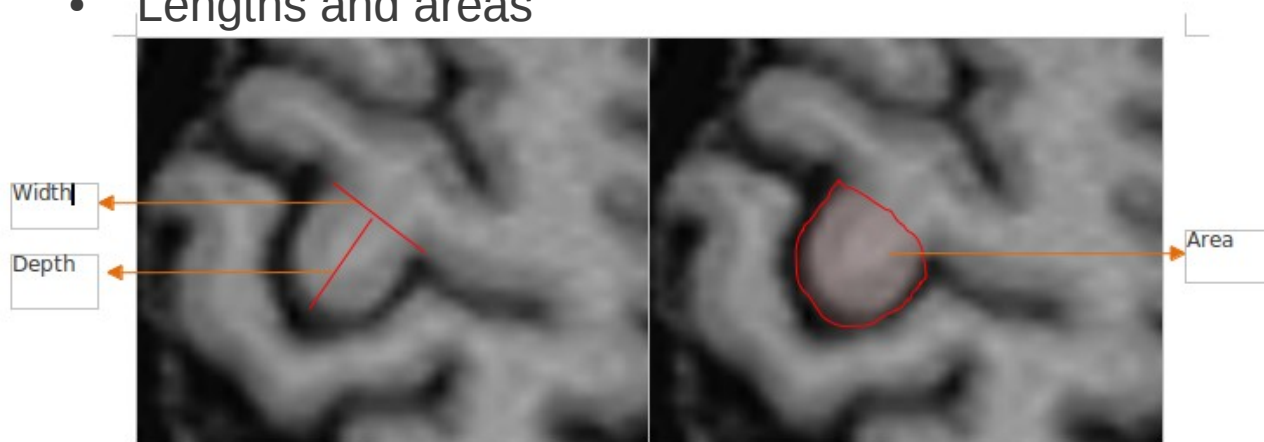


Can Music Change The Brain?

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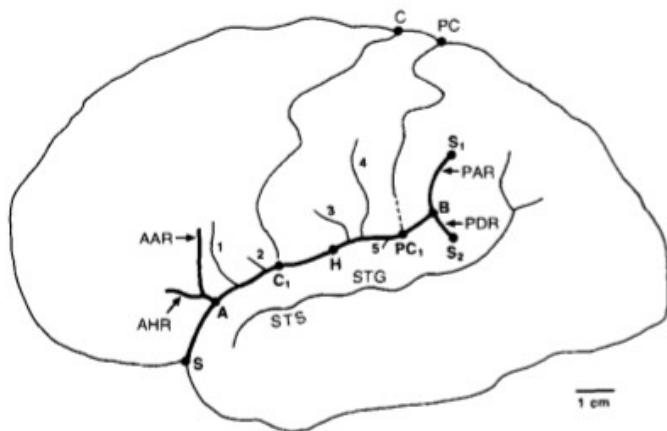
Region of Interest Measurements: 2D

