

DTI fiber tracking and fractional anisotropy-reaction time correlations in visual word recognition

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Introduction

Speed of visual word recognition is an important variable affecting linguistic competence, but the neural basis of reaction time (RT) differences is poorly understood. Participants completed a speeded lexical decision task. We used DTI (diffusion tensor imaging) to explore whether visual word recognition RT correlates with regional fractional anisotropy (FA) values in the WM (white matter) of healthy young adults. DTI tractography was performed in order to determine if two RT-FA correlation clusters were connected.

Materials and Methods

Sixteen young healthy volunteers (9 females; mean age = 24, SD = 5) participated. Subjects participated in a visual lexical decision task that involved visual input, linguistic processes, and a motor response output in a behavioral testing room immediately prior to the scanning session. DTI data were then collected on a 3T Siemens Magnetom Trio MRI scanner, using an 8-channel head array coil. A standard 3D 1mm³ mprage image was acquired for the localization of RT-FA correlation in the stereotactic space of the Montreal Neurological Institute (MNI). Diffusion tensor images (DTI) using a fluid attenuated inversion recovery EPI sequence (TR = 13600 ms, TE = 84 ms, TI = 2500 ms, flip angle = 90°) with six signal averages, six directions and a voxel dimension of 1.75x1.75x3.5mm³ were acquired. Analysis of the relationship between RT and FA was conducted using Statistic Parametric Mapping software (SPM2; <http://www.fil.ion.ucl.ac.uk/spm/>). FA images were smoothed with a 4-mm FWHM Gaussian filter. The correlation between RT and FA was computed using nonparametric Spearman rank regression [2] instead of parametric Pearson regression because of the potential nonnormality of the FA distribution across individuals. Monte Carlo simulations were run in order to determine the number of contiguous voxels needed to be correlated in order to achieve a corrected significance level of $p < .05$. A voxel-level threshold of $p < .001$, and a minimum cluster size of 20 contiguous correlated voxels was chosen to achieve a corrected significance level of $p < .05$. The Spearman correlation coefficient (r) map was visualized as an overlay on the standard MNI T1-template and the averaged FA image. DTI analysis was done using the DTI Task Card developed at Harvard. A two-ROI approach was used by defining ROIs in the FA volume, reconstructing all fibers passing through both, and visualizing DTI-based tracts using illuminated steamtubes [3].

Results and Discussion

Results indicated that lexical decision RT was correlated negatively with FA in WM of inferior parietal and frontal language regions rather than visual or motor regions. Figure 1 shows the location of the peak of correlation clusters on both the mean FA volume (left panel) and mean diffusion tensor map (right panel) for the frontal (panel A; MNI peak: -28 30 18) and parietal (panel B; MNI peak: -33 -48 32) regions. Figure 2 shows the regression plots of overall lexical decision RT and FA in the frontal (panel A) and parietal (panel B) regions. The correlation was $r=0.78$ for the inferior frontal region (cluster size = 22 MNI voxels) and $r=0.82$ for the inferior parietal region (cluster size = 44 MNI voxels). Tractography analyses revealed that these inferior parietal and frontal language regions were connected by the superior longitudinal fasciculus (SLF), see Figure 3. These results provide new microstructural evidence demonstrating that speed of visual word recognition is associated with the degree to which frontal and parietal components of SLF are oriented toward each other

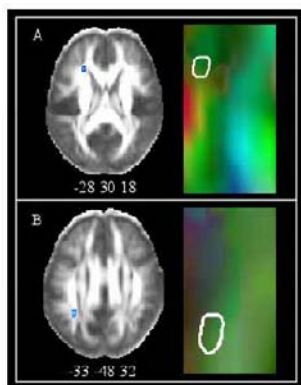


Figure 1

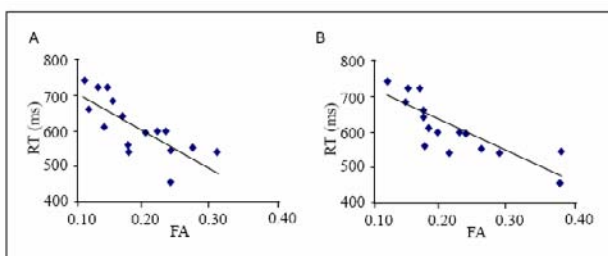


Figure 2

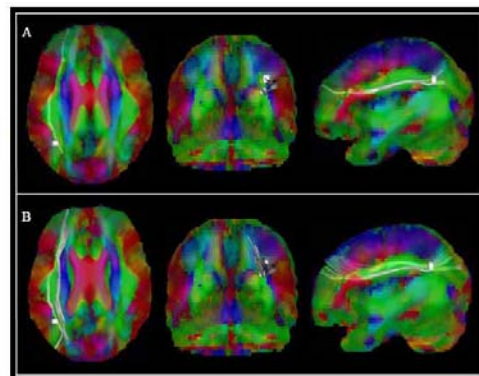


Figure 3

References

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