Distortion Correction Improves DTI Visualization of the Microscopic Elements of the Medial Temporal Lobe

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Introduction: Alterations in medial temporal lobe (MTL) microcircuitry may be important to neurologic disorders such as Alzheimer's disease and focal epilepsy. Our prior work utilized ultra-high resolution DTI to characterize the microscopic subregions and connections within the MTL [1]. Distortion in echo-planar (EPI) DTI makes coregistration with structural imaging difficult, both complicating segmentation and creating inaccuracies in tractography [2]. To improve the anatomic accuracy of DTI, we performed distortion correction on the EPI source data from our prior work [1].

Methods: *Acquisition:* Five right-handed subjects provided consent and were imaged on a GE 750HDx 3.0T magnet using an 8-channel receive head coil and body transmit [1]. Structural sequences included a thin-section axial and coronal T2FSE. After a 2nd order shim, DTI was collected with axial plane EPI, GRAPPA R 2, two shots, b=1500 s/mm^2, TR 3150 ms, TE 69 ms with a partial Fourier acquisition, Stejskal-Tanner diffusion preparation, 70 diffusion directions, 10 T2s, phase encoding A/P with positive polarity ('blip up'), chemical fat saturation, 128 x 128, 18cm FOV, 1.4mm thick contiguous, 27 continuous slices, 1.4mm isotropic resolution, 8.5 min per repetition, 7 repetitions. A single b=0 volume with opposite phase-encoding polarity ('blip-down') was also collected. *Image Processing:* Eddy-current and motion correction were performed [1]. Distortion correction was achieved by calculating and applying a transformation field using the FSL 5.0 functions `topup` and `applytopup` [2]. *Segmentation and Tractography:* On the isoDWI, a detailed segmentation was performed of all hippocampal subregions according to anatomic atlases [1] and warped via the distortion correction transformation field.

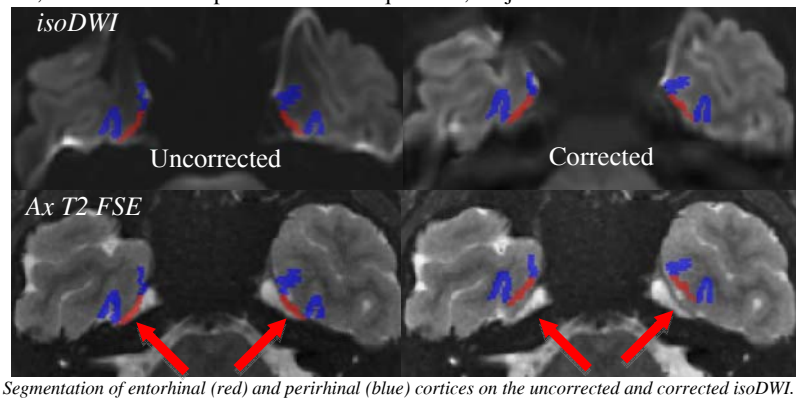

Figure 1: Segmentation of entorhinal (red) and perirhinal (blue) cortices on the uncorrected and corrected isoDWI. Note the improved coregistration with the T2 FSE of the entorhinal cortex (red arrows) on the corrected images.

Results: *Overlap of Structural on DTI Data:* Before distortion correction, the segmentation showed poor overlap between EPI data and structural imaging (Figure 1). After correction, this overlap improved in key regions such as the entorhinal cortex. *ROI Analysis:* In both distortion corrected and uncorrected datasets, overall FA was higher and MD lower on the left (p<=0.003, n=35 (5 patients x 7 regions)). Examining each subregion separately, both datasets showed a higher FA in the left ERC and fornix (p=0.033, n=5), but only the distortion corrected data showed an increased FA in CA 1 and decreased MD in the subiculum, left compared to right (p=0.04 & 0.0005, respectively). *Tractography:* All of the seven medial temporal pathways were present in each subject with both distortion corrected and uncorrected datasets. Tracks subjectively appeared more confined to the expected pathways after distortion correction (Figure 2, red arrows, tracks 3-5). Track counts were not significantly different in this small cohort (p=0.17). Tract-based measurements demonstrated a higher FA, lower MD, and longer tracks on the left side in both datasets (p<=0.05).