- Lengths and areas



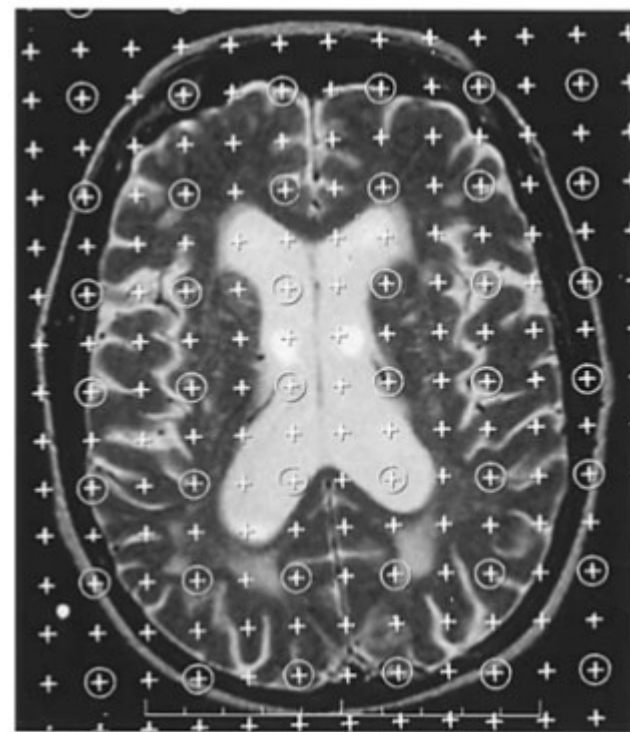
Source: CRIC, Dhinkaran 2011

- Classification schemas



Source: Witelson et al, J. Comp Neurol 1992

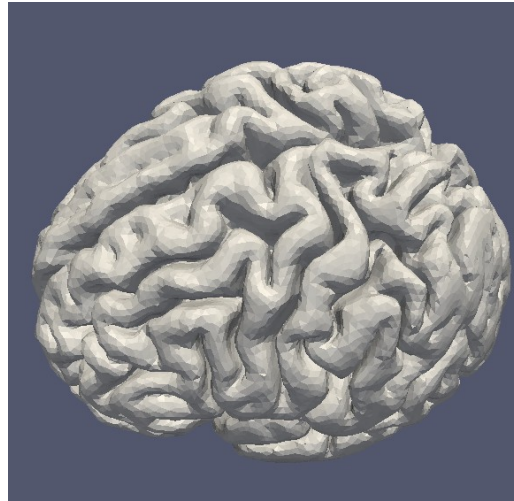
- Volumes via stereology



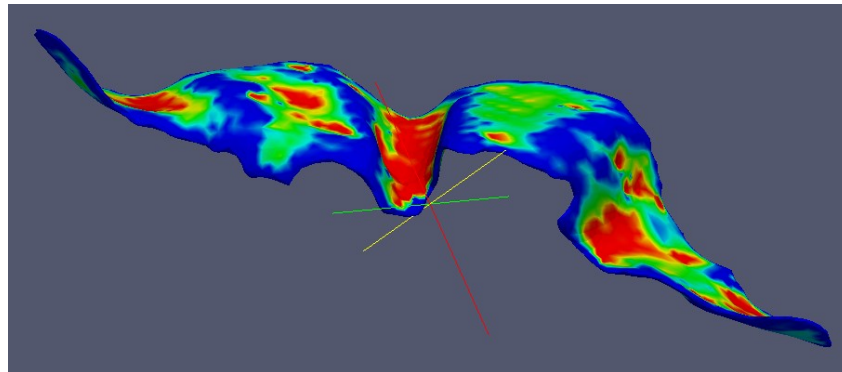
Source: Tang et al., J. Neuroimaging, 2001

Region of Interest Measurements: 3D

- Volumes
(Cortical mesh)



- Surfaces
(Sulcus curvature computation)

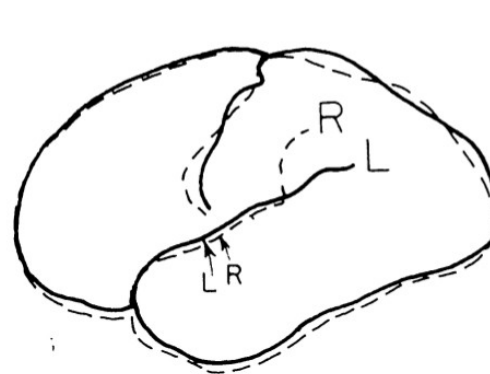


- ROI measurements capture individual variation, but can be hard to apply across subjects

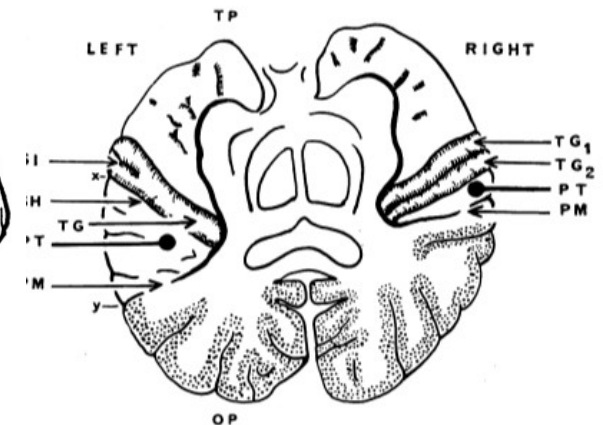
Hemisphere-based comparisons

- Comparisons of asymmetries between sides controls for some individual differences
- Many brain activities are specialized by hemisphere and measuring asymmetries allows for study of their development and pathology

