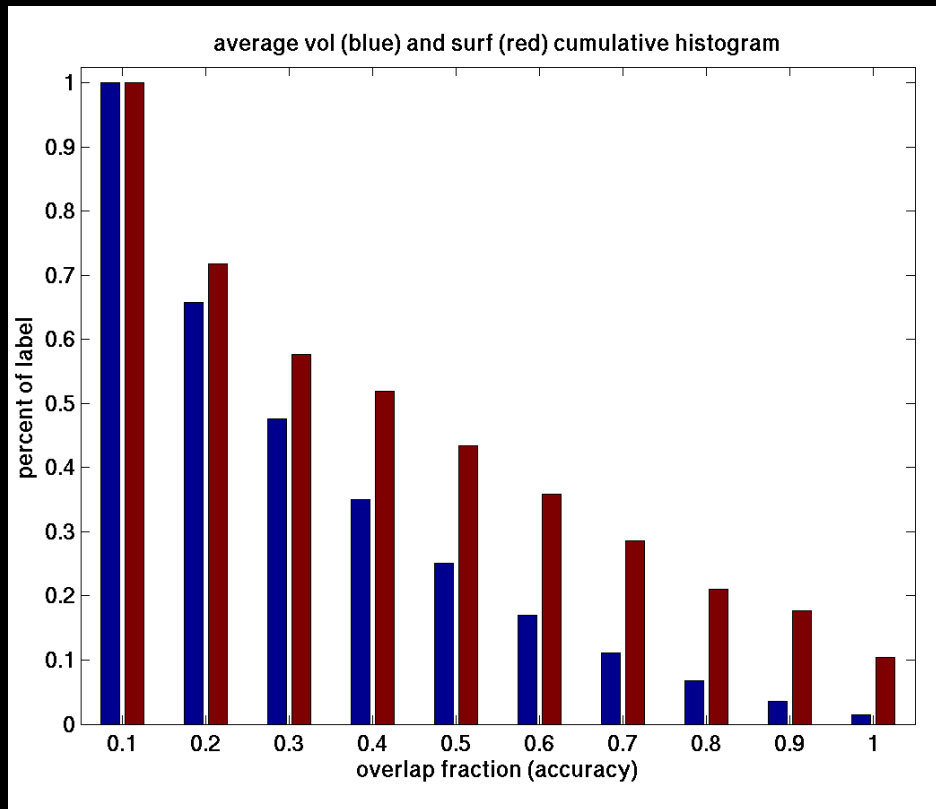


# A Surface-Based Coordinate System

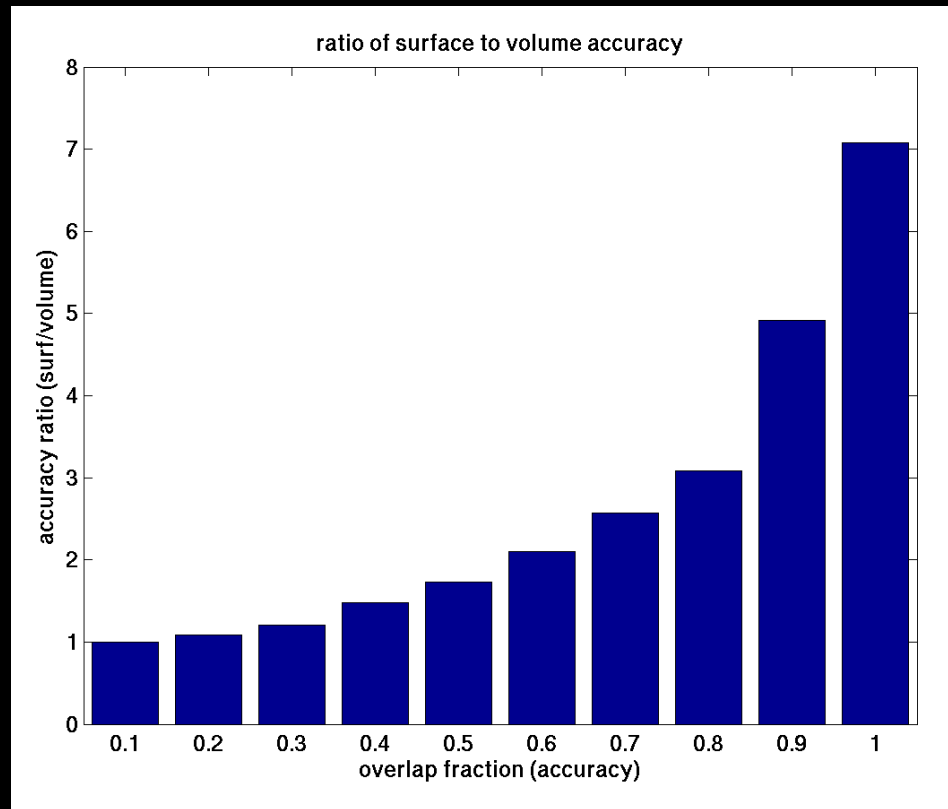




# Comparing Coordinate Systems and Brodmann Areas



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

