

# WITHIN SUBJECT AVERAGING OF DIFFUSION TENSOR MRI DATA SETS: A TEST-RETEST REPRODUCIBILITY EVALUATION

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## INTRODUCTION

The accuracy and precision of a Diffusion tensor imaging (DTI) acquisition of *in-vivo* human brains depends on both the acquisition protocol [1] and post-processing used for data analysis. In many cases multiple acquisitions from the same session are averaged to increase signal-to-noise ratio and reduce sensitivity to motion during the acquisition. The complexity of DTI datasets allows for several processing paths to complete eddy current correction, co-registration, averaging and tensor fitting. Here we assess the sensitivity of fractional anisotropy (FA) test-retest reproducibility to different methods for merging multiple within-subject DTI acquisitions.

## MATERIALS AND METHODS

**Data Acquisition:** Five healthy volunteers (3m, 2f, mean age 33±8 years) were scanned in two separate sessions at least a week apart (test-retest) using a 4.0 T Bruker Medspec scanner equipped with an eight-channel multi receive system. In each session we acquired a structural image (3D MPRAGE, 1x1x1 mm<sup>3</sup>, GRAPPA IPAT = 2) and 2 identical sets (hereafter named a and b) of Diffusion Weighted Images (DWI) (twice Refocused SE-EPI sequence [2], GRAPPA IPAT=2, 5 b0 images, 30 diffusion images [3], total scan time about 4:30min per acquisition, voxel size 2<sup>3</sup> mm<sup>3</sup> and b-value 1000 s/mm<sup>2</sup>).

**Data Analysis:** For each subject FA estimates using the 2 homologous DWI sets have been done using 4 different post-processing procedures: **1) "AveDWI"**: For each of the 2 datasets eddy currents (EC) correction was performed with FSL using the first b0 volume of each dataset as reference. Then the b0 reference volume of the scan b was co-registered to the b0 reference volume of the scan a using a rigid body transformation with FSL and the transformation matrix applied to all the EC corrected b dataset. The homologous images of the two datasets were finally averaged and TrackVis used to calculate FA maps. **2) "CONCAT"**: a and b datasets were concatenated using a Matlab script (merging first the 5+5 b0 volumes from the two scans and after the 30+30 DWI images as it was a 10+60 gradient directions single acquisition). EC correction was performed using the first b0 volume of this dataset (belonging to the scan a). Finally FA maps were calculated using TrackVis with a "doubled" gradient table. **3) "CONCAT/2"**: The 2 datasets were separately EC corrected and co-registered using the b0 reference volumes as in 1). The resulting datasets were concatenated and the FA maps were calculated as in 2). **4) "AveFA"**: The two datasets were independently EC corrected and processed and the 2 resulting FA maps subsequently co-registered and averaged.

Finally the FA maps of each subject were co-registered to a single FA map of another subject (reference). FA reproducibility across the 2 sessions was compared on an ROIs basis for all the described methods. Three ROIs were considered: "Corpus Callosum" (hand-drawn using MRICro on the sagittal view of the reference FA map), "Arcuate fasciculus" (AF) and "Cingulum" (both hand-drawn with TrackVis following the guidelines described in [4]). On the 3 ROIs the mean FA and its Standard Deviation were measured using MRICro, and from this the test-retest reproducibility was calculated as  $200 \cdot (FA_{test} - FA_{retest}) / (FA_{test} + FA_{retest})$ .

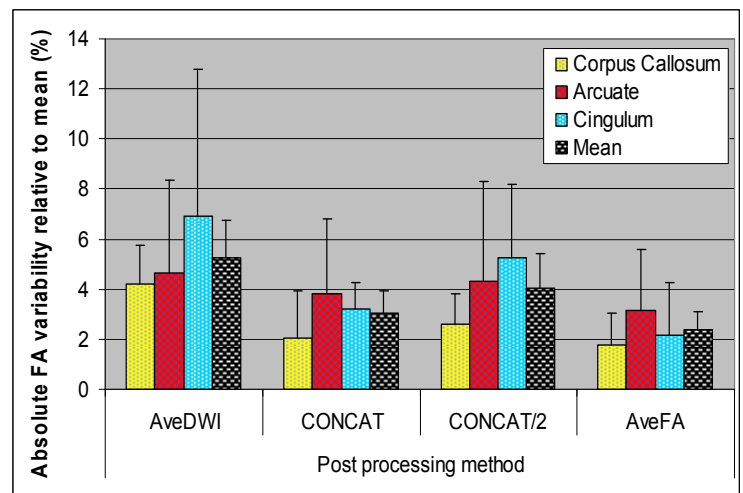
## RESULTS

Figure 1 summarizes the group average FA reproducibility for the 4 processing methods.

The methods 2) and 4) seem to give the best reproducibility and have been found to be statistically equivalent. Since method 4) is not very convenient because it needs many co-registrations if other tensor metrics besides FA are of interest, the method 2) (moreover the simplest among all) has to be preferred. Method 1) seems to be the one in which the bias introduced by noise propagation is the worst.

## DISCUSSION AND CONCLUSION

We evaluated the test-retest reproducibility of FA when using different methods to average multiple within-subject DTI acquisitions. The most reliable method was the one that treats multiple measurements as they were a single acquisition. These are preliminary results given the low number of subjects. Sensitivity to head motion between and within acquisitions remains to be studied, as well as reproducibility of the whole tensor rather than scalar quantities.



**Figure1:** Group reproducibility on the selected ROIs

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## REFERENCES

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