Conclusions: Distortion-corrected DTI coregisters with high-resolution structural images, which should facilitate more accurate or even automated segmentation. Furthermore, this correction should improve the veracity of tractography by removing the errors associated with susceptibility-induced distortions. Comparison of the left and right sides in this right-handed cohort suggests that distortion correction data matches or exceeds the capabilities of uncorrected data to detect putative differences in MTL language dominance.

References: 1. Zeineh MM et al., NeuroImage 2012. 2. Andersson JL et al. NeuroImage 2004.

Acknowledgement: GE Healthcare

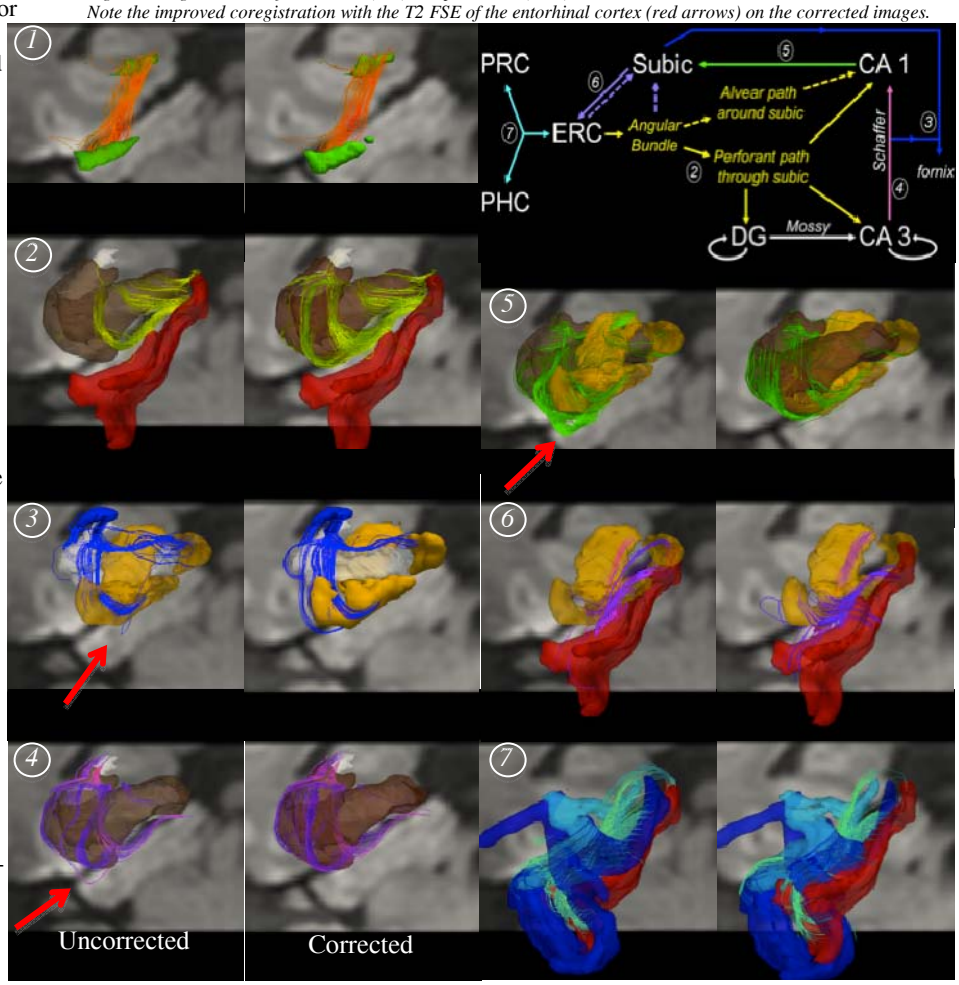

Figure 2: Seven MTL tracks, uncorrected (left) and corrected (right) for EPI distortion. CA = cornu ammonis, DG = dentate gyrus, ERC = entorhinal cortex, PHC = parahippocampal cortex, PRC = perirhinal cortex, Subic=subiculum. Track 1 = Cingulum Bundle. See inset at top right for other tracks. Arrows highlight differences due to distortion.