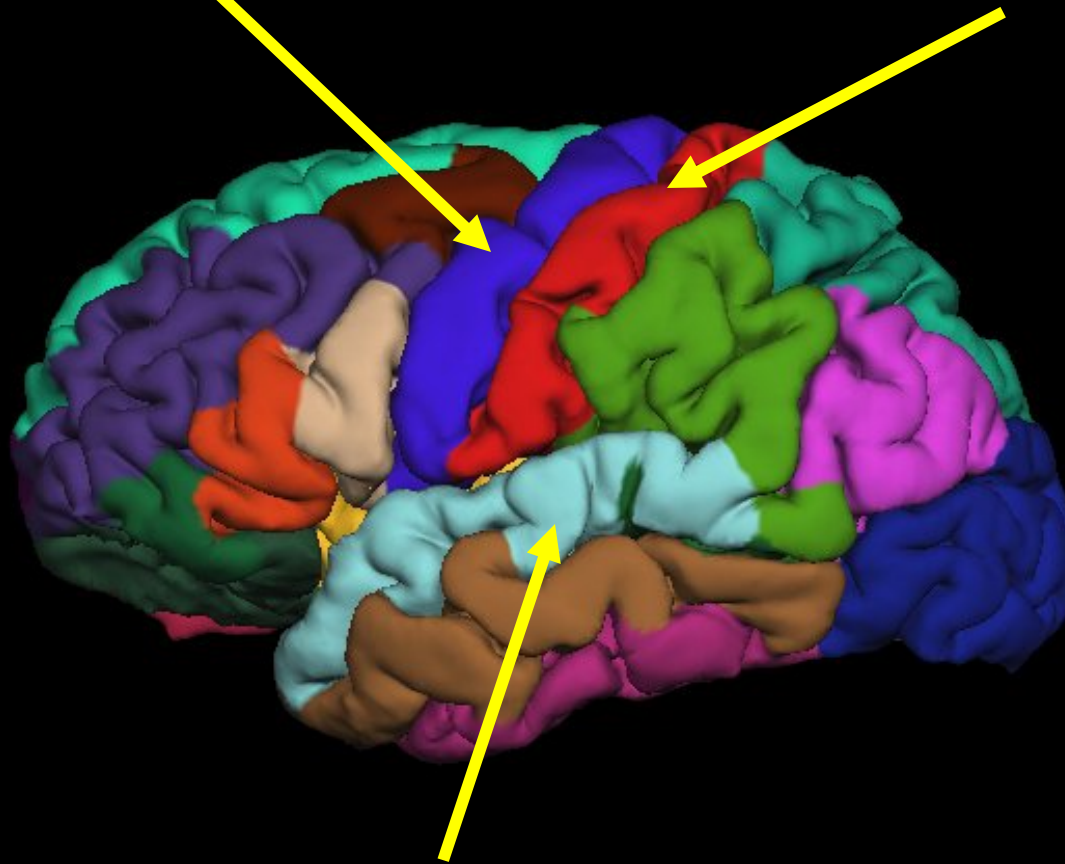


Ratio of surface accuracy to  
volume accuracy

# Automatic Surface Segmentation

Precentral Gyrus

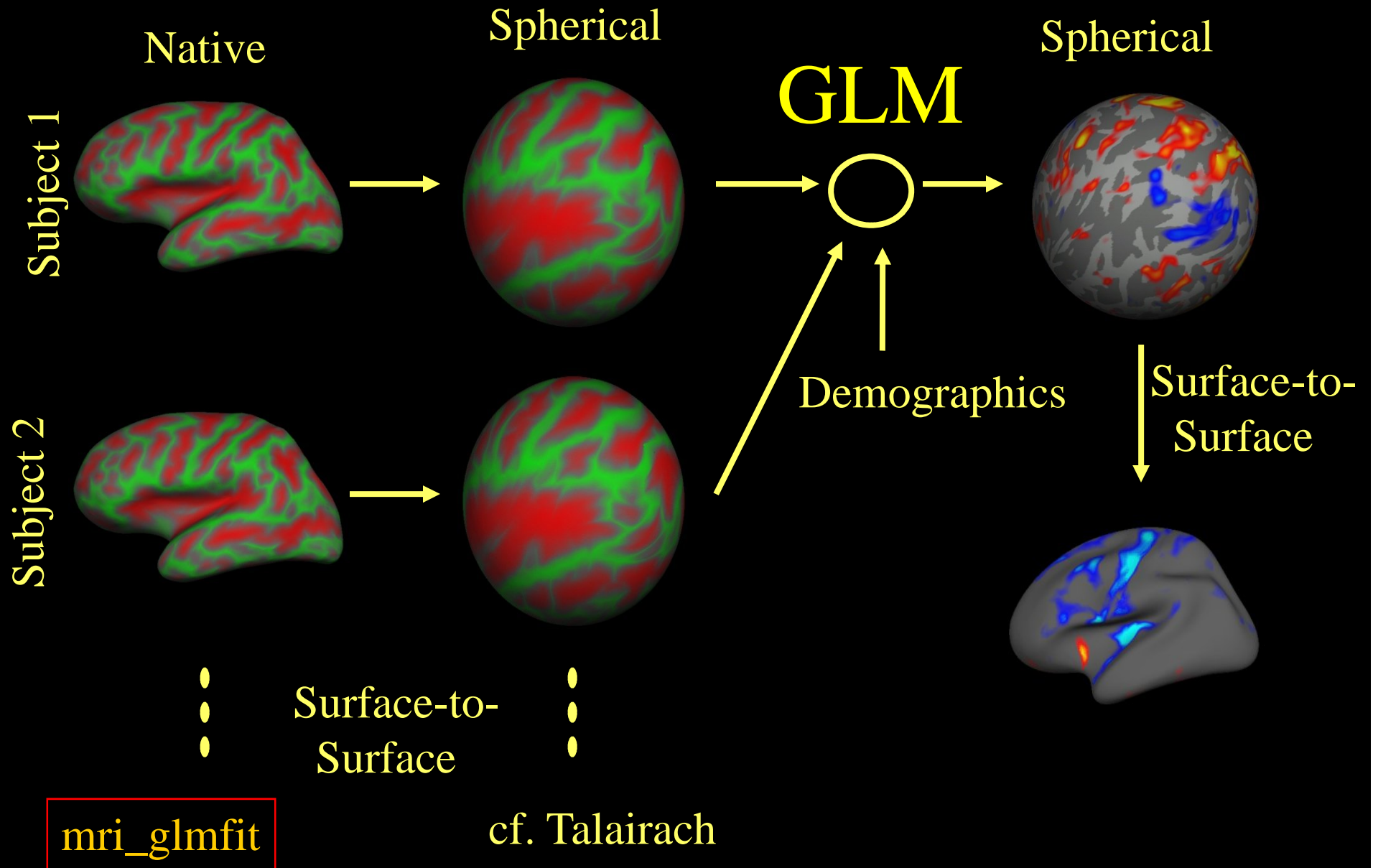
Postcentral Gyrus



