MRC Cognition and Brain Sciences Unit

UNIVERSITY OF CAMBRIDGE

Diffusion MRI: preprocessing, model fitting and TBSS

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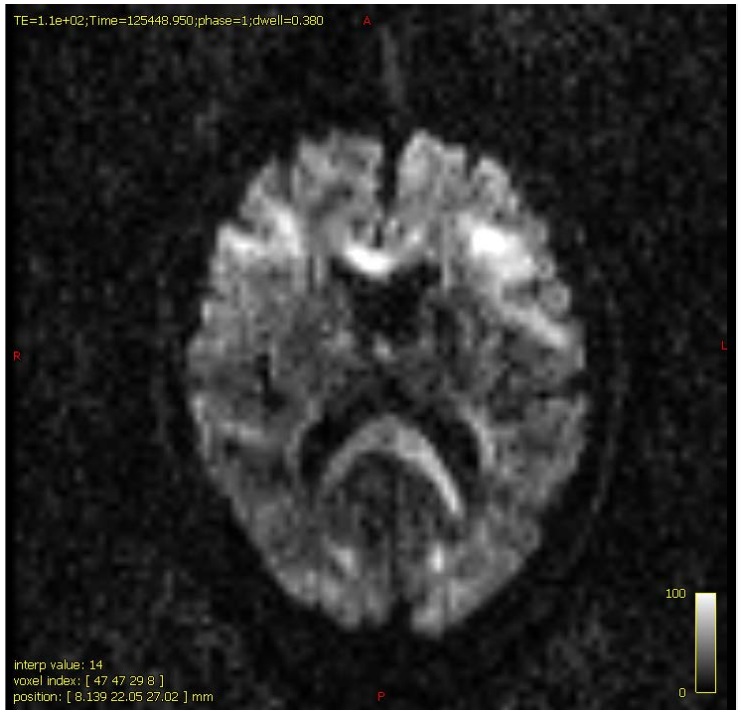
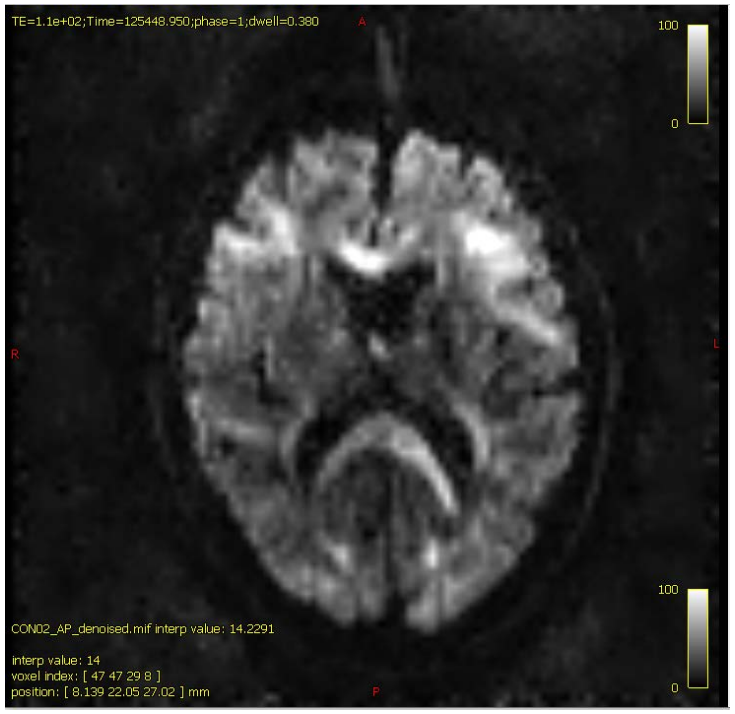
Preprocessing

DWI denoising

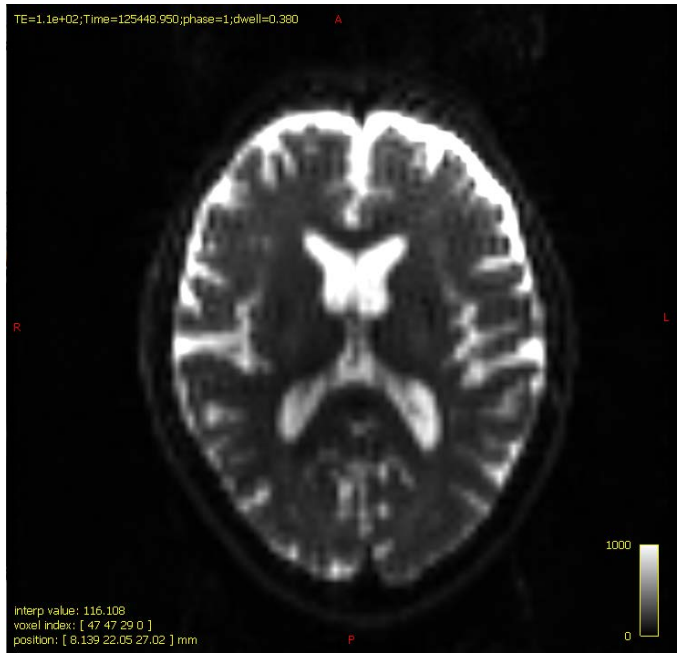
- Denoising must be performed as the first step of the pipeline
- Exploits data redundancy in the patch-level PCA domain

