Cortico-cortical connectivity revealed by DTI-based tractography

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Introduction

Diffusion tensor imaging has been shown to be an effective way to delineate trajectories of the white matter tracts. Anatomy of large white matter tracts in deep white matter has been well documented in histology in the past and many of these tracts can be faithfully reconstructed by DTI-based fiber tracking [1,2,3]. On the other hand, little is known about the anatomy of subcortical white matter. The purpose of this study is to use tractography to identify reproducible short-range cortico-cortical fibers.

To perform this study, it is necessary to parcellate the cortex in each subject, use them as regions of interest (ROIs) for fiber tracking, and create statistical map to evaluate the reproducibility of the findings. The cortical parcellation is conducted by transforming the gyral labeling of standard ICBM (International Consortium for Brain Mapping) atlas to the subject. The tractography is performed with brute force and multi-ROI line tracing method based on FACT [4]. Group averaging of the results will be based on 12-mode affine transformation. Ipsilateral and contralateral cortico-cortical connectivity were studied. Based on the contralateral cortico-cortical connectivity information, the midsagittal callosal was further parcellated with gyral connectivity [5].

Results

Ipsilateral Cortico-cortical connectivity: As a first step, we began with the study of the connectivity between cortical lobes. The cortical surface was segmented into 5 lobes, namely frontal, parietal, occipital, and limbic lobes by unifying the gyri labeling in the same lobe. For the traced fibers, some are well recorded in the literature, but others are not. For example, fig. 2 shows snapshots of fibers connecting frontal and occipital lobes from later al view (Fig. 2a) and parietal and occipital lobes (Fig. 2b).

Fig 1: (a) MPRAGE raw data, (b) parcellated cortical surface with ICBM gyral labelings, (c) averaged diffusion weighted image after distortion correction, (d) DTI colormap.

Fig 2: 3D reconstruction of fibers connecting frontal and occipital lobes (a) and parietal and occipital lobes (b).


Table 1: Cortico-cortical fiber count and ratios of fiber count over the cortical surface area.

As illustrated in a way similar to [7], table 1 (see Fig. 3 legend for abbreviation) shows the quantitative cortico-cortical connectivity information between lobes. Among the total 4 blocks of table 1, the ipsilateral connectivity information is listed in the upper left and lower right blocks, and the contralateral connectivity information is listed in the upper right and lower left blocks. The fiber counts are listed in lower triangles of Table 1. Surface area of each lobe was also calculated. To explore how intense the lobe connectivity is, fiber count was divided by the summation of surface areas of two lobes with which the cortico-cortical fibers are connected. These ratios are listed in the upper triangle of Table 1 and ranked with different color paintings. It shows that connectivity between temporal lobe and parietal/occipital lobe is most intense for ipsilateral connections. The contralateral connectivity is almost symmetric with occipital connections most intense.

Discussion

This abstract shows some preliminary results of the cortico-cortical connectivity study. We expect that this technique will help us to identify reproducible axonal bundles in the subcortical white matter and allows us to quantitatively evaluate white matter connectivity. Data from more subjects is under way.