HST 583:

Functional Magnetic Resonance Imaging:

Data Acquisition and Analysis

Fall 2001

Brain Structure: I

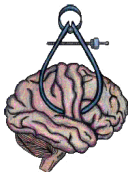
David N. Kennedy

Center for Morphometric Analysis

Departments of Neurology and Radiology, MGH, HMS

HST/MGH/MIT

Athinoula A. Martinos Center for Biomedical Imaging

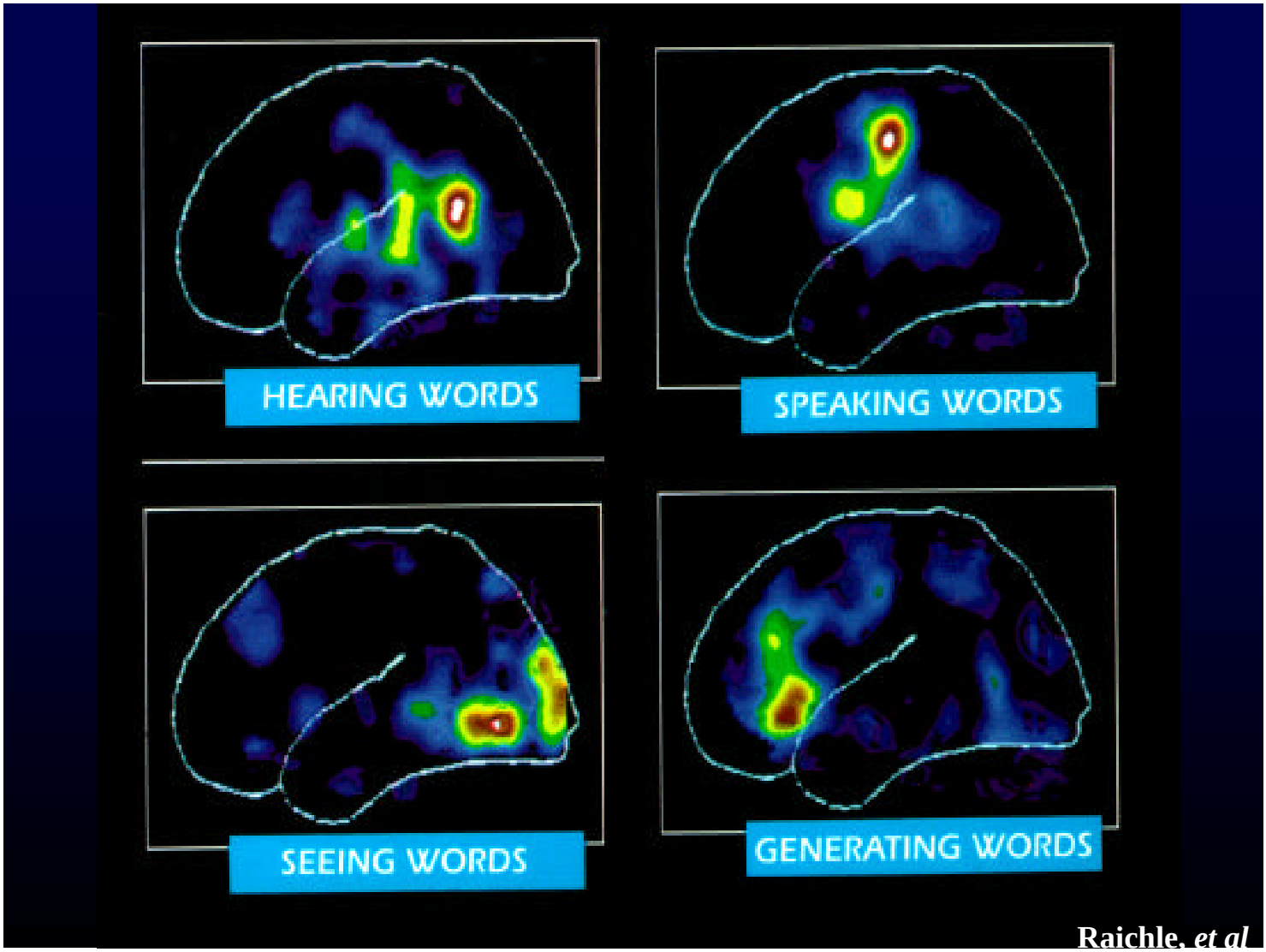


SUPERIMPOSED BRAIN IMAGE BY BASSEM MORA AND GEORGE CARMAN

Outline

- Characterization of Structural MR Data
  - Anatomic Analysis
- Structural-to-Functional Registration
  - Talairach Coordinate System
- Individual Variability
- Spatial Information

- Diffusion Tensor Imaging for White Matter



Raichle, *et al*

Why Study Anatomy?

- Intrasubject Analysis

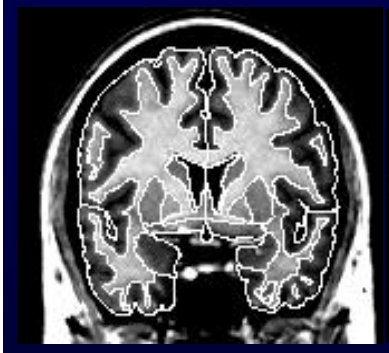
  "What brain areas are active in this subject using this paradigm?"