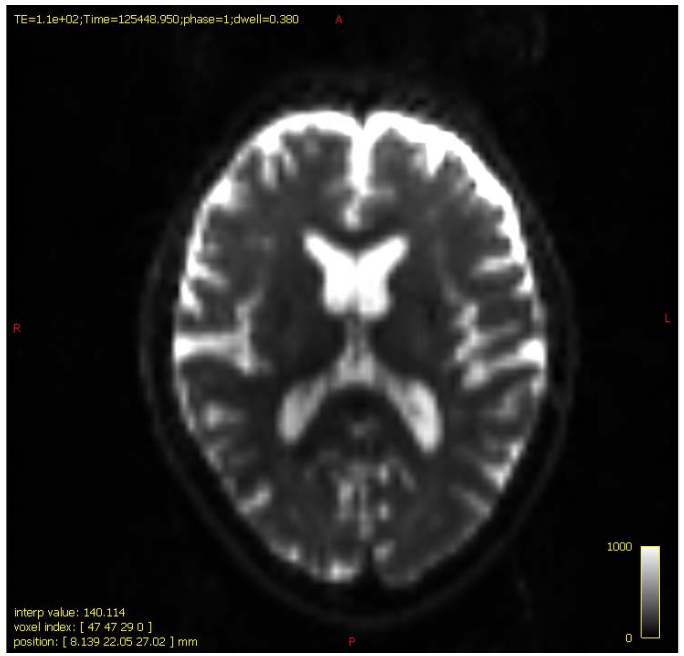




Removal of Gibbs artefacts (optional)

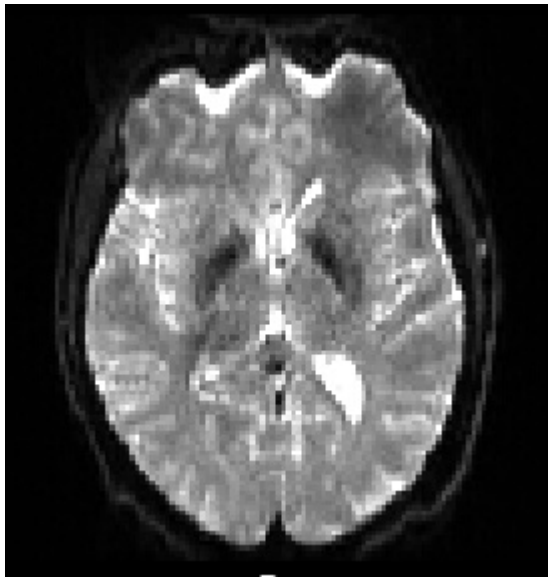
- Removes Gibbs ringing artefacts from DWI images
- Designed for data acquired with full k-space
- May fail for data acquired with Partial Fourier – always inspect the output