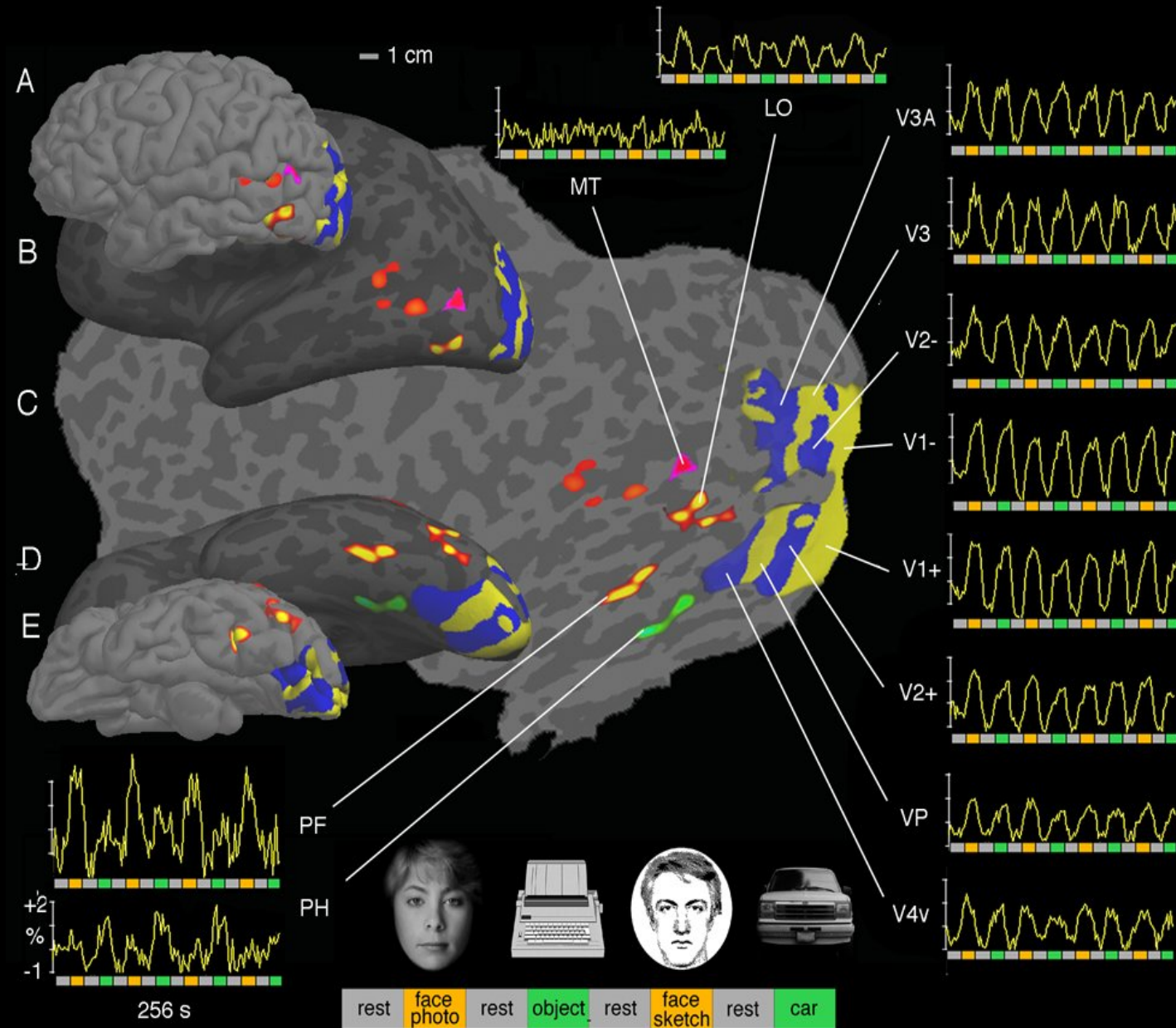
Superior Temporal Gyrus

Based on individual's folding pattern

# Inter-Subject Averaging



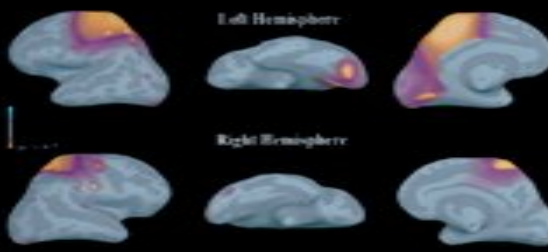
# Visualization



Borrowed from (Halgren et al., 1999)