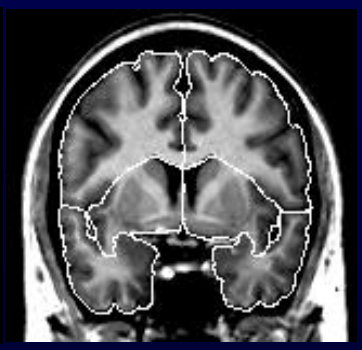
  "How do those areas changed when the paradigm is changed?"
- Intersubject Analysis

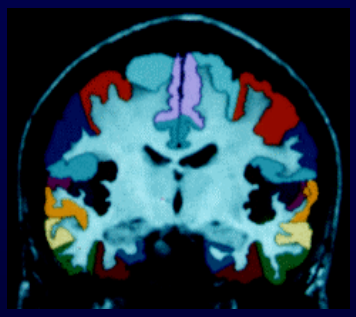
  "Are the similar brain areas activated in all subjects using this paradigm?

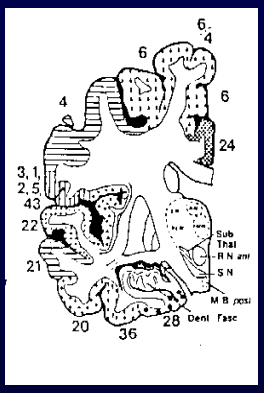
  "How does the average activation pattern change when the paradigm is changed?"

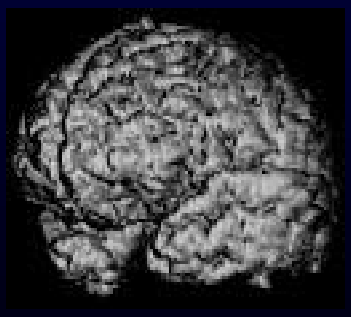
Neuroanatomic Description Hierarchy:

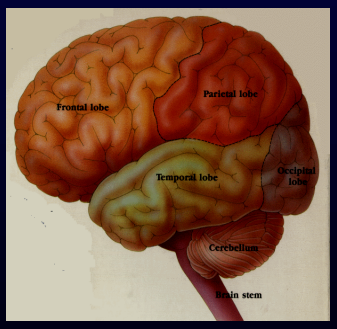


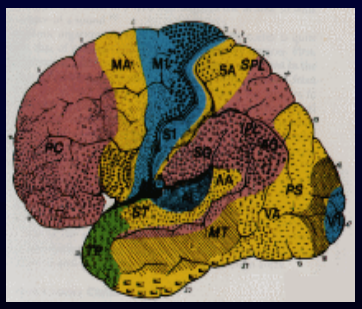


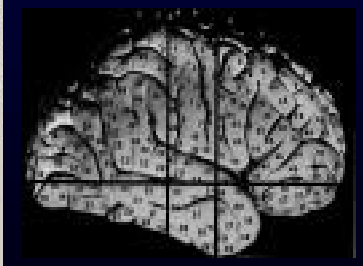












WHOLE BRAIN/STRUCTURE

LOBES

SYSTEMS

CYTO- & MYELO-ARCHITECTURE

Neuroanatomical Description Hierarchy

- Whole Brain
- Whole Cortex
- Lobes
- Whole Substructures (ie. Basal Ganglia, etc.)
- Systems Organization
- Cytoarchetectonic Areas

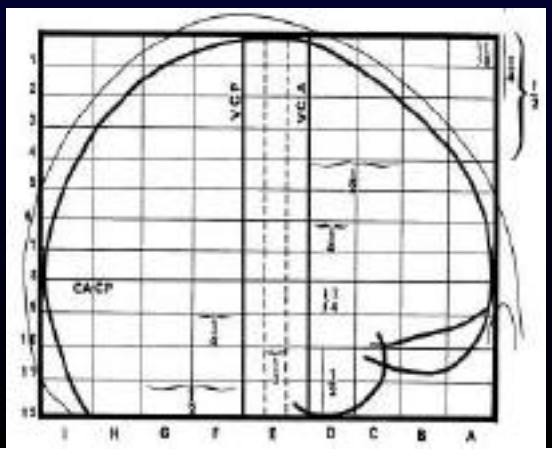
Methods for Anatomical Localization

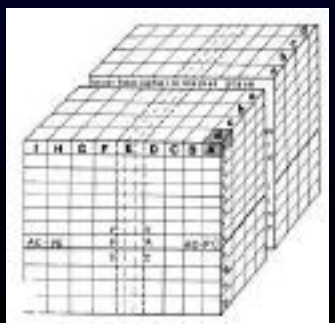
- Metric *(hetero-referencial)*
  i.e. Talairach Proportional Scaling System
  35mm Posterior, 15 mm Superior, 47 mm Right
- Taxonomic (auto-referencial)
  i.e. Cortical Parcellation
  Posterior 1/3 of Superior Temporal Gyrus

Spatial Normalization
Common Coordinate System

Talairach Proportional Scaling System

- Orientation: Normalized relative to AC-PC line and inter-hemisphere fissure
- Regional Scale Factors: frontal pole, occipital pole, superior parietal margin, inferior temporal margin, right & left lateral margin



