

# SUBREGION PARCELLATION AND TOPOGRAPHIC CONNECTIVITY MAPPING OF THE HUMAN CORPUS CALLOSUM USING DIFFUSION TENSOR IMAGING

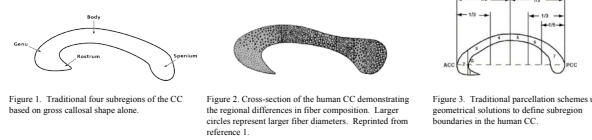


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## Background

Along its anteroposterior axis, the human corpus callosum (CC) is typically divided into four or five subregions: the rostrum, genu, body, isthmus, and splenium (from anterior to posterior; Figure 1). Primate and human histological studies have demonstrated that these subregions vary in microstructural cytology (Figure 2). These variations are believed to reflect the type of information being transferred between the two hemispheres within a particular subregion, as each subregion has different cortical connectivity patterns<sup>1-3</sup>. In this study, we use diffusion tensor imaging (DTI) to parcellate the human CC based on cortical connectivity patterns. This method provides a more sensitive means of defining callosal subregions than the geometrical solutions that are typically employed in the human brain (Figure 3).

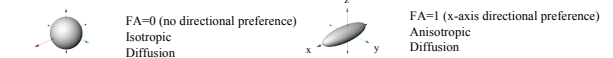


## Methods

Microstructural characteristics and topographic connectivity patterns that delineate callosal subregions cannot be detected with T1-weighted anatomical magnetic resonance imaging. A relatively new in vivo neuroimaging technique, DTI, provides an opportunity to refine these parcellation schemes. DTI is sensitive to regional variations in axon density, axon size and myelination. In this study, diffusion-weighted MRI scans were performed on 20 subjects (10 female), age 24-39 (mean 30.1). Brodmann area (BA) cortical masks<sup>1</sup> were used to define distinct cortical regions. Probabilistic tractography<sup>5</sup> was then used to demonstrate cortical connectivity with distinct regions of the CC.

## Image Analysis

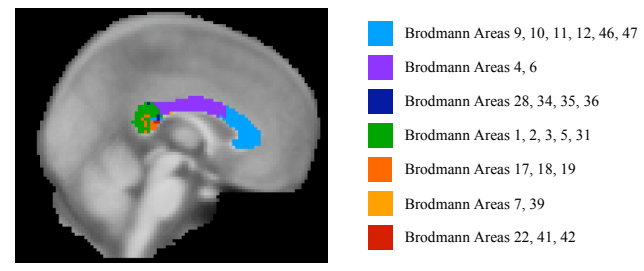
Diffusion weighted MR data were collected using a 3T Philips MR scanner. Diffusion data were acquired with high angular resolution (32 directions) using single-shot spin echo EPI. Matrix size=128x128; FOV=240mm; slice thickness=2mm, no gap; TR=9023ms; TE=91ms; b-value=1000s/mm. Data were post-processed using FDT (FMRIB's Diffusion Toolbox)<sup>5</sup> to calculate the 3x3 symmetrical tensor,  $\underline{D}$ , which describes mobility of water molecules along each axis, x,y,z, and the correlation between them. The fraction of the magnitude of  $\underline{D}$ , ascribed to a directional preference along a particular axis is known as Fractional Anisotropy (FA).



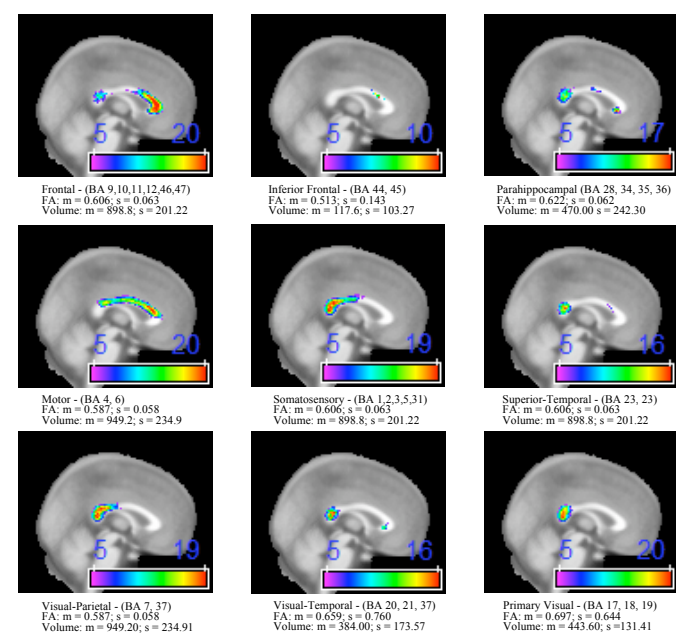
Fiber tracking was implemented using FSL's BEDPOST software<sup>5</sup>. Probabilistic tractography uses Bayesian techniques to estimate a probability distribution function (PDF) on the principle fiber direction at each voxel. Probability distributions of connectivity between the seed area (the CC) and all targets (Brodmann areas) are generated by repeatedly sampling connected pathways through this PDF field (5).

## Results

Seed Based Connectivity Classification: Each seed voxel within the CC is classified according to the target Brodmann mask with which it shows the highest probability of connection. For each voxel in the CC, a probability of connection to each Brodmann mask was calculated as a proportion of the total number of samples from that voxel that reached any Brodmann mask.

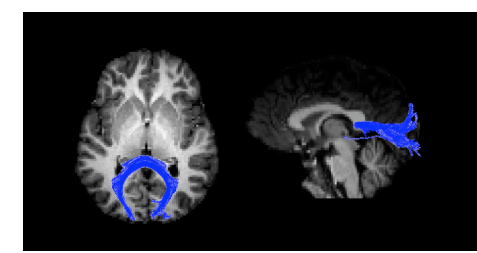


For each cortical area, individual subject results were thresholded and binarized to include only those CC voxels with a connection probability >25%. These images were overlaid to create group probability maps of CC subregions. The mean FA and volume (cm<sup>3</sup>) are shown below each result.



## Single Subject Tractography

Example of primary visual area connections through the CC. The "termination points" in the CC were used to show topographical connectivity of CC with cortex.



## Gender Differences

No overall or subregion differences in fractional anisotropy were found to be significant between genders. Results of paired t-tests revealed significantly larger callosal subregion volumes in females for the Brodmann groups listed below.

Paired Samples Tests for Volumetric Gender Differences in CC Subregions (10 Male/10 Female). The four significant areas showed larger subregion volume in females.

Brodmann Group	T	df	p
47, 46, 9, 10, 11, 12	2.288	9	0.048
22, 41, 42	2.257	9	0.05
7, 39	2.243	9	0.052
28, 34, 35, 36	3.082	9	0.013

## Summary and Future Directions

- The CC can be divided into distinct callosal subregions based on cortical connectivity patterns using DTI:
  - The anterior third of the CC primarily connects the frontal cortices, although some callosal connections are found in the posterior fifth of the CC.
  - The middle region of the CC is primarily dedicated to connecting motor cortices.
  - The posterior fifth of the CC is typically defined as the splenium. Axonal fibers in this region connect temporal, occipital, and somatosensory cortices.
- Mapping the human CC based on cortical connectivity should provide insights into disconnection syndromes and a means of relating patterns of cortical activity to interhemispheric connectivity.
- Future studies will compare fractional anisotropy between callosal subregions and further characterize the extent of individual differences in cortical connectivity patterns throughout the CC.

## References:

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## Acknowledgements:

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