Comparison of Inter-Regional and Inter-Subject Variations of Cortical NODDI and DTI Parameters

Presented During: Poster Session
Monday, June 26, 2017: 12:45 PM - 02:45 PM

Stand-By Time

Monday, June 26, 2017: 12:45 PM - 2:45 PM

Submission No:

2024

Submission Type:

Abstract Submission

On Display:

Monday, June 26 & Tuesday, June 27

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Introduction:

The aim of the study is to investigate the relationship between the regional microstructural differences of the cerebral cortex and diffusion MR parameters, that are obtained by fitting a single tensor model or three compartmental NODDI model [Zhang,2012].

Methods:

10 unrelated subjects of the Human Connectome Project WU-MINN HCP dataset are included in the study. The details of the diffusion MRI data acquisition protocol and preprocessing pipeline are given in [Sotiropoulos,2013]. To compute the parametric maps of the NODDI model, namely intra-cellular volume fraction (ICVF), isotropic volume fraction (ISOVF) and orientation dispersion (OD), an accelerated optimization algorithm (AMICO) is used [Daducci,2015]. Diffusion tensor parameters, MD and FA, are calculated by "dtifit" tool of the FSL package. Obtained parametric maps are normalized to the MNI152 atlas using the segmentation based normalization method of SPM 12 [Ashburner,2005].
34 Anatomical regions for the cerebral cortex are defined using the parcellation provided by the Desikan atlas [Desikan,2006]. Although, the boundaries of the functionally segregated areas of the cerebral cortex do not necessarily overlap with the anatomically defined regions based on sulcus/gyrus, we prefer to choose anatomical labeling based on sulcal representations to avoid biasing by the cytoarchitectonic observations. Median values of each diffusion parameter for each of the 34 anatomic region are calculated and averaged over left and right hemispheres.
Our analysis is based on the assumption that; a parameter, which is more related with the microstructural differences of the cortical regions, demonstrates a higher variation among the regions and lower variation within the same region between the subjects.
Linear Discriminant Analysis (LDA) is performed in SPSS 20, to obtain a linear combination of the parameters, which maximizes the inter-regional variability, whereas minimizes the within region variation. The average over the subjects for the value of the LDA function corresponding to the maximum eigenvalue is evaluated and painted on the MNI template of the Freesurfer.

Results:

The median values of the diffusion parameters for each subject and each region, are given in Figure 1. The function corresponding to the largest eigenvalue, which explains the 49.5% of the total variation, is given in standardized form in equation 1.

F1 = -1.55 OD + 0.21 ISOVF + 1.37 ICVF + 1.46 MD – 1.11 FA (eq. 1)

The average value of the 1st LDA function over the subjects is evaluated for each voxel and painted on an inflated cortical surface in Figure 2, for the left and right hemispheres.

OD, MD, ICVF and FA values presented in Figure 1 are able to differentiate specific but different regions. For example, the best separation for insula and transverse temporal regions is achieved by OD, whereas pars orbitalis and medial orbital frontal regions are better differentiated by MD. The discriminant function coefficients for each parameter in Equation 1 indicates that OD is the most important

parameter where ISOVF is less important to capture the regional structural differences of the cortex. The obtained LD function has lower values especially in central sulcus, paracentral lobule and occipital lobe.