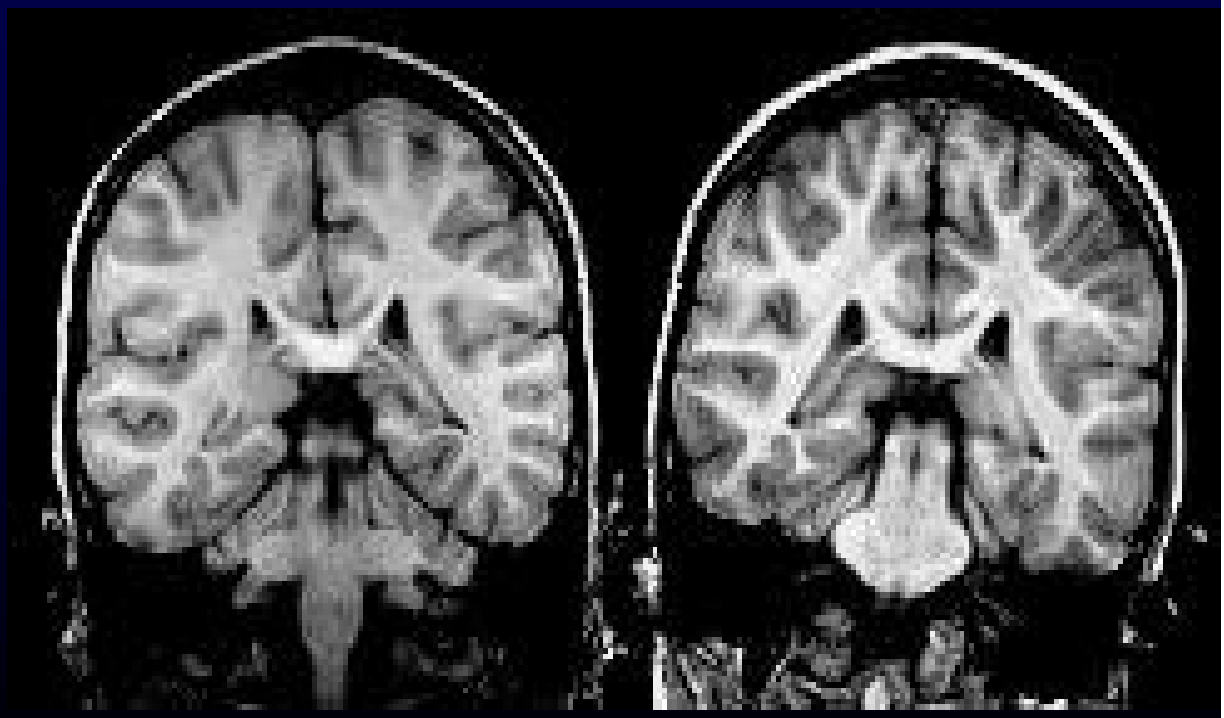


Positional Normalization

Example

1 2

Native



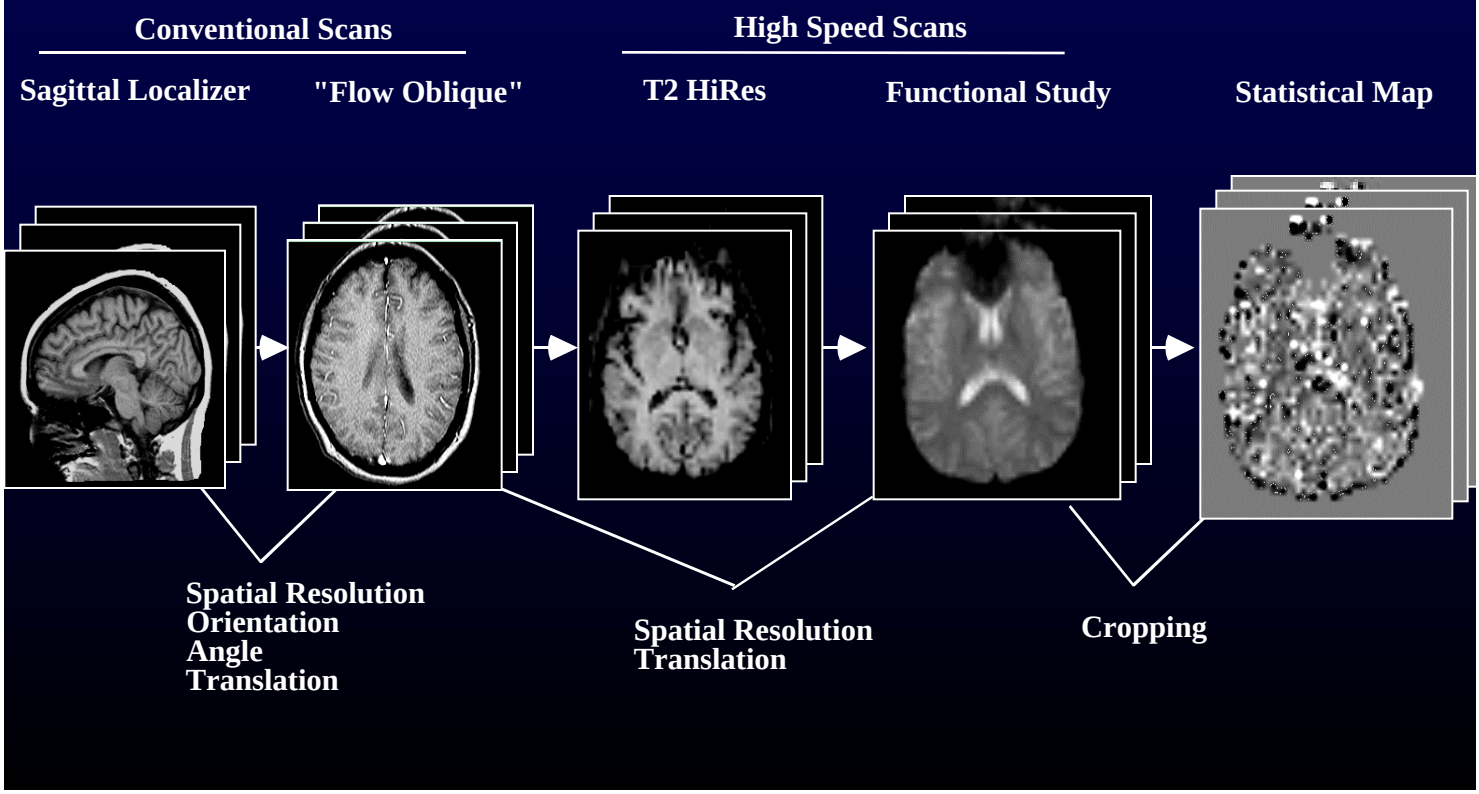
Positional Normalization

Example

1 2

Normalized

Spatial Transformations