- Shapes and features



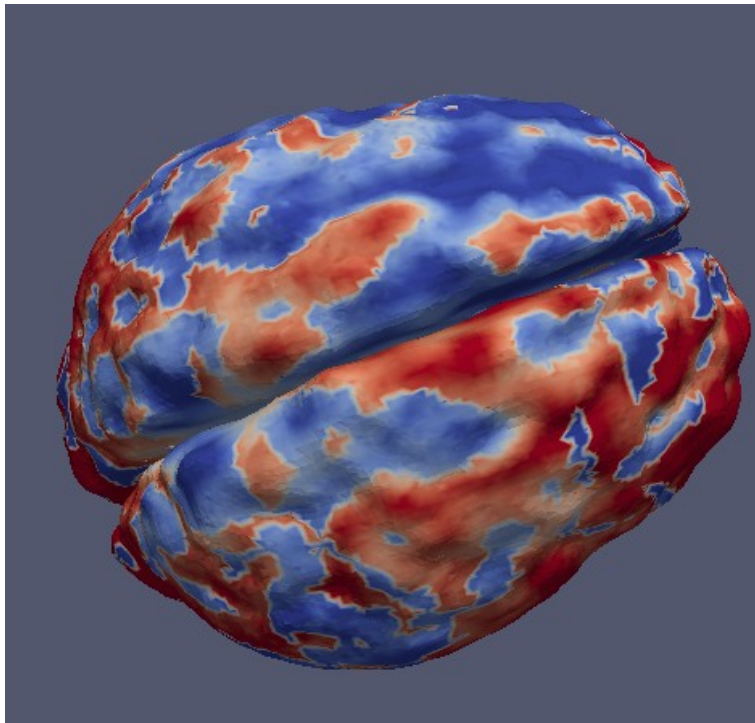
Source: Rubens 1976



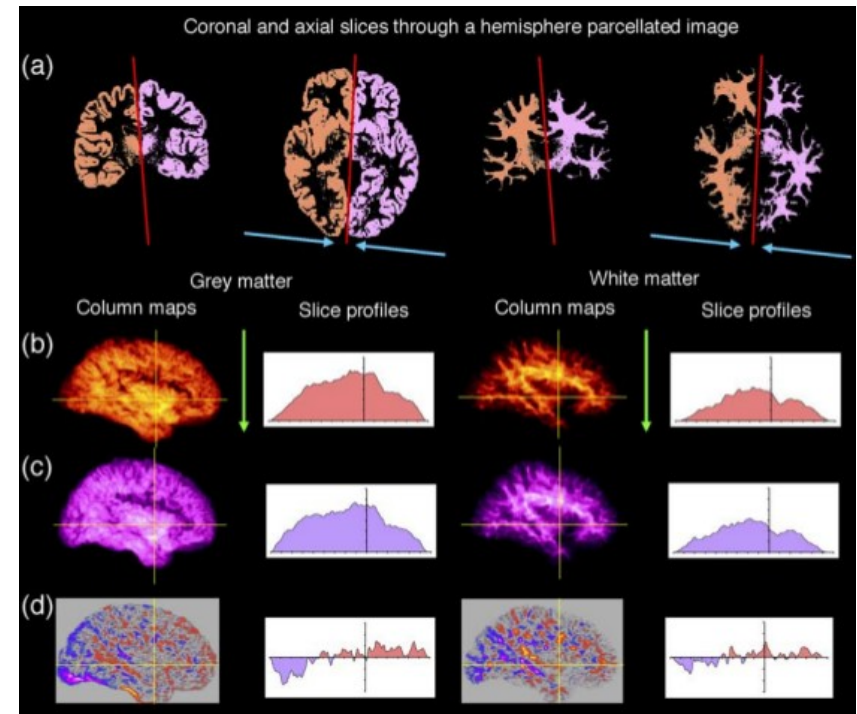
Source: Geschwind & Levitsky 1968

Hemisphere-based comparisons

- Overall twist/torque/skew
- Individual quantities



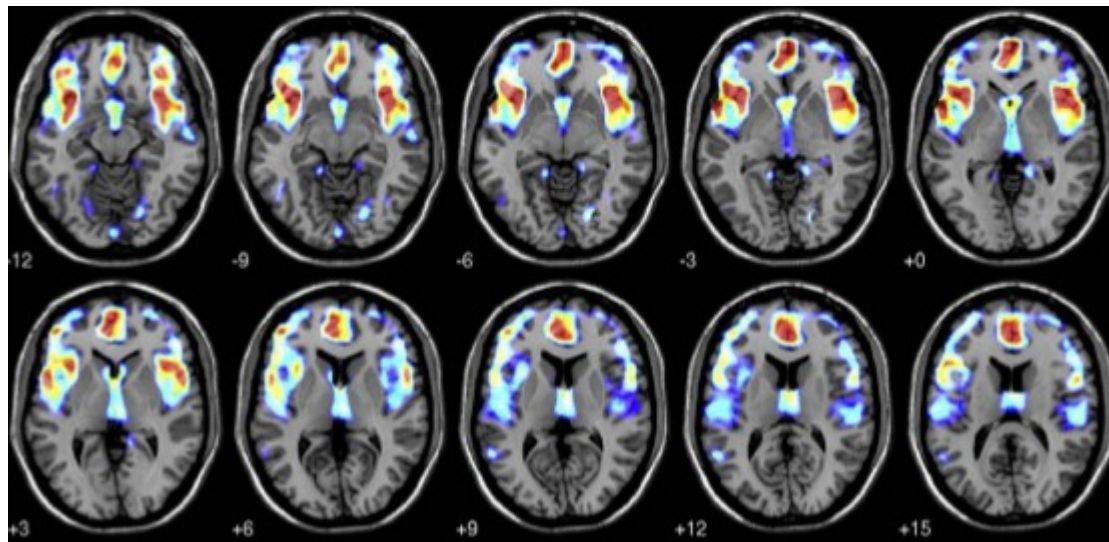
Source: CRIC



Source: Barrick T, Neuroimage 2005

Template-based comparisons