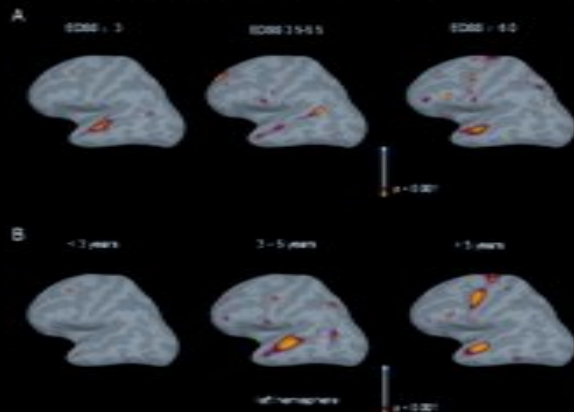


## Huntington's Disease



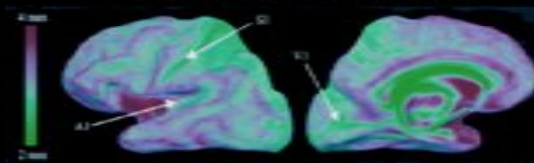
Rosas et al., 2002

## Multiple Sclerosis



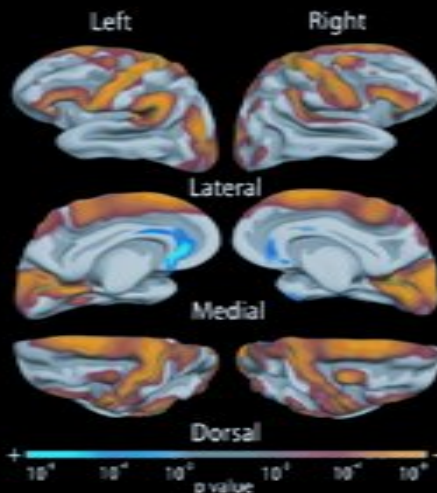
Sailer et al., 2003

## Normal Variation



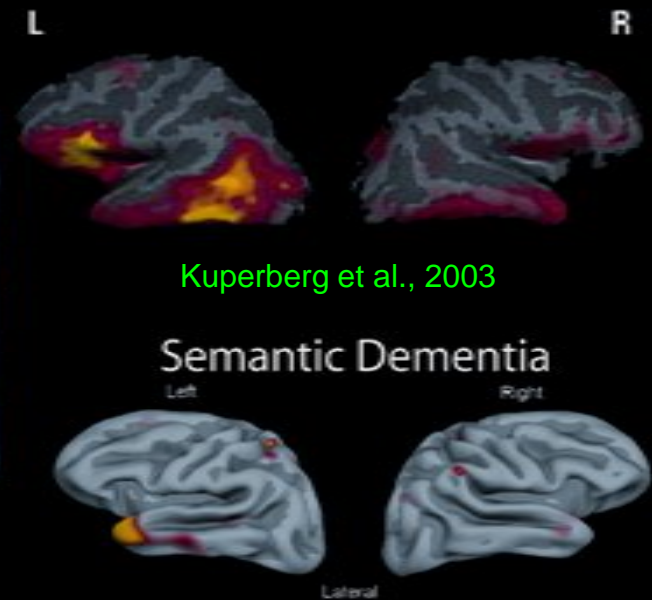
Fischl et al., 2000

## Aging



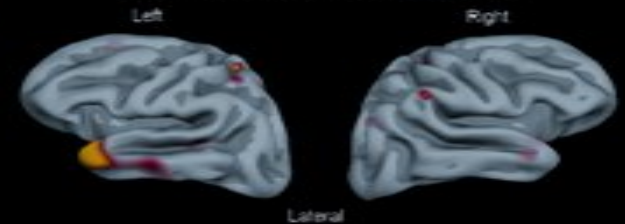
