Asymmetrical inferior fronto-occipital fasciculus in Chinese children: correlation with Chinese reading

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Introduction:
In this study, we use diffusion tensor imaging (DTI) to study connectivity asymmetry in terms of fractional anisotropy (FA) and its correlations with reading scores among three age groups of normal population. VBM-like study was first used as exploratory method to detect regions of significant asymmetry and tractography based analysis was performed to confirm the findings and the resultant indices were correlated with reading scores to elucidate functional-structural relationship.

Method and Materials:
Seventy-five right-handed normal Chinese subjects from 3 age groups were recruited for this study (Table 1). They underwent conventional T2-weighted imaging and DTI with a 3T Siemens imager using EPI sequence with diffusion weighted images in 6 non-collinear direction and one non-diffusion weighted (b0) image, repeated 4 times (TR/TE=6000/84ms, FOV = 192 mm, acquisition matrix = 64 by 64, slice thickness = 3mm without gap, b factor = 1000 mm^{-2}s). Using SPM2, FA image and its left-right flipped version were normalized to standard space via corresponding T2 images. The difference image was created and smoothed with 12 mm FWHM Gaussian kernel. One sample t-test with FWE correction was used to detect significant FA

Table 1 showing subject demographics and cognitive scores

Subject demographics	Group 1	Group 2	Group 3
No. of subjects (No. of male)	24 (13)	27 (11)	24 (13)
Age Mean (SD) /years	7.4 (0.3)	10.3 (0.5)	22.8 (2.3)
IQ score(Raven) Mean (SD)	35.5 (7.0)	44.1 (3.4)	N/A
No. of subject with reading scores	23	26	17
Chinese reading scores Mean (SD)	56.6 (21.6)	97.4 (13.8)	113.5 (16.4)
English reading scores Mean (SD)	8.0 (9.6)	43.7 (35.9)	94.5 (13.4)

asymmetry among three groups. We then performed tractography based ROI analysis to confirm our findings [1]. Tractography failed for one subject in group 1 and she was excluded from further analysis. Left and right inferior frontal occipital (IFO) fasciculi were traced out and the fiber masks produced were transformed to standard space and averaged to create commonality image[2] representing possibility of a voxel being intercepted by fibers. Mean FA values of both side of IFO fasciculi were also quantified using respective fiber masks and denoted as LFA and RFA, respectively and lateralization index (LI) [2] was calculated as LI=(LFA-FA)/((LFA+RFA)/2) to reflect level of asymmetry(positive/negative for leftward/rightward asymmetry, respectively) . Using SPSS, repeated measures GLM was used to test the difference between LFA and RFA with age entered as covariate. Simple linear regression was also performed to test the change of LI with age. Multiple linear regression analysis was performed to test the correlation between both Chinese and English reading scores and LI after controlling for the effect of age.

Results:
Consistent regions of significant leftward asymmetry of FA were detected among three age groups in fronto-temporal, temporo-occipital and occipital regions, constituting arcuate fasciculus and IFO fasciculus as confirmed by commonality maps (Fig. 1, only group 1 shown). Repeated measure GLM showed LFA was significantly higher than RFA (p <0.001) and both increased significantly with age (p<0.001), no interaction was detected (p = 0.869) (Table2). LI was not found to change significantly with age (p = 0.883). Multiple regression analysis revealed LI to be highly significantly independent predictor of Chinese reading score after controlling for the effect of age (B = 156.7, p = 0.001, Fig. 2), while similar result was not found for English reading score (p = 0.092).

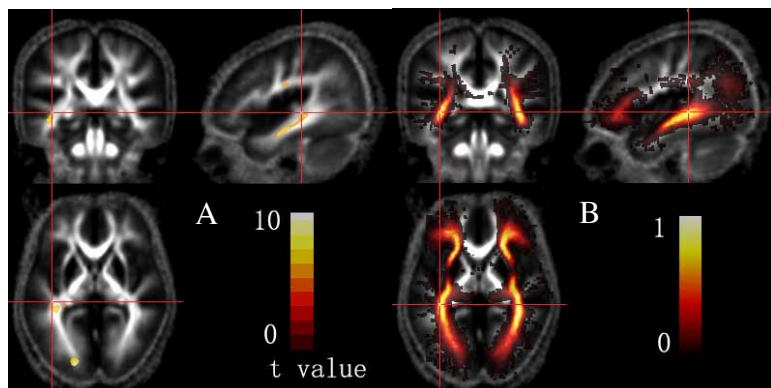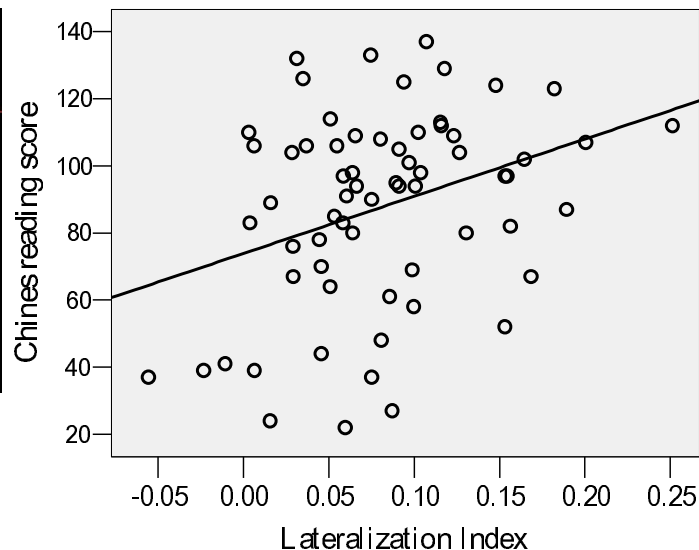Fig. 1 Region of asymmetry of Group 1 (A) and commonality map (B) confirming the region of asymmetry being IFO

Fig. 2 showing scatter plot of Chinese reading against LI

	Group 1	Group 2	Group 3
LFA Mean(SD)	0.407 (0.026)	0.426 (0.027)	0.445 (0.032)
RFA Mean(SD)	0.379 (0.023)	0.387 (0.019)	0.412 (0.033)
p value	<0.001		

Table 2 showing LFA and RFA among 3 age groups

Conclusions: We have used VBM-like study to detect region of significant FA asymmetry and confirmed the findings using tractography based analysis. Arcuate fasciculus and inferior fronto-occipital fasciculus were found to show significant left-ward asymmetry, consistent with previous findings [2,3]. Lateralization of IFO was implied to occur early by 7.4 yrs of age (group 1) and remain stable over adolescence to young adulthood despite the continuous maturation as reflected by FA change. LI was predictive of Chinese but not English reading performances, lending support to a prominent view that the left hemisphere is more relevant to the first language processing while both hemispheres are involved in second language acquisition and representation.

References: **1.** Jones D, et al, 2005. NeuroImage. 26(2):546-54 **2.** Parker G, et al, 2005. NeuroImage. 24:656-66 **3.** Catani M, et al, 2005. Ann Neurol.57:8-16.