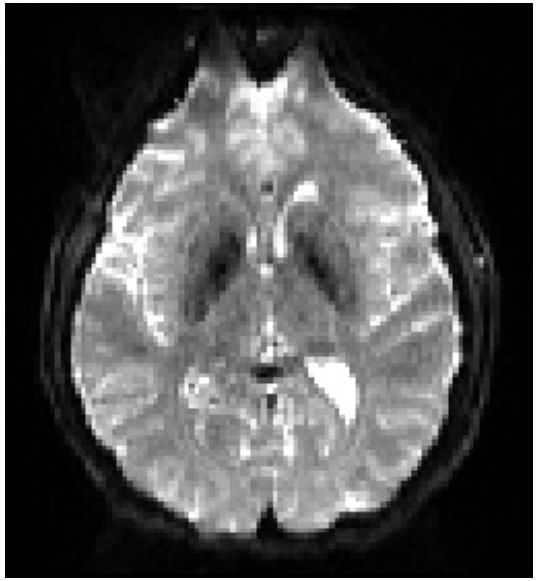


TOPUP: correction for EPI distortions

- EPI distortion due to B0 inhomogeneity depends on phase-encode direction



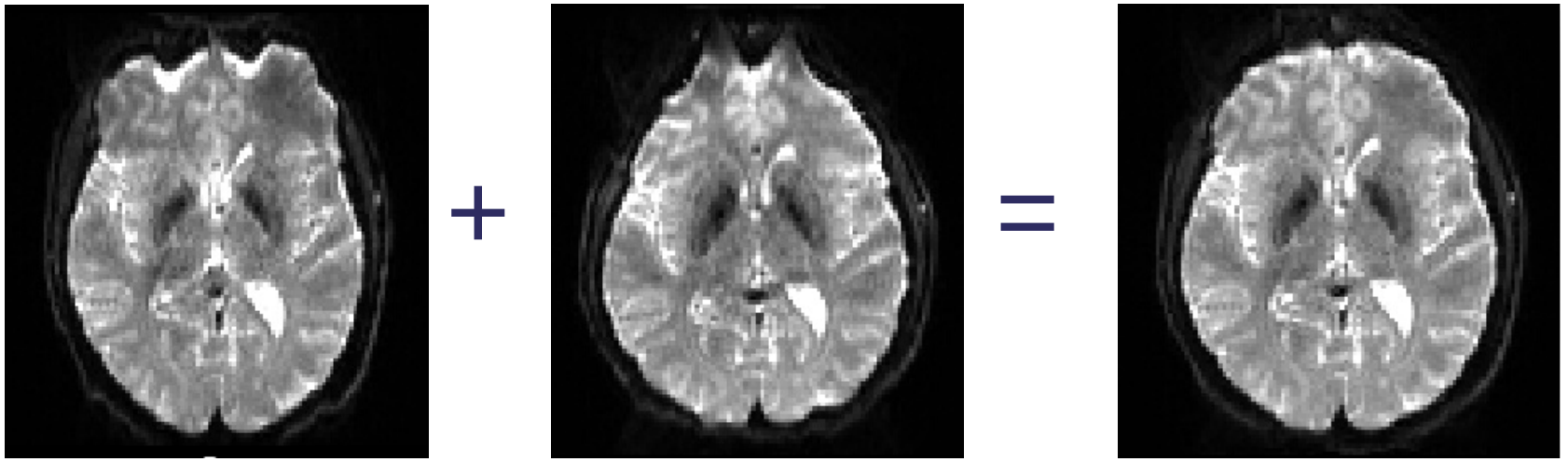
A>>P



P>>A

TOPUP: correction for EPI distortions

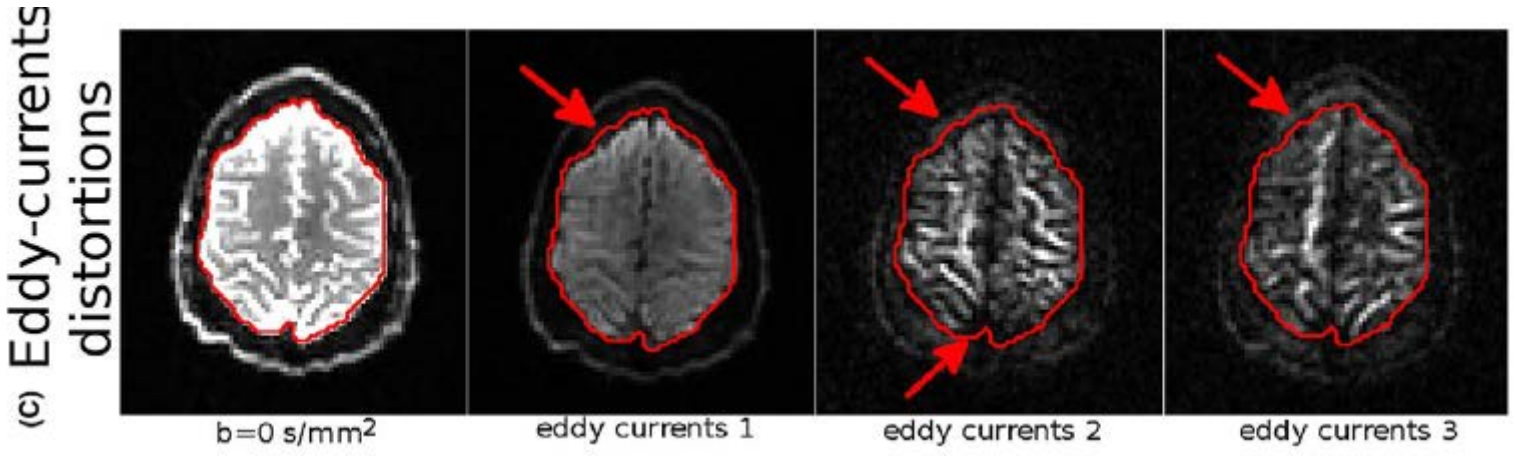
- EPI distortion due to B0 inhomogeneity depends on phase-encode direction
- Can it be corrected?



A>>P P>>A

EDDY: correction for eddy currents and motion

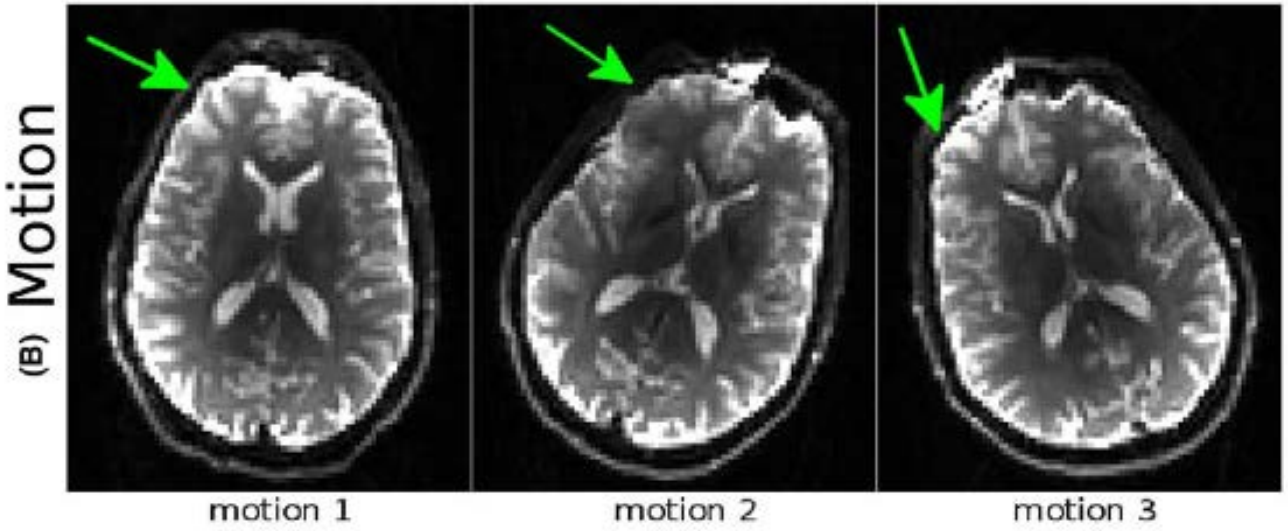
- Eddy-current distortions occur due to the rapid switching of diffusion gradients.
- Depend on gradient magnitude and direction.
- They affect the diffusion weighted images (DWI) but not the b=0 image.
- Results in mismatching between b=0 and DWI volumes.



