White matter differences between bilinguals and monolinguals revealed by diffusion tensor imaging (DTI)

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Introduction

The two main areas in the human brain associated with language are Broca's and Wernicke's areas. Broca's area (BA) is responsible for speech production, language processing, language comprehension, as well as controlling facial neurons (language outputs). Wernicke's area (WA) is thought to be the language receptive center, which processes the words that we hear or read (language input). A large bundle of neurons, called Arcuate Fasciculus, connects these two areas. White matter pathology and morphology can be investigated by means of DT-MRI based fiber tracking. Previous study has shown significant differences between bilinguals and monolinguals in the ratio of the anterior midbody (AMB) and the total corpus callosum (CC) midsagittal areas [see Figure 1 Left]. The AMB is dedicated to primary motor and somatosensory interconnections.

Aim

The hypothesis of our study was that the regions associated with language exhibit structural differences in bilinguals and monolinguals and that MRI DTI can be used to assess these differences. Our specific goal was to demonstrate differences in the white matter fibers connecting BA to WA, fibers going from BA to CC and also from AMB to the primary motor cortex.

Materials and Methods

The experiments were conducted on a 3T MR system (Philips Achieva Release 2.5), with an 8 channel SENSE head coil. Two groups , respectively containing 6 monolingual and 7 bilingual children (right-handed, healthy males and females, 8-11 year old), were scanned. A single-shot spin-echo, echo-planar sequence (SS-SEEPI) with 15 non-collinear diffusion gradient directions and b= 700 s/mm^2 was used. Other imaging parameters were: TR/TE=6484ms/ 60ms, FOV=224x224x120 mm^3, 60 oblique axial 2mm slices, total scan duration=454s. Mean fractional anisotropy (FA) in selected bundles of neurons was calculated for each subject using DTIstudio software (Johns Hopkins University, Baltimore, USA). The bundles were obtained by tracing three sets of fibers [see Figure 1]: from the white matter region underlying BA to WA (shown in red); from CC to BA (shown in green) and from AMB to the primary motor cortex (shown in yellow). Independent samples t-tests were performed to compare the mean FA values between groups. A P-value of less than 0.05 was considered significant.

Results and Discussion

Table 1 shows that the mean FA values of the fibers connecting BA to WA is higher in bilinguals, whereas the fibers going from BA to CC have higher mean FA value in monolinguals. No significant difference could be found between the FA values of the fibers connecting AMB and primary motor cortex.

These results support the hypothesis that bilingual and monolingual brains are different. The study demonstrates that DTI can help understanding structural differences between the white matter of bilingual and monolingual brains.

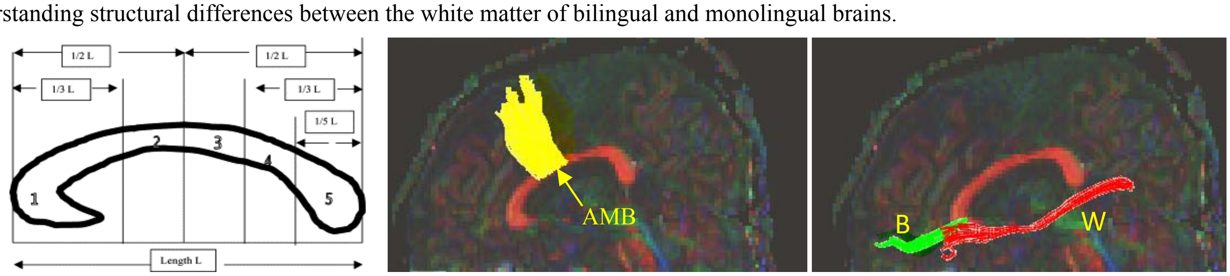

Figure 1 Left: Regional subdivision of the midsagittal CC (in studies on bilingualism the second sub-region CC2 is of interest); Middle: Fibers from AMB to motor cortex; Right: Fibers going from CC to BA (Green) and from BA to WA (Red).

FA	Bilinguals			Monolinguals			p-value		
	BA to WA	CC to BA	From AMB	BA to WA	CC to BA	From AMB	BA to WA	CC to BA	From AMB
	0.552 ± 0.020	0.585 ±0.017	0.580 ±0.019	0.513 ±0.030	0.615 ±0.017	0.578 ± 0.016	0.007	0.003	0.435

Table1: Fractional anisotropy for bilingual and monolingual individuals; The FA value (mean ±SD) was obtained for the bundles of fibers connecting: BA to WA; CC to BA and AMB to the primary motor cortex. The P–values refer to independent samples t-tests.

Reference: 1-Coggins et al 2004.2 -Clare Kelly et al 2010; 3-Susumu Mori 2006