Spatial Transformations

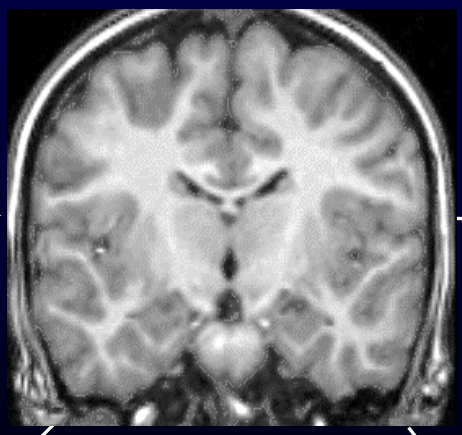
Original Scans

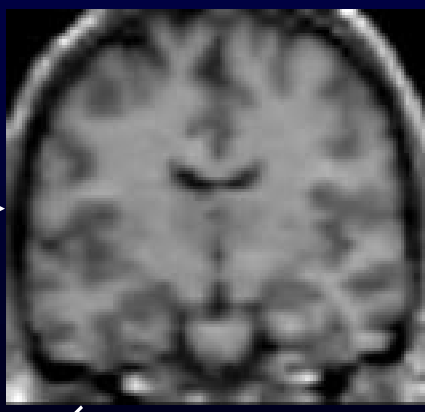
Reformatted Scans

Sagittal Localizer

"Normalized Orientation"