Irfanoglu et al, MRM 2018

EDDY: correction for eddy currents and motion

- Motion artefacts occur due to involuntary head movements.
- Results in mismatching between DWI volumes.
- Can also result in signal changes due to coil sensitivity.



Irfanoglu et al, MRM 2018

EDDY QC: quality control

- For individual subjects: eddy_quad

Volume-to-volume motion

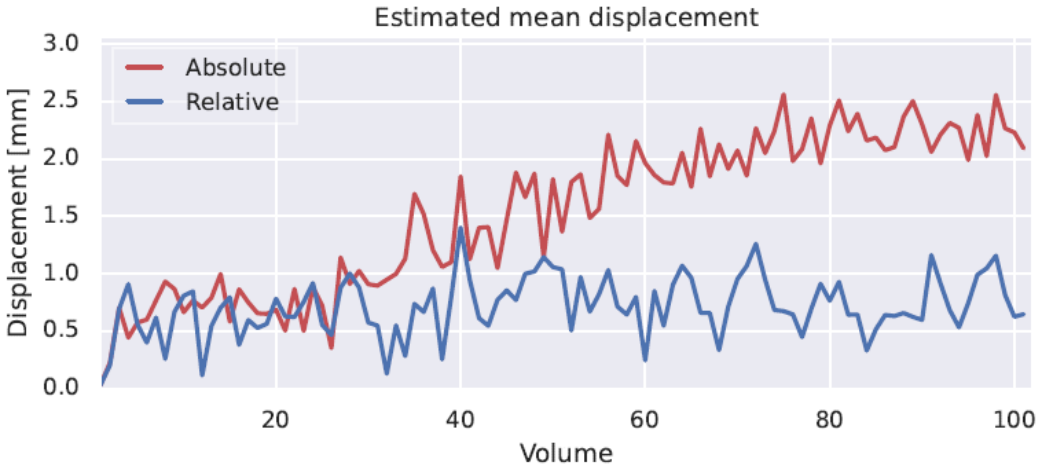
Average abs. motion (mm)	1.52
Average rel. motion (mm)	0.70
Average x translation (mm)	0.10
Average y translation (mm)	-0.90
Average z translation (mm)	0.98
Average x rotation (deg)	-0.02
Average y rotation (deg)	0.19
Average z rotation (deg)	-0.15

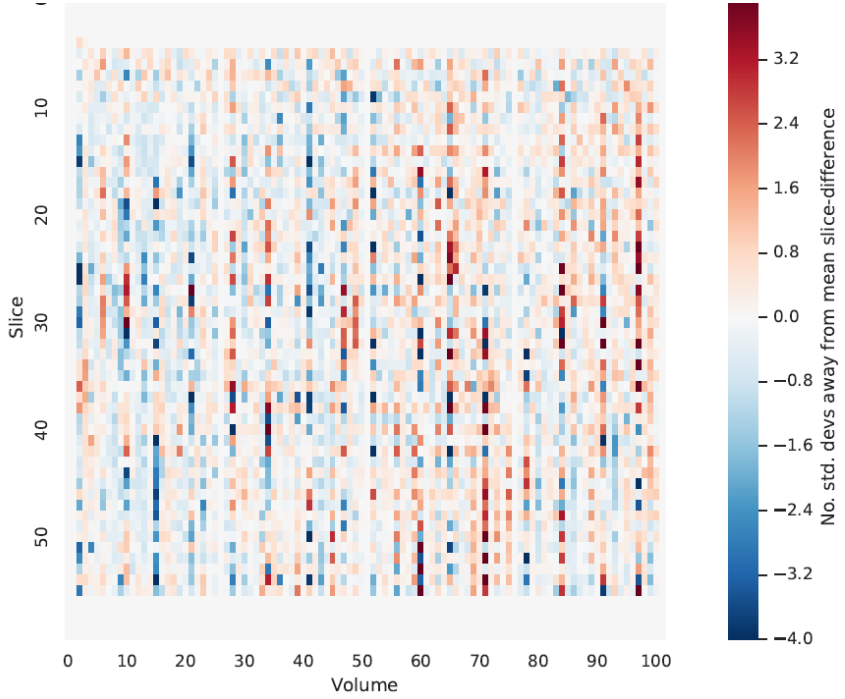
Outliers

Total outliers (%)	0.45
Outliers (b=700 s/mm^2)	2.71
Outliers (b=1200 s/mm^2)	0.00
Outliers (b=2800 s/mm^2)	0.00
Outliers (PE dir=[0. 1. 0.])	0.42