Salat et al., 2004

## Schizophrenia



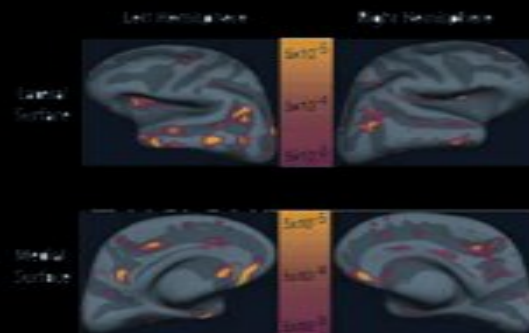
Kuperberg et al., 2003

## Semantic Dementia



Gold et al., 2005

## Animal Phobia



Rauch et al., 2004

# Talk Outline

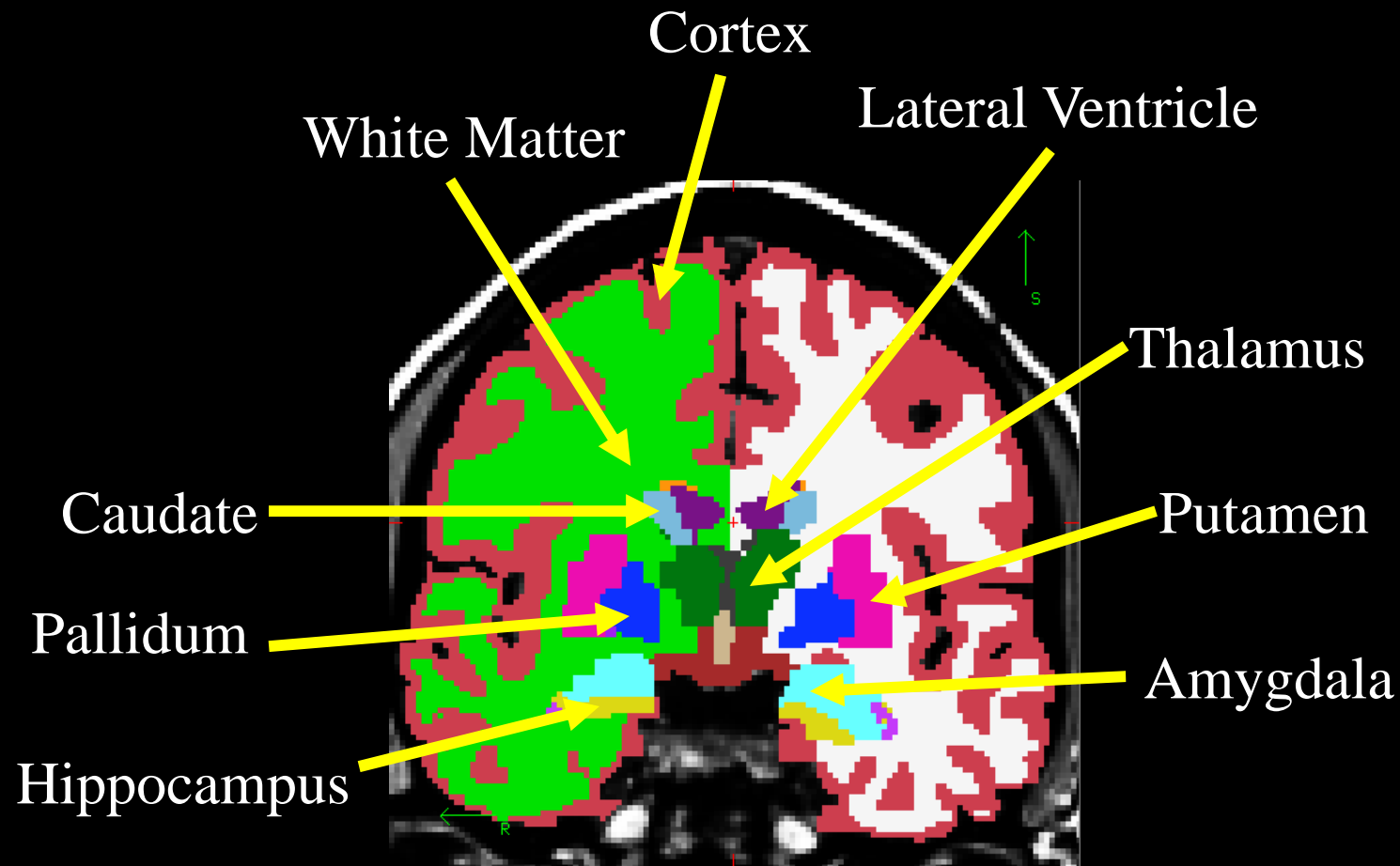
1. Cortical (surface-based) Analysis.
2. Volume Analysis.