Talairach Proportions





Orientation
Angle
Translation

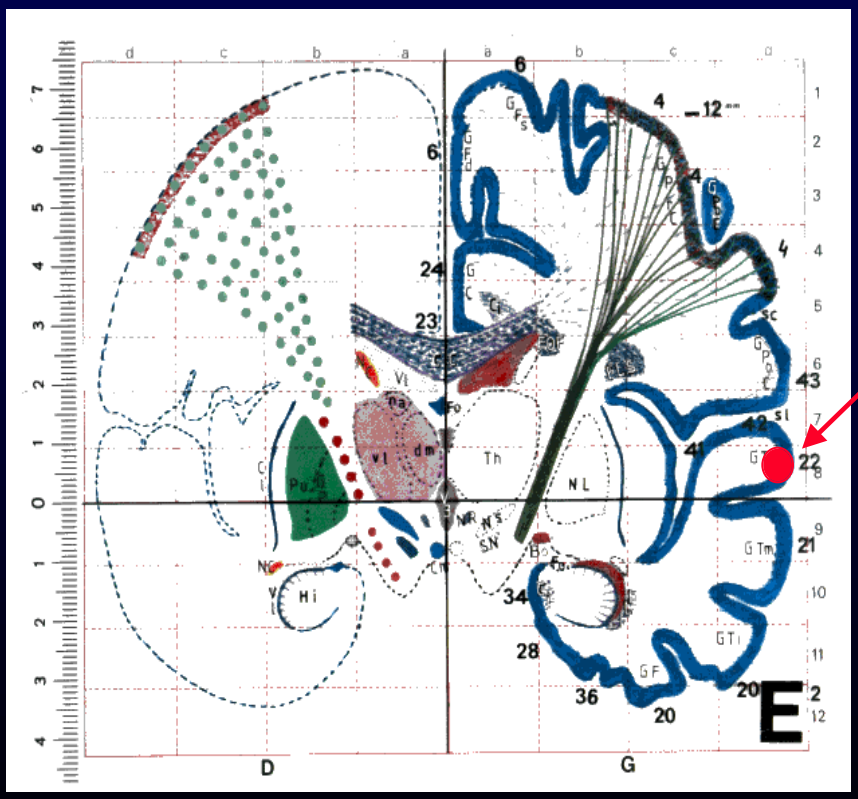
Spatial Resolution
Translation

Atlas-Based Localization

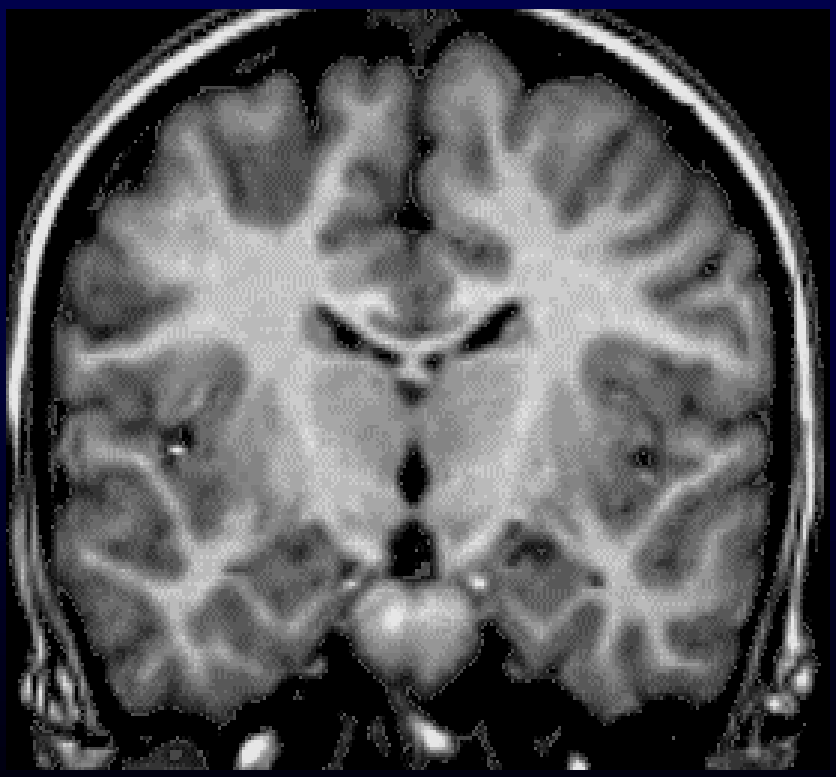
Proportional Coordinate:
- .50 (Between AC-PC)
- .85 Lateral
- .06 Superior