SNR/CNR

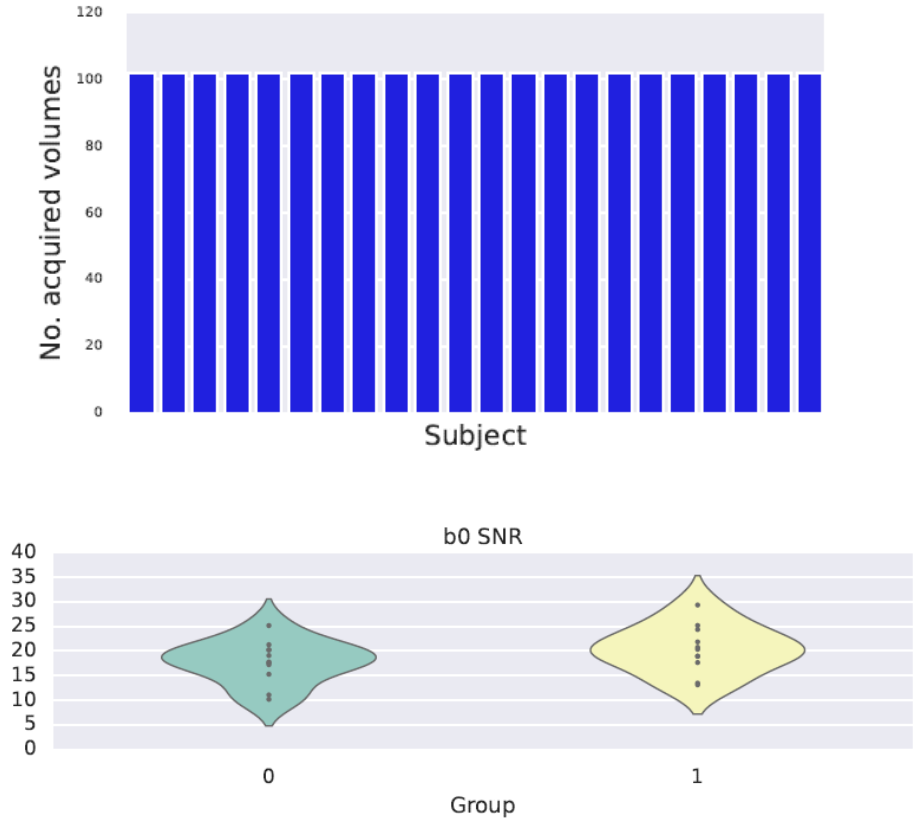
Average SNR (b=0 s/mm^2)	17.57
Average CNR (b=700 s/mm^2)	0.96
Average CNR (b=1200 s/mm^2)	1.33
Average CNR (b=2800 s/mm^2)	1.54