# 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)!

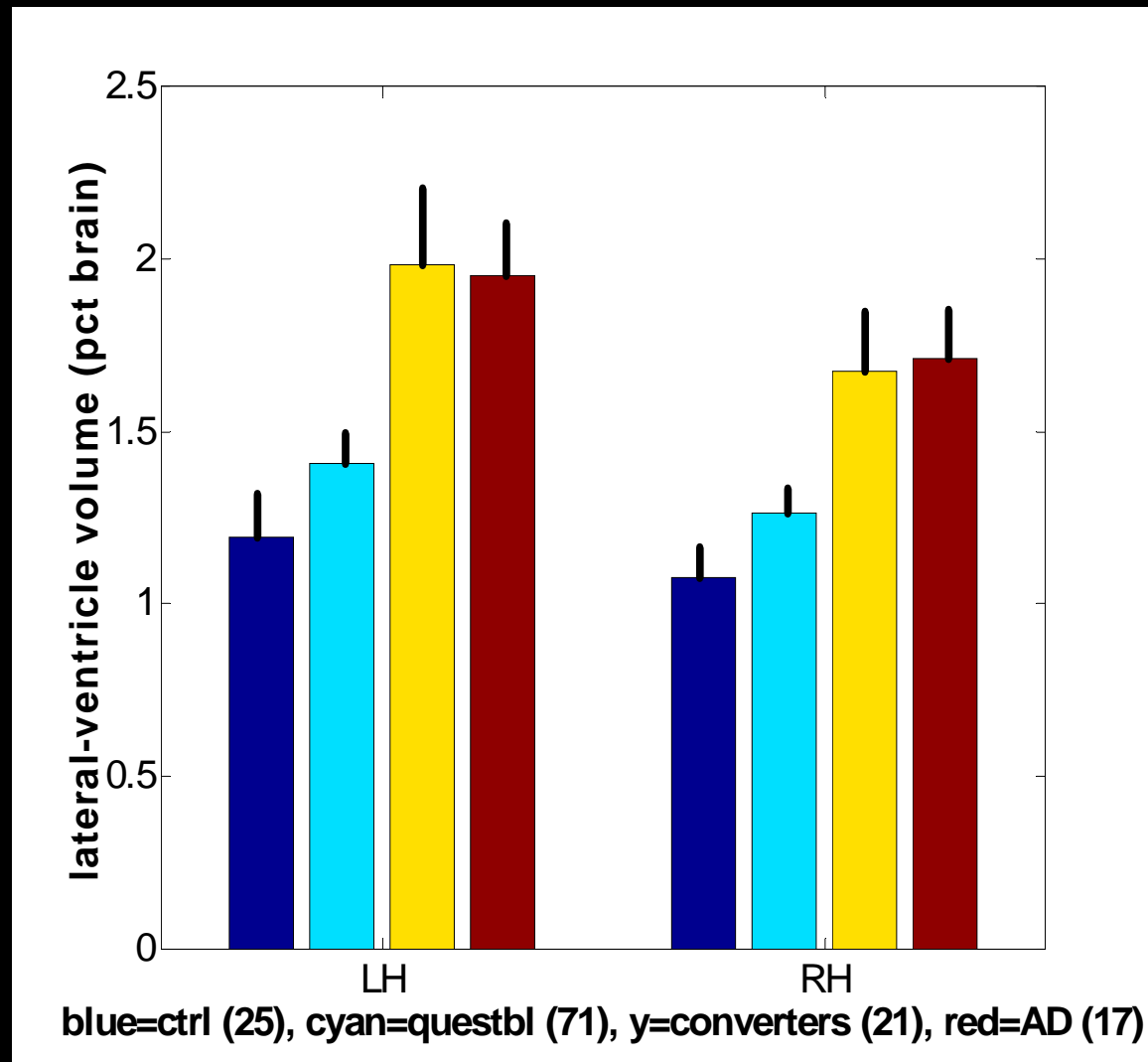
# Volumetric Segmentation (aseg)