Talairach Coordinate:
- -12mm Posterior
- 63mm Lateral
- 5mm Superior

Anatomic Interpretation:
- GTs (Superior Temporal Gyrus)
- BA 22

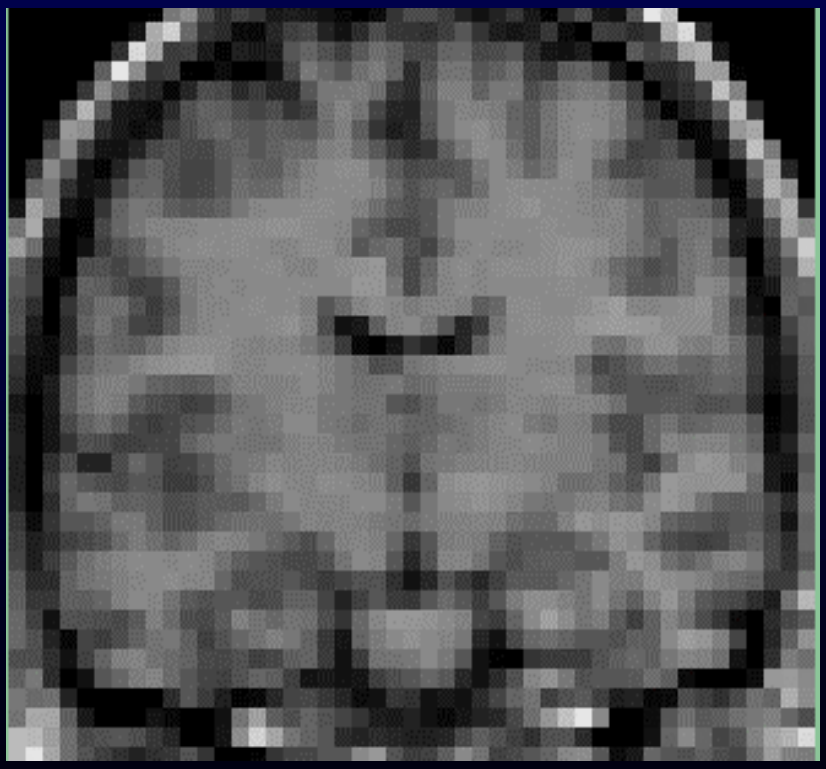


Resolution



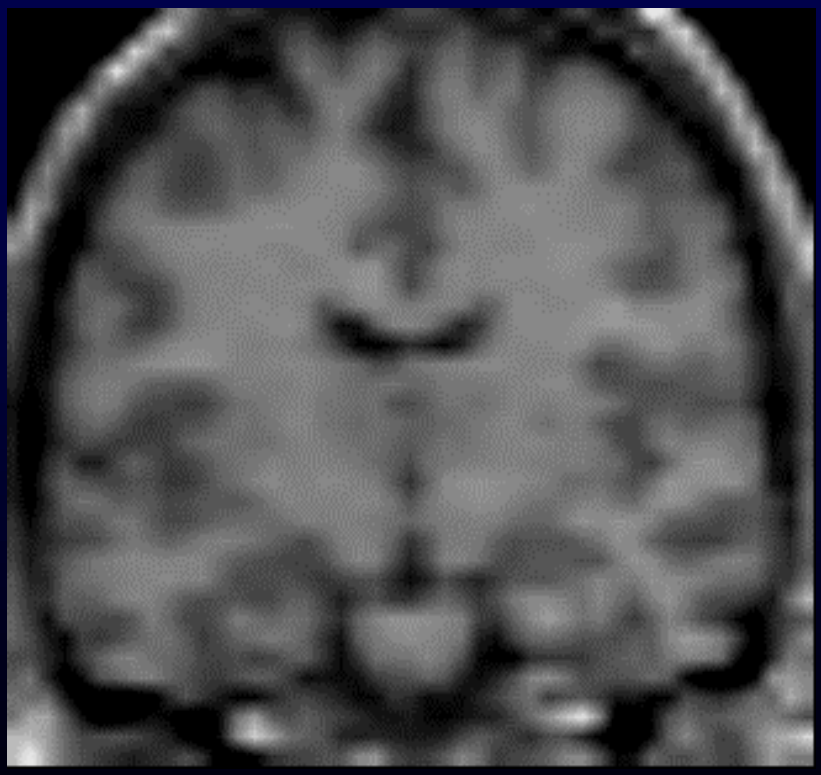
"High" Resolution
(0.9375 mm / Pixel)

Resolution



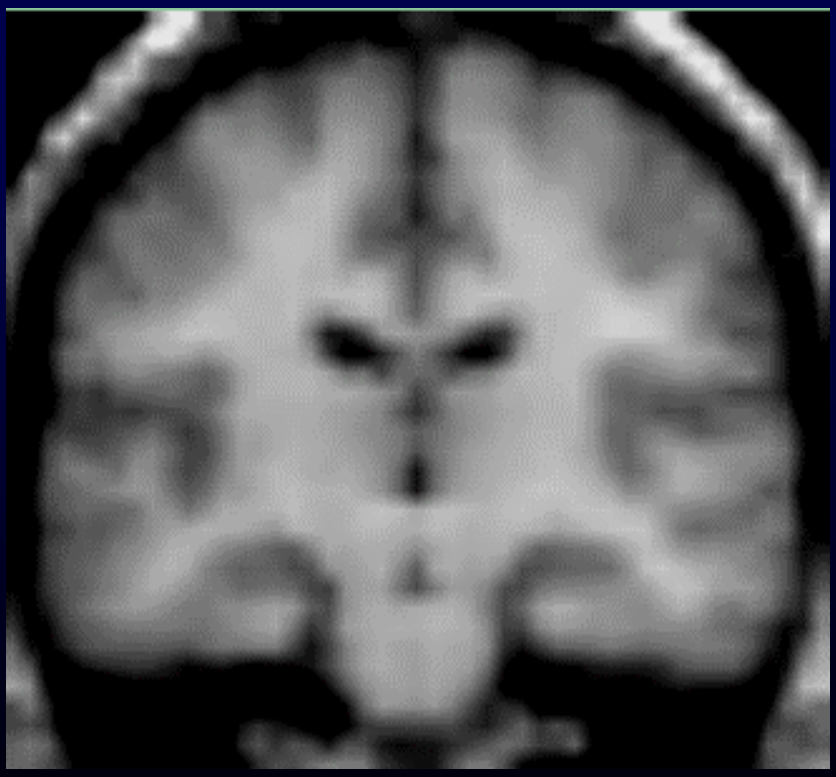
“Functional” Resolution
(3.125 mm / Pixel)

