Functional MRI results guided ROI selection & probability map making on DTI study: the white matter route for orthography-to-phonology transformation in Chinese

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Introduction

Reading involves complex information processes, and most of all it needs expertise in transforming the visual word form into auditory representation, namely orthography-to-phonology transformation (OPT). There are two theories debating about the information processes in OPT. Dural-route theory [1] asserts two independent routes responsible for processing highly used or irregular words as well as words of pronunciation highly accordant to the spelling-to-sound rules, respectively. However, the connectionist view in OPT supports words of different kinds are processed in the same circuitry. The differences in using frequency and spelling regularity come from the processing depth and the level of neuronal activation in stead [2]. The writing system in Chinese is quite different from the alphabetic ones, because the former needs deeper orthography processing. The neural substrates for OPT of Chinese characters were revealed in the fMRI research study of Lee et al., [3], and result showed the brain activation patterns were similar across different depth of OPT processing. In the present study, the first goal was to use diffusion tensor imaging (DTI) to delineate possible connection between the main activated foci for OPT in Chinese. The superior longitudinal fasciculus (SLF) in the left brain was the main concern for analysis, for the reason that it is believed to involve in the language process. Finding the correlation between the white matter indices and the reaction time of word naming was the second goal to investigate whether the tracts play important roles in the processing of OPT.

Method

Eighteen male, right-handiness participants with mean age 24.3 ± 2.4 were recruited in the study. They first received a naming task outside the MR scanner. The task was a 2 by 2 factorial design (Frequency × Consistency), and each factor had two levels (high & low).Therefore, the naming task contained four types of Chinese characters (HFHC, HFLC, LFHC, LFLC), and the reaction time in each condition was recorded. Whole brain diffusion-weighted images were acquired on a GE 1.5 T system, with single shot diffusion spin-echo EPI sequence, TR/TE = 1700/68.9 ms, voxel size = 2 ×2 × 2.2 mm^3, b = 900 s/mm^2, 13 directions, and NEX = 6. The flowchart about the analysis following was shown in Fig. 1.The left SLF was delineated first by manual selection of ROI for tractography, and 2-ROI-and method was used to segment SLF into three parts which connect frontal, parietal, and occipito-temporal regions one by one. Each track bundle was saved as a track data file for further spatial transformation. T_1WI of each subject was coregistered and resliced to accord with the DTI data. SPM nonlinear registration was used to transform the resliced T_1WI into MNI152 space, so that a generated transformation function obtained. The saved track files were mapped to the standard space through the transformation function, and then were collected to build probability maps of SLF and the three segments [4]. The threshold of probability maps was set at 33%, which means the voxels belonging to a track bundle were shown & calculated only when more than 33% of population devotes tracks passing through. The white matter indices (FA, RD, & TRACE) were calculated by applying probability maps onto the transformed index maps individually. After all, a non-parametric correlation test (Spearmans' rho) between reaction time and white matter index was performed, with the alpha = .05.

Results

The left superior longitudinal fasciculus was segmented into three parts (Fig. 2) by 2-ROI-and method, which the ROIs were selected according to the activated foci in the fMRI study, although not all the participants devoted tracks to every segment. However, the averaged reaction time in each word condition did not correlate with the white matter index, neither of the three segments nor the whole SLF itself ($-0.025 < r < 0.212$, $p > .05$, generally speaking).

Discussion

Among all the white matter tracts, the superior longitudinal fasciculus was thought to be involved in language processing, and the regions it connected accorded with the activated foci in performing OPT of Chinese characters. The present study segmented left SLF into three parts, and the results were more supportive for the connectionist model of OPT, which held the opinion that the information was processed in the parallel and distributed neural network. In the meanwhile, the current results conformed to the finding of Catani et al., [5], which averaged all the DTI images first and then reconstructed further detailed dissections, instead of making a probability maps on each part. There was no significant correlation between the behavioral data and the white matter integrity indices. Nevertheless, it could not come to a conclusion that all the tracks within SLF or SLF itself do not play important roles in the processing of OPT. Three possible reasons could explain the negative finding. First, the probability maps may diminish individual difference for it emphasizing the homogeneity within groups. There may be more detailed dissection within SLF, however current results just show the macro-structures. Finally, the tracks other than SLF may also involve in the processing OPT, so it will be better to recruit other related tracks into consideration in the future study.

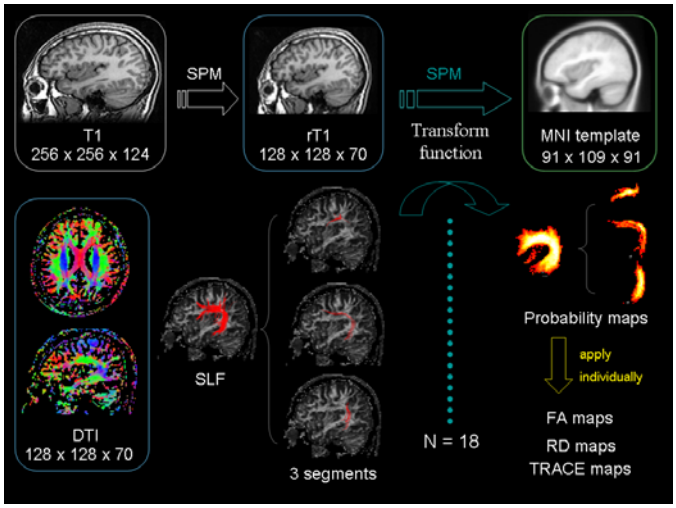

Fig. 1. The flowchart for analysis. Tractography and probability map making were performed by an in-house program. SPM was used for

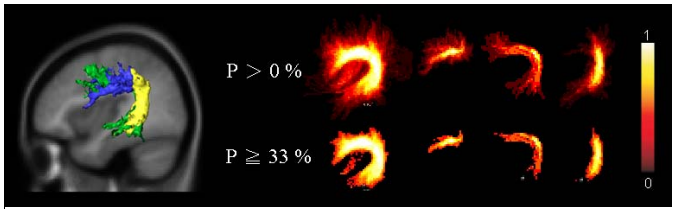

Fig. 2. The results of segmentation and probability maps. The P value for probability maps meant the proportion of the population devoting tracks

Reference

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Acknowledgements

This study was support by National Science Council grant (NSC 97-2752-H-010 -004 –PAE).