Not Shown:  
Nucleus Accumbens  
Cerebellum

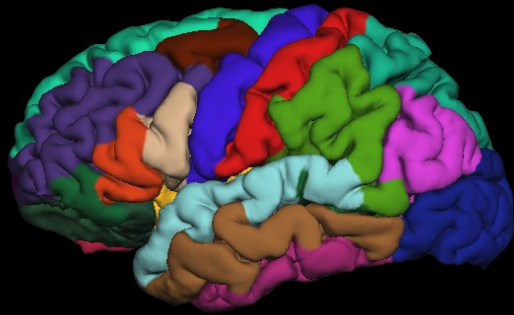


# Volume Differences Predictive of AD

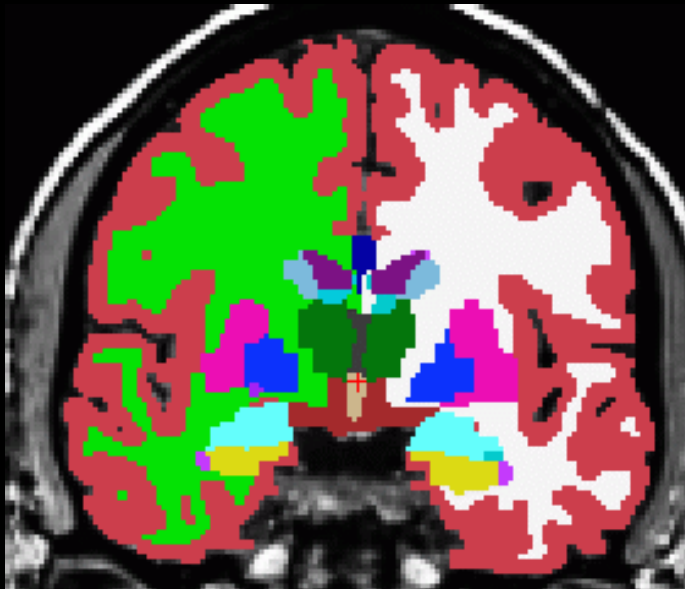


Data courtesy of Drs Marilyn Albert and Ron Killiany

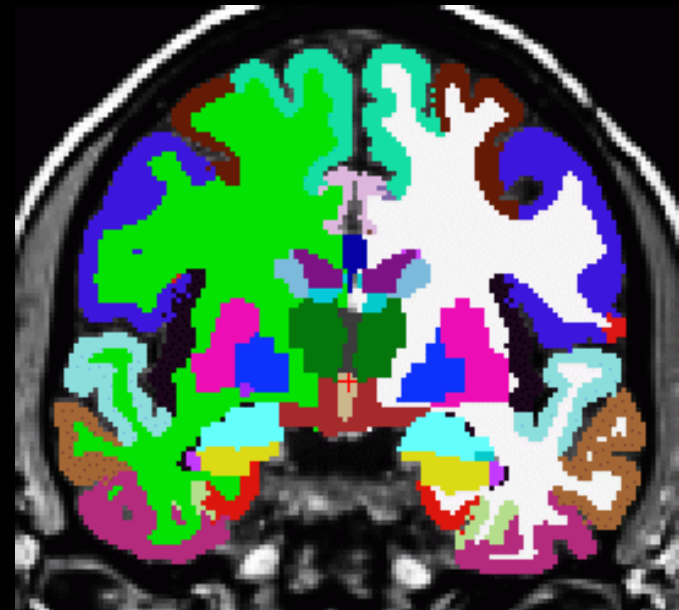
# Combined Segmentation



aparc

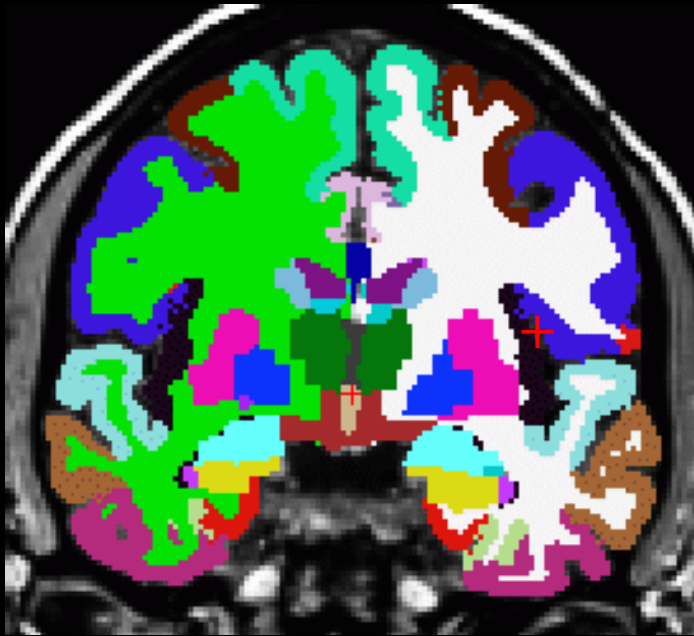


aseg