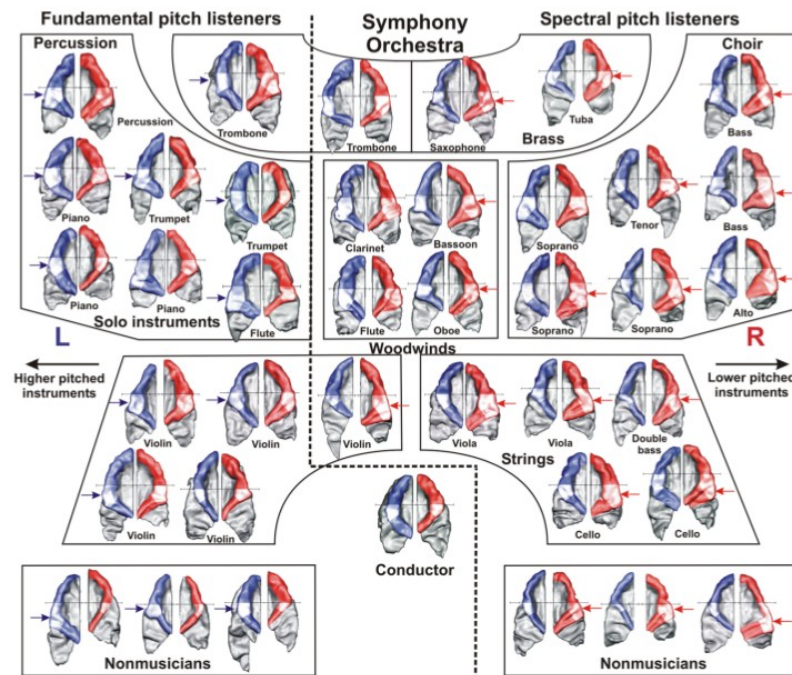
- All the brains in the study are mapped onto a template or “standard brain”
- Allows for stable comparison across subjects
- Can be done with algorithms, allowing for quick comparison of many subjects
- Information about shape difference, type of difference, quantities of gray matter
- Many specifics of individual variation are lost