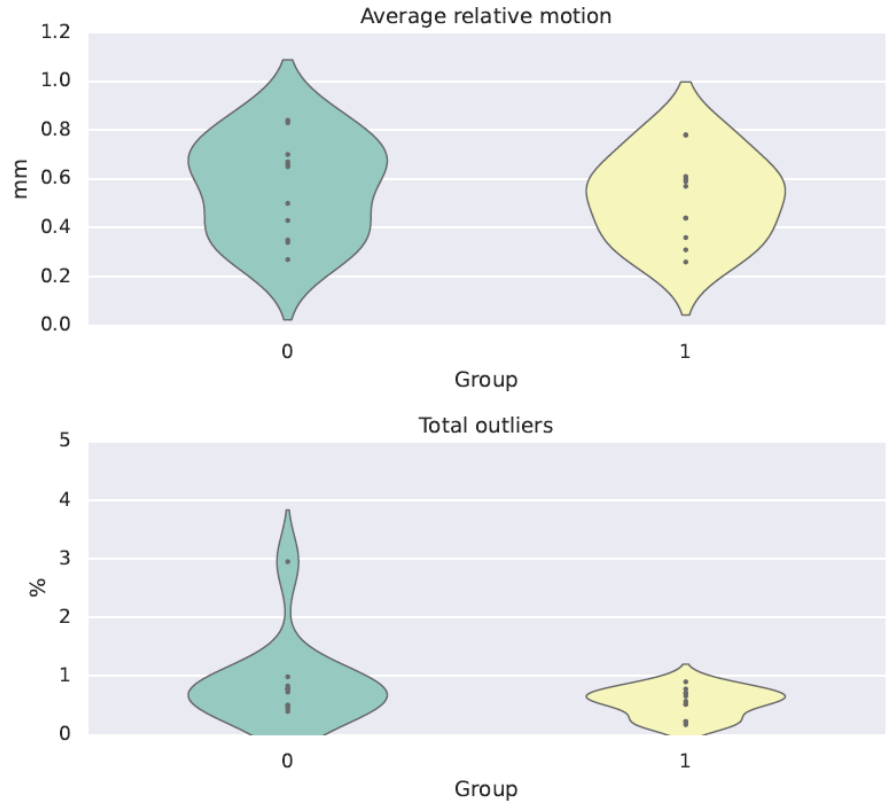




EDDY QC: quality control

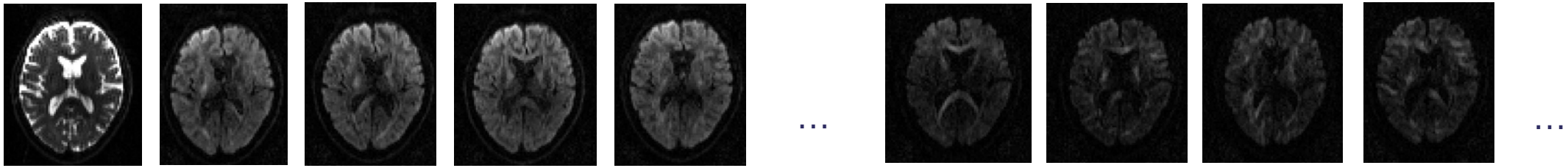
- Study-wise quality control: eddy_squad