Effect of Averaging



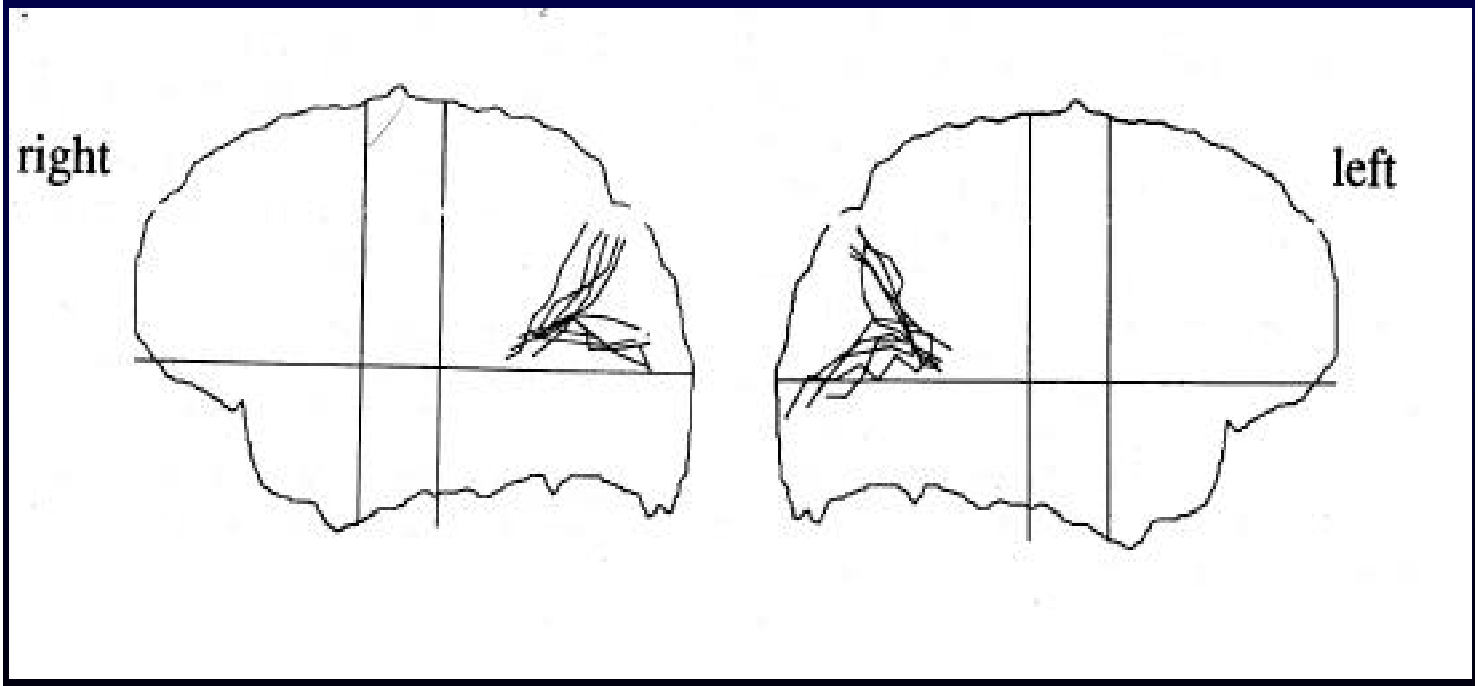
One Individual
(3.125 mm / Pixel)