Source: Nenadic et al., Neuroimage 2010

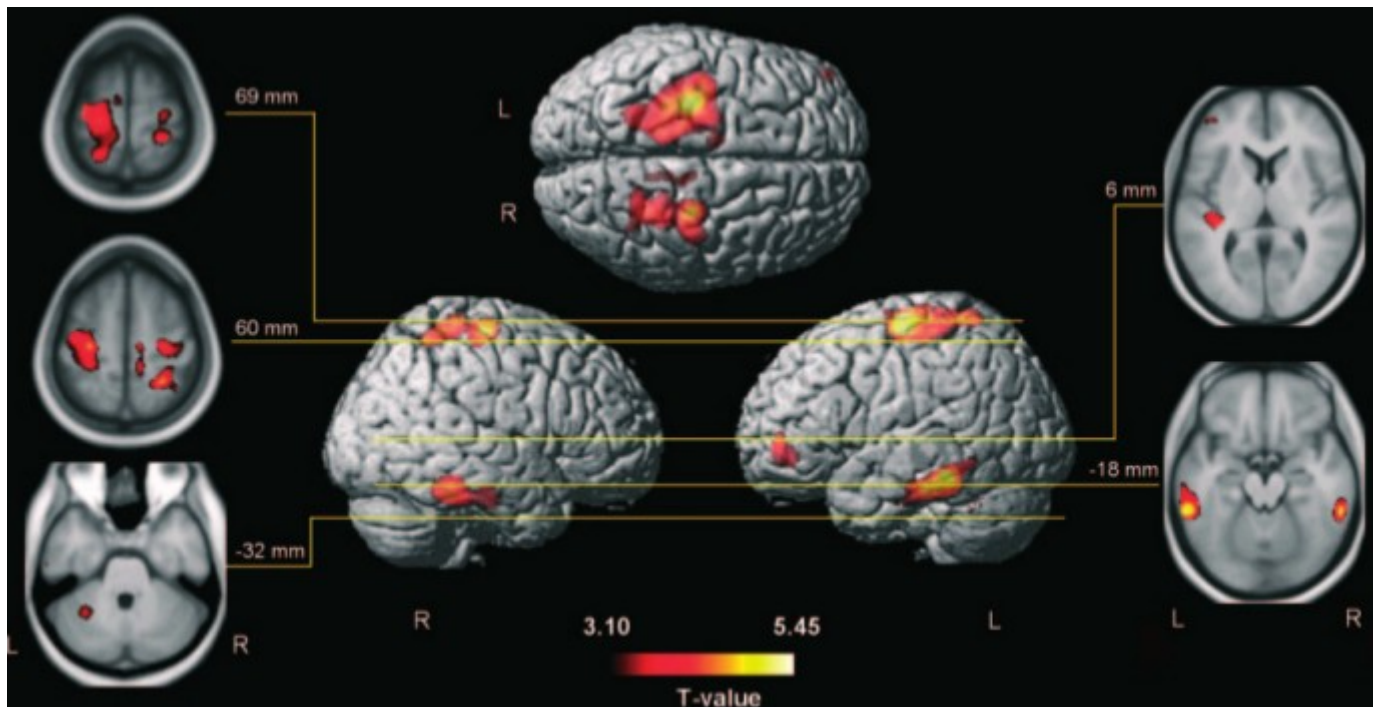
Some findings: Higher gray matter volume

- Higher gray matter volume:
 - Heschl's gyrus (auditory processing)
 - Broca's area (spoken language, spatio-temporal tasks)
- Also no age-related decline in Broca's area (frequent result in musicians)
- Suggests music enhances ability to process sounds, syntax, and spatial relationships