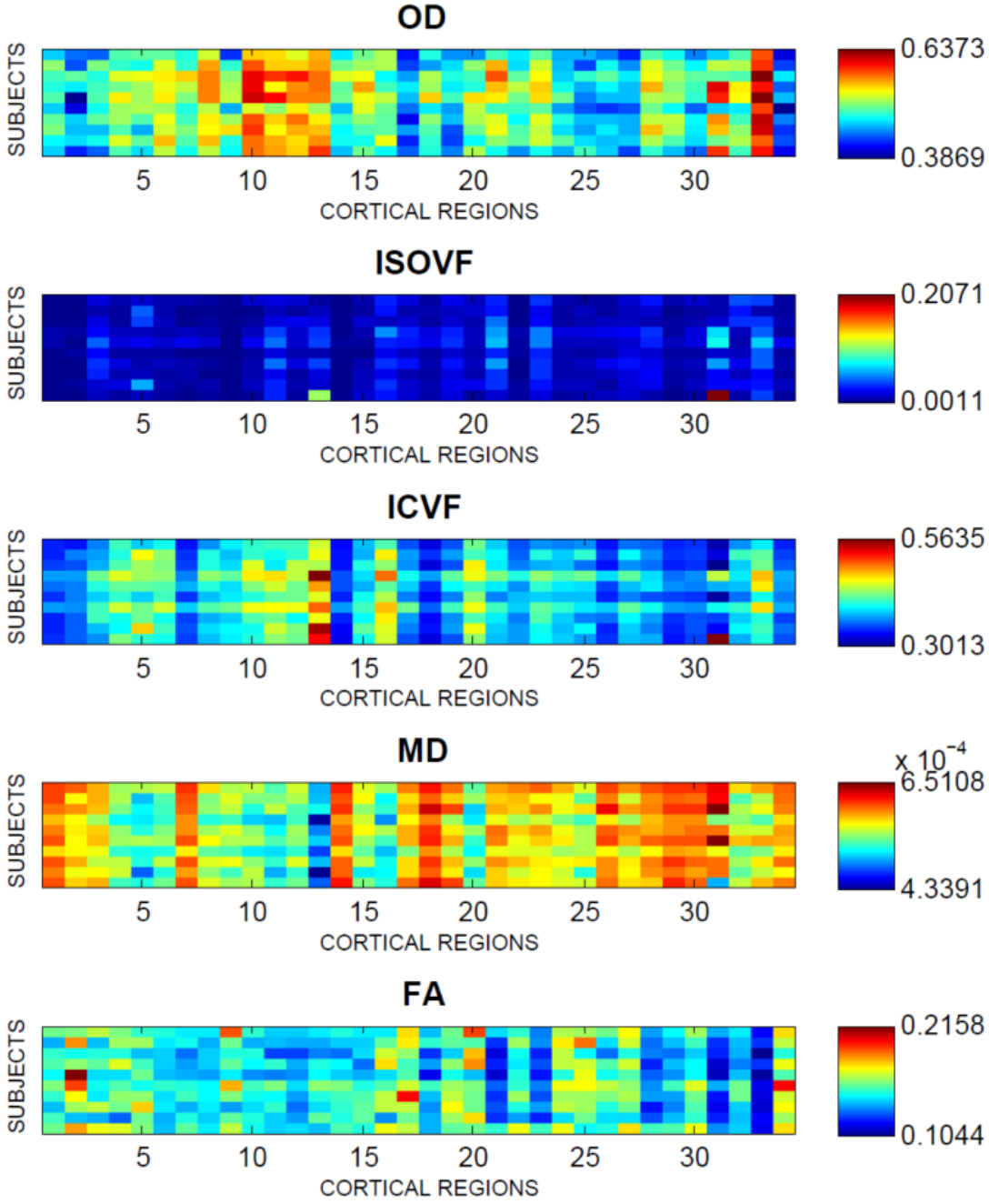
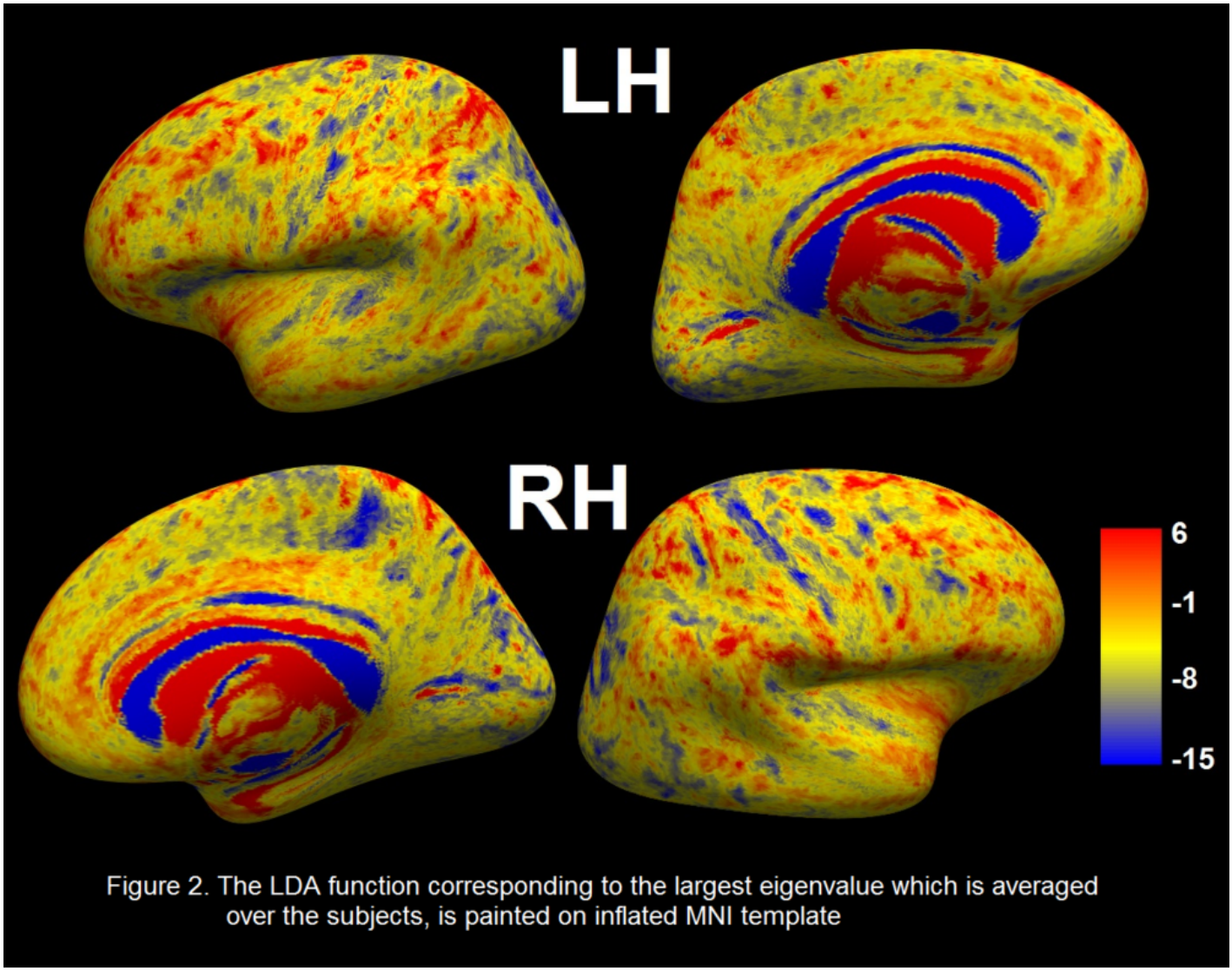


Figure 1. Median values of the diffusion parameters for each subject and each of the 34 cortical regions

·Figure 1



·Figure 2

Conclusions:

The parameters measured by diffusion MRI have some regional specificities through the cortex. Number of included subjects need to be increased to support the obtained results. DTI and NODDI models are used in this study. Other models which claim to explain microstructural differences, such as Mean Apparent Propagator (MAP-MRI) [Ozarslan,2013] and Diffusion Kurtosis (DKI) [Jensen,2005], should also be included. The obtained results need to be discussed, considering the cytoarchitecture of the cerebral cortex, to investigate the relation between the MR diffusion parameters and the gray matter microstructure.

Imaging Methods:

Diffusion MRI [2]

Informatics:

Brain Atlases

Modeling and Analysis Methods:

Classification and Predictive Modeling

Neuroanatomy:

Cortical Cyto- and Myeloarchitecture [1]

Keywords:

Cortex
NORMAL HUMAN
Other - NODDI

[1|2]Indicates the priority used for review

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Not applicable

Please indicate which methods were used in your research:

Diffusion MRI

For human MRI, what field strength scanner do you use?

3.0T

Which processing packages did you use for your study?

SPM
Free Surfer
Other, Please list - AMICO
FSL

Provide references in author date format

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