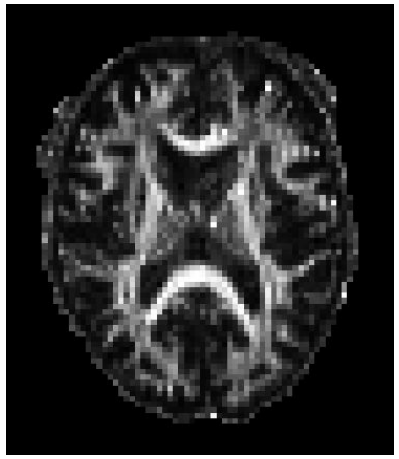


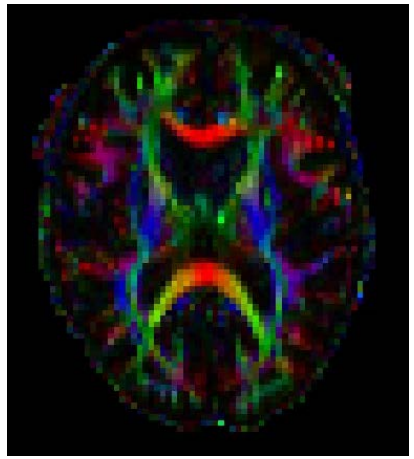
Model fitting

DTI: diffusion tensor model fitting

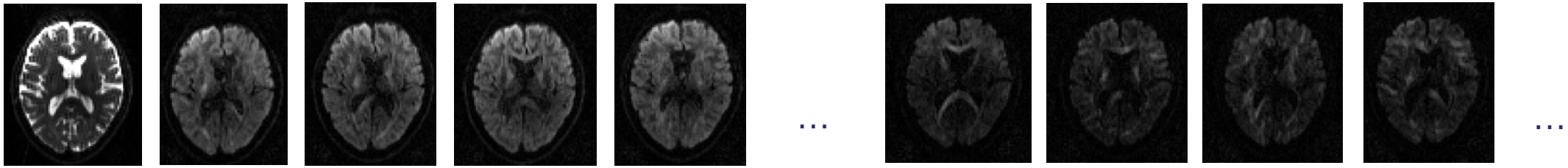


DTI model

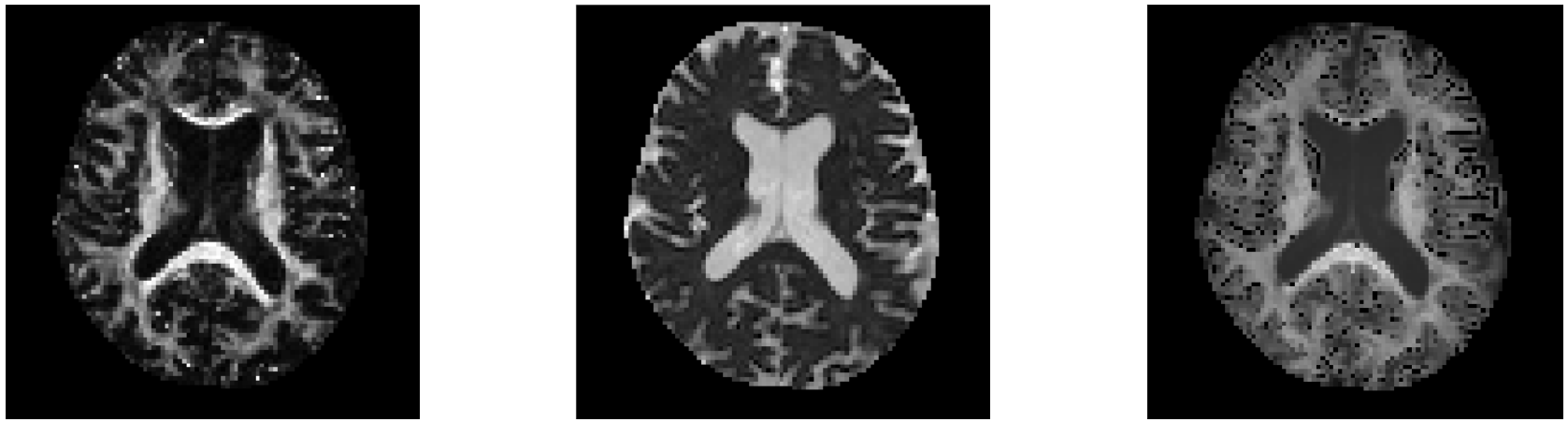




DKI: diffusion kurtosis model fitting



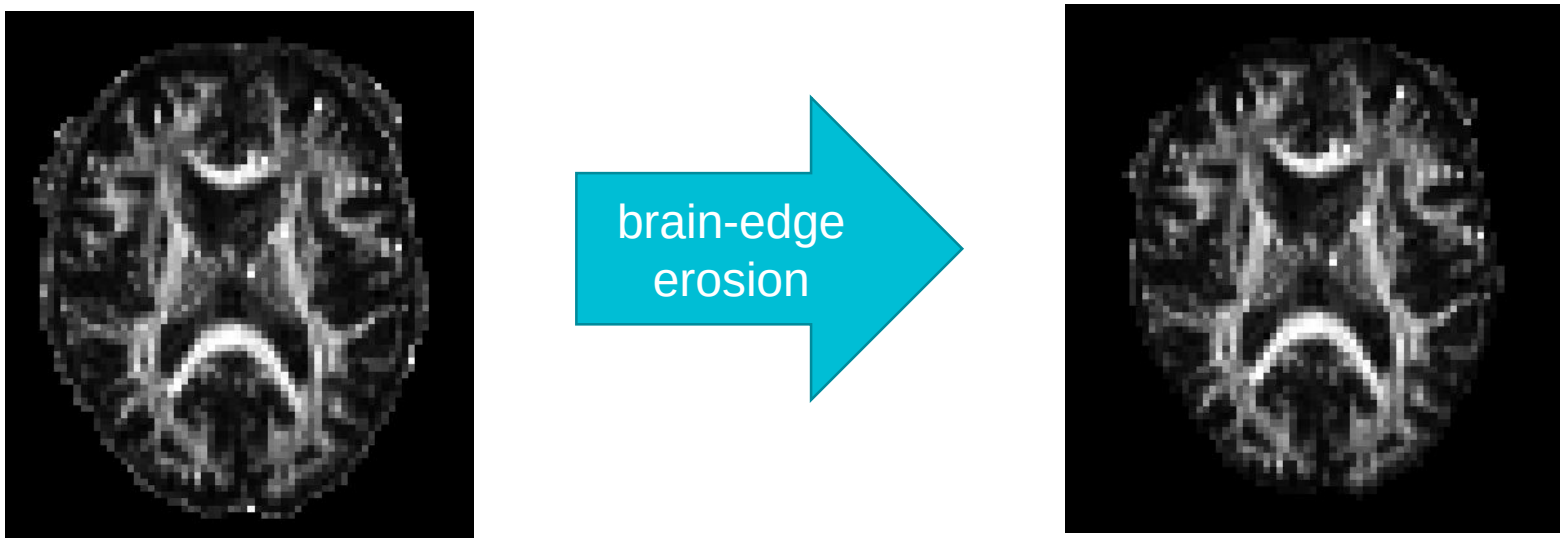
DKI model



Group Analysis: TBSS

TBSS: Group Analysis of DTI data

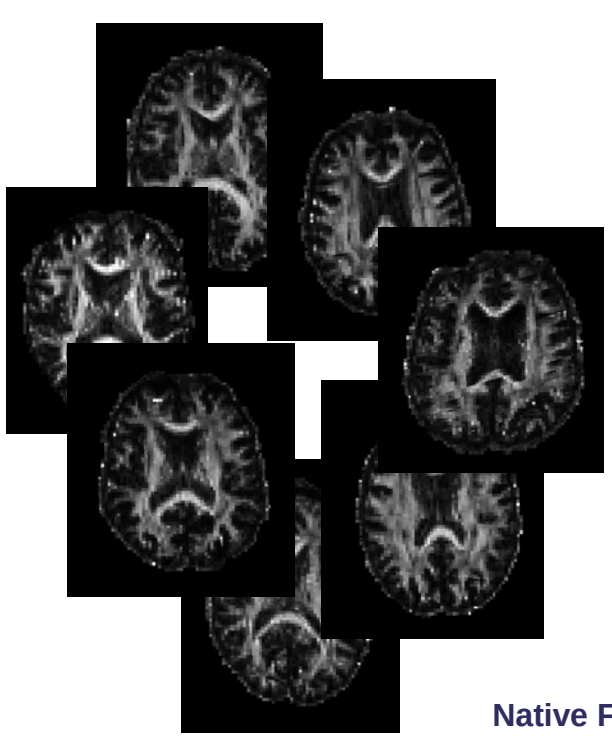
1. Preparing FA data for TBSS:
   - Rename files
   - New folder structure
   - Erode FA images to reduce brain-edge artefacts



