# TBSS result variations: is the analysis dependent on the fitting algorithm?

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**Introduction:** Voxel-based analysis is an important approach in the comparison of subject groups. It allows one to detect and localize grey/white matter changes in the brain. One of the principal problems in the inter-subject comparison is the absence of a "gold standard" in the analysis pipeline. As a result, different studies might arrive at contradictory conclusions based on the data processing variations, e.g. in the data normalization or smoothing procedure. Tract-based spatial statistics (TBSS) has great potential for overcoming this gap between automatic detection of white matter changes and variations in the analysis performed. We show that a minimal variation effect can be expected by using an approach based on the robust diffusion imaging framework exploiting the modified least trimmed squares estimator [1].

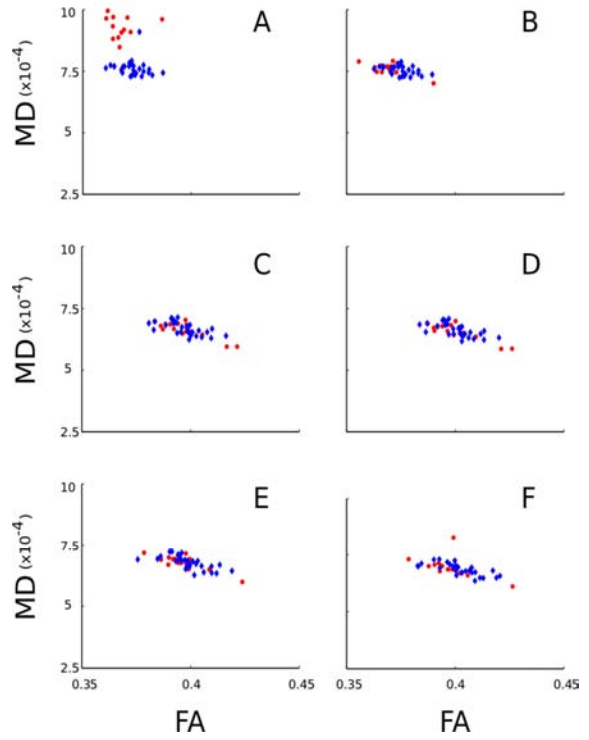


Figure 1. The scatter plots of the mean whole brain FA/MD values for Tourette group (red points) and control group (blue points). FA and MD images were estimated using different fitting algorithms: A – OLS ExploreDTI, B – WLS ExploreDTI, C–OLS FSL, D – WLS FSL, E – NLS Matlab, F – robust framework Matlab.

**Methods:** We used six algorithms for the estimation of typical scalar diffusion metrics such as FA and MD: ordinary and weighted least squares implemented in ExploreDTI [2], ordinary and weighted least squares implemented in FSL [3], non-linear least squares and MLTS implemented by in-house MATLAB scripts [1,4]. The data preprocessing (noise, motion, and eddy currents corrections) and TBSS pipeline were the same for all six algorithms. We used Tourette patients (N=16) and control (N=29) groups as a basis for our tests. Diffusion-weighted images were acquired on a 1.5T Sonata Vision MR machine (Siemens Medical Systems, Erlangen, Germany) with an 8-channel phased array head RF coil and a maximum gradient strength of 40 mT/m. The diffusion-weighted data were acquired using the following parameters: 2 mm slice thickness, no inter-slice gap, repetition time TR = 11000 ms, echo time TE = 89 ms, field-of-view FOV = 256 × 208 $mm^2$, imaging matrix = 128 × 104, number of slices in the transverse orientation = 71. The Tourette patient and control group selection criteria were described in detail in [5].

**Results:** In Fig. 1 we present scatter plots showing FA vs MD in order to demonstrate a possible variation in mean estimations for selected groups. In Fig. 2 we show 3D overlapping between two regions detected by TBSS: the blue region corresponds to mean common area obtained by overlapping the results from all algorithms except the robust framework [1]; the red region corresponds to the results of TBSS analysis obtained by robust framework [1].

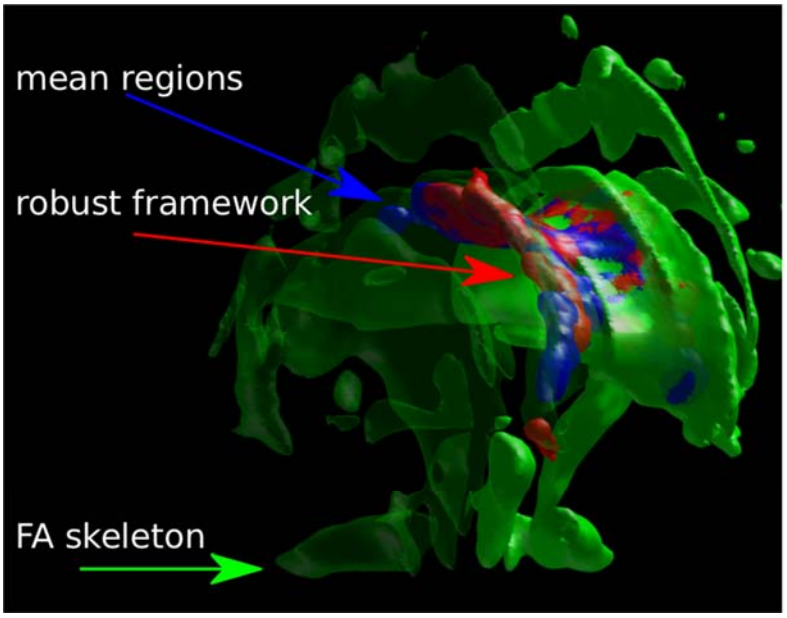


Figure 2. The visualization of regions obtained by common TBSS results based on fitting algorithms (blue coloured isosurface) and region obtained by TBSS analysis based on robust framework only (red coloured isosurface). The overlapping between blue and red isosurfaces is 75%. Green coloured isosurface corresponds to the FA values from range [0.5; 1]. 3D rotation is available on http://www.youtube.com/watch?v=-5OoZCHrv38

**Discussion and Conclusions:** We address potential problems that arise in voxelwise statistics based on the TBSS approach when different fitting algorithms are applied for the estimation of diffusion scalar metrics. As a result, TBSS analysis can produce a substantial difference in spatial detection of white matter changes (see, for example, the scatter plots in Fig. 1). We can hypothesize that in the case of common results such as TBSS analysis based on all algorithms producing the decreased/increased detection of diffusion scalar metrics, the overlapping region using all localized areas can be treated as the most reliable region. In turn, we can estimate a variation of TBSS results in spatial localization of white matter changes associated with that mean common region and use it as a criterion of reliability. The robust estimator based on the modified least trimmed squares algorithm exhibits good improvement in TBSS analysis due to the reduction of artefact variations in the results. In the case of the Tourette group analyses, the robust framework demonstrated 75% coincidence with mean common region. Thus, the approach which allows one to reproduce stable FA estimations is highly desirable in voxel-based analysis of inter-subject groups. Furthermore, the robust estimators could potentially improve the reproducibility of the fibre tracking assessed from DTI in clinical studies or in preparation for surgery planning [6].

**References:** **[1]** Maximov et al., NeuroImage (submitted); **[2]** Leemans et al., Proc. ISMRM 17 (2009); **[3]** Smith et al., 2004; NeuroImage 23(S1):208 **[4]** Maximov et al., 2011; JMR 213:136 **[5]** Neuner et al., 2010; NeuroImage 51:1184 **[6]** Wakane et al., 2007; NeuroImage 36:630.