Some findings: Higher gray matter volume

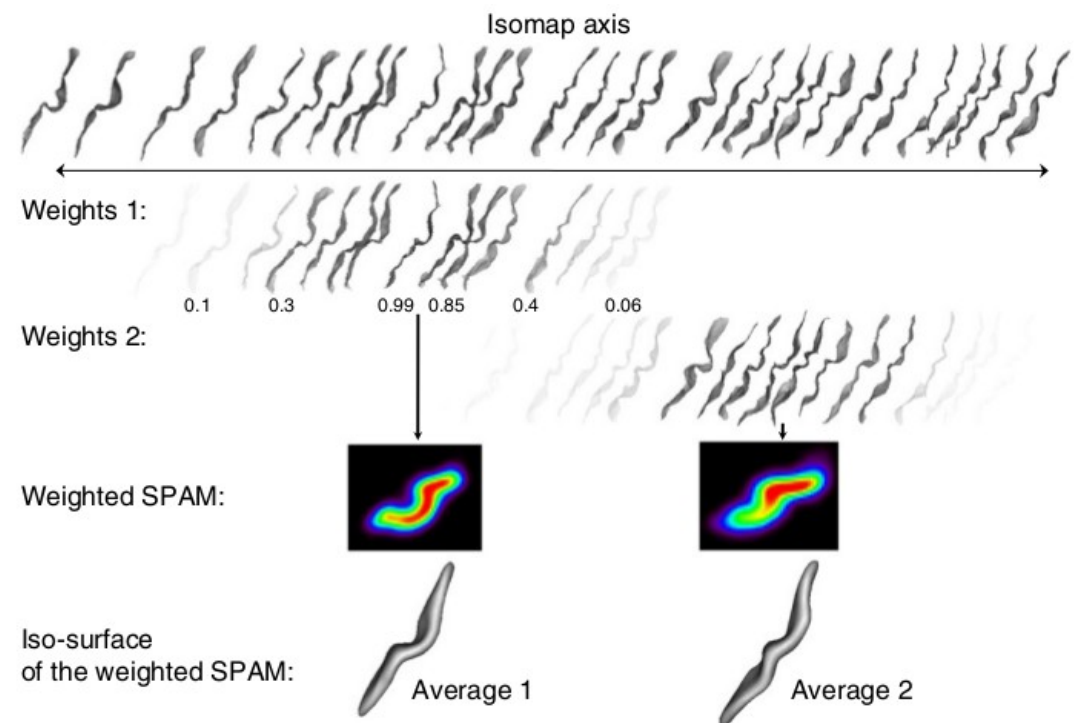
- Higher gray matter volume:
 - Inferior temporal gyrus
 - Motor cortex
- Ties music to motor coordination and spatial/episodic memory



Source: Gaser et al., *J.Neurosci* 2003

Some findings: Complexity of cortical folding patterns

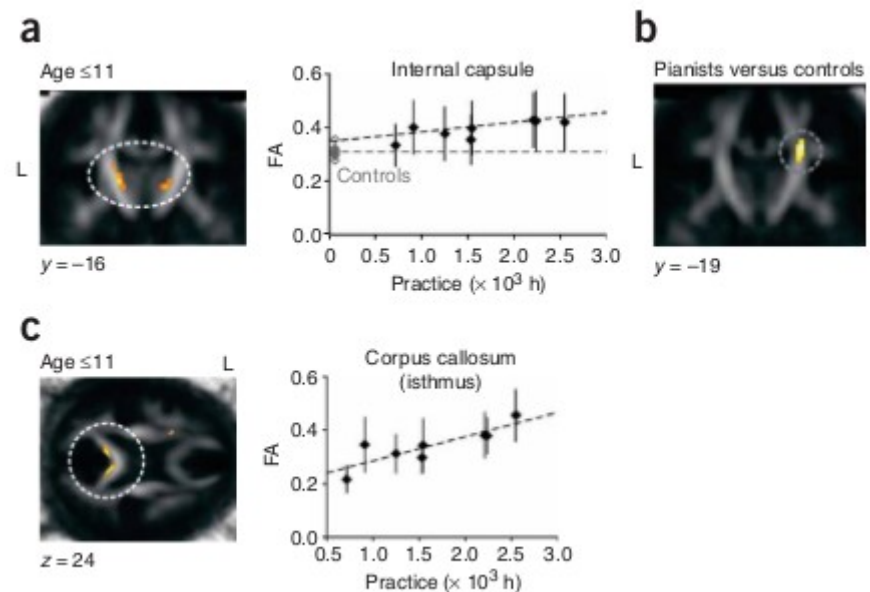
- Cortical folding in motor-speech regions develops by adding increasing curvatures
- Strongly suggests musicians develop more fine motor control. May also develop motor speech regions through transfer



Source: Sun et al., Neuroimage 2012

Some findings: White matter connectivity

- Musical practice has impact on connective fibers of white matter. Age is a strong factor with practice before age 11 making the most difference
- Likely allowing different parts of the brain to communicate and coordinate



Source: Bengtsson et al., Nature Neuroscience 2005