Effect of Averaging

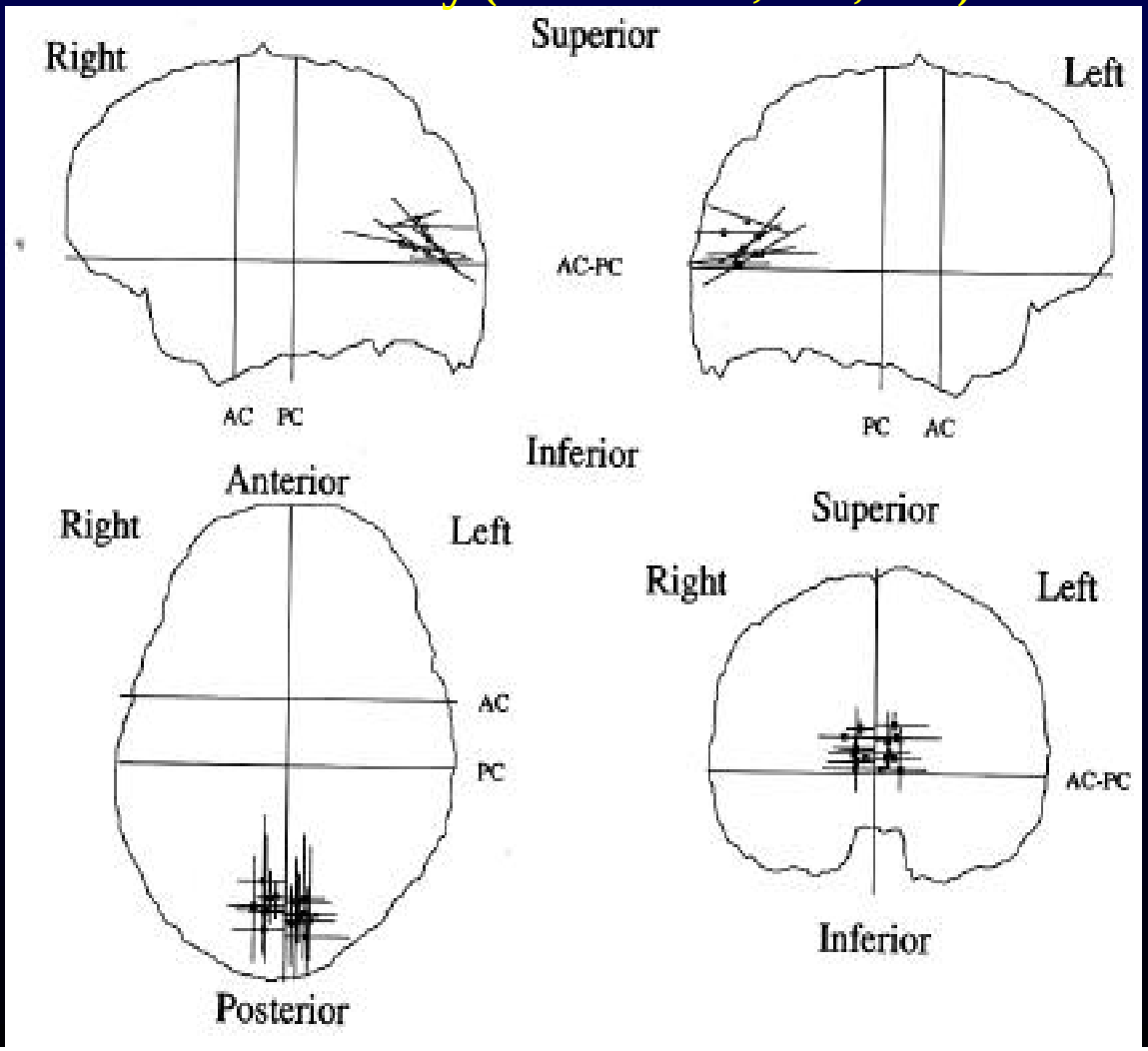
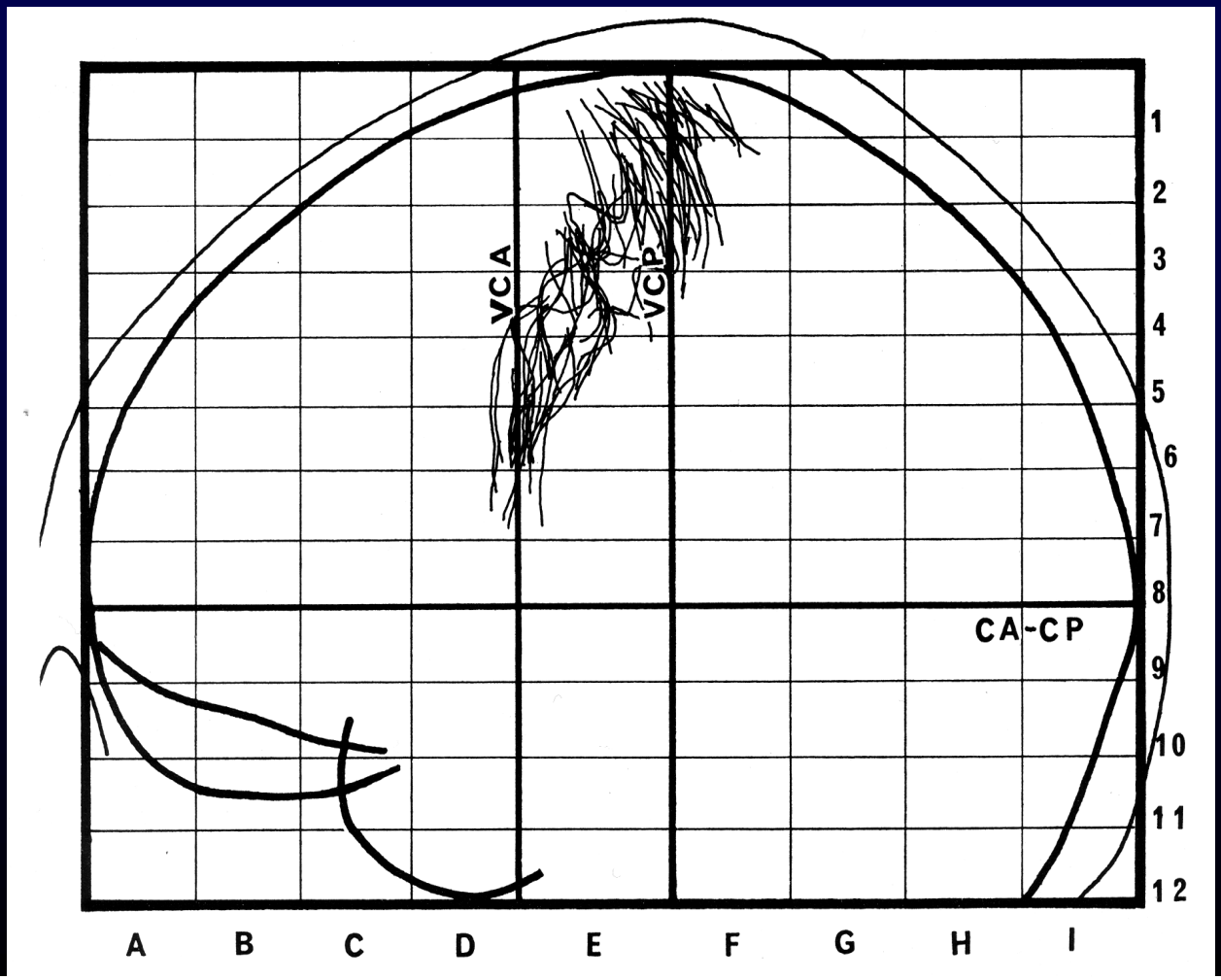


Group Average (N=12)
(??? mm / Pixel)

Sulcal Variability (from Belliveau, *et al.*, 1991)



Functional Variability (from Belliveau, *et al.*, 1991)



Sulcal Variability (from Talairach Atlas)