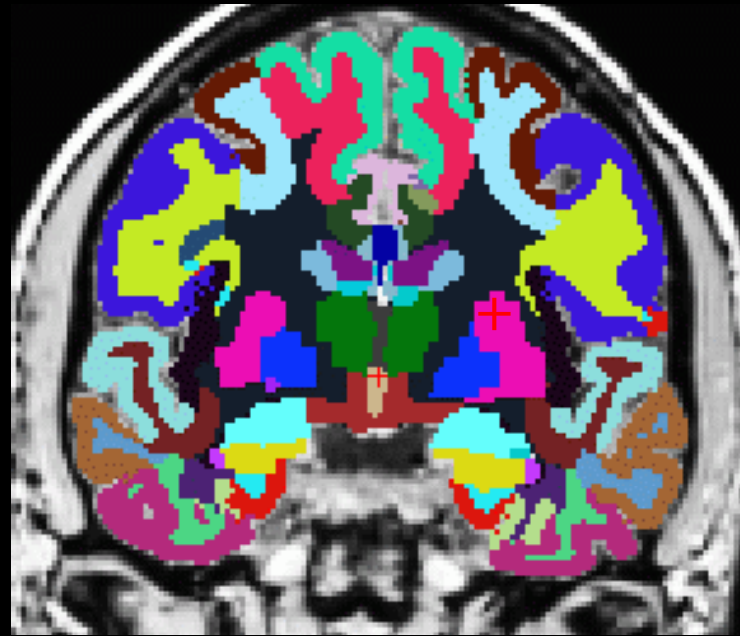


aparc+aseg

# Gyral White Matter Segmentation

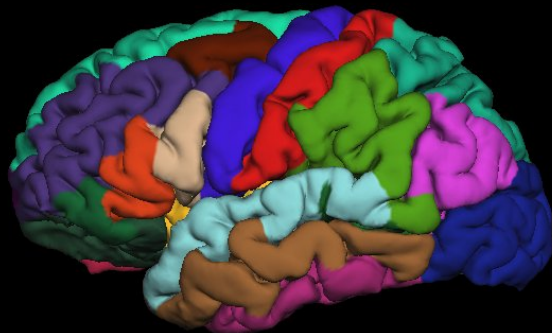


aparc+aseg



wmparc

Nearest Cortical Label  
to point in White Matter

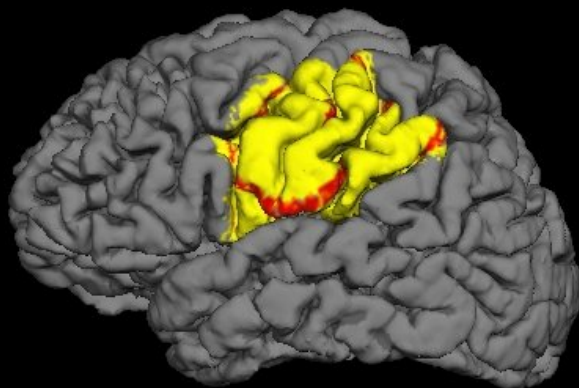


aparc

# 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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