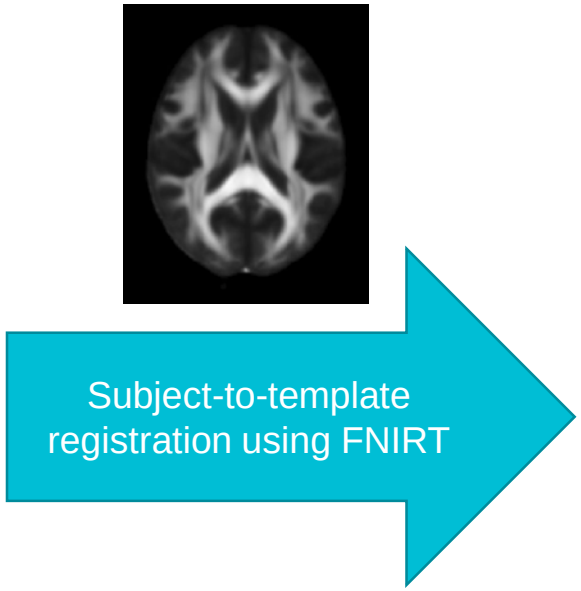
TBSS: Group Analysis of DTI data

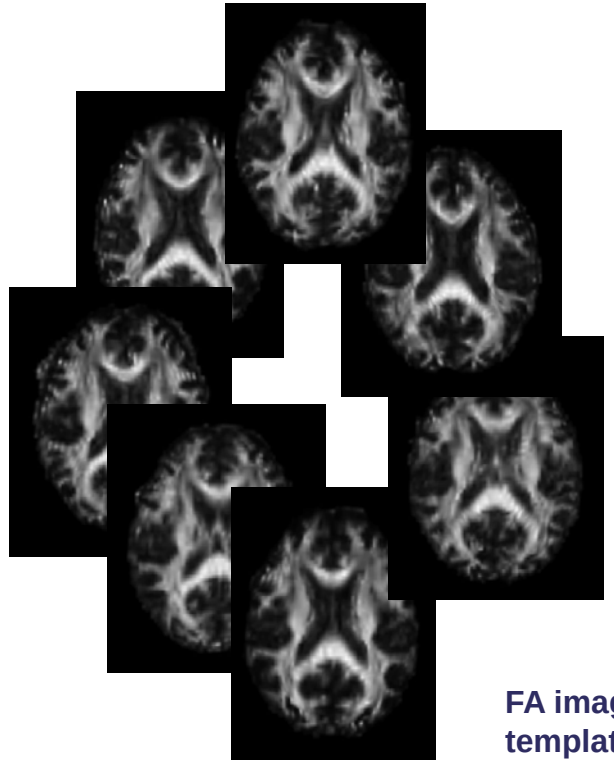
2. Registering the FA data:

- Register FA images to the FMRIB58_FA template using non-linear registration (FNIRT)



Native FA images



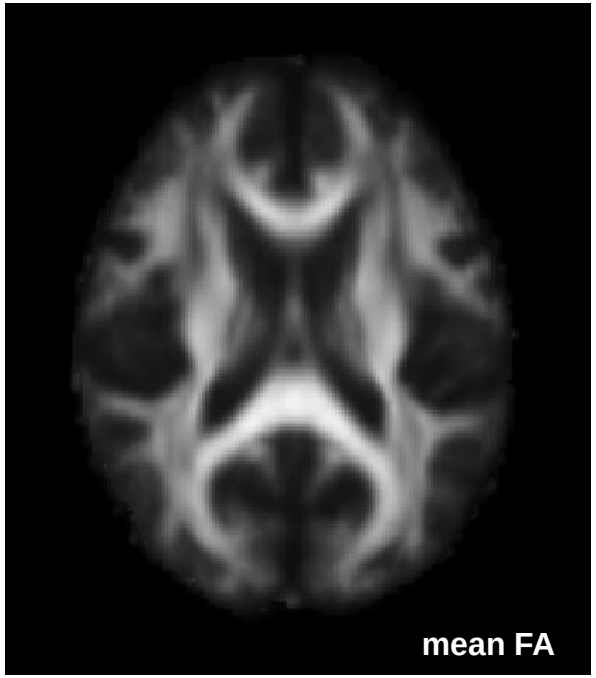


FA images in
template space

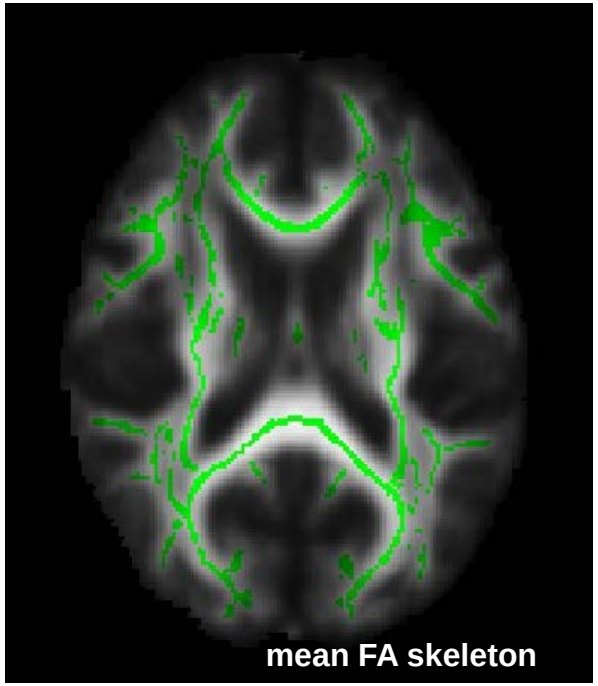
TBSS: Group Analysis of DTI data

3. Post-registration processing:

- Average all registered FA images
- Create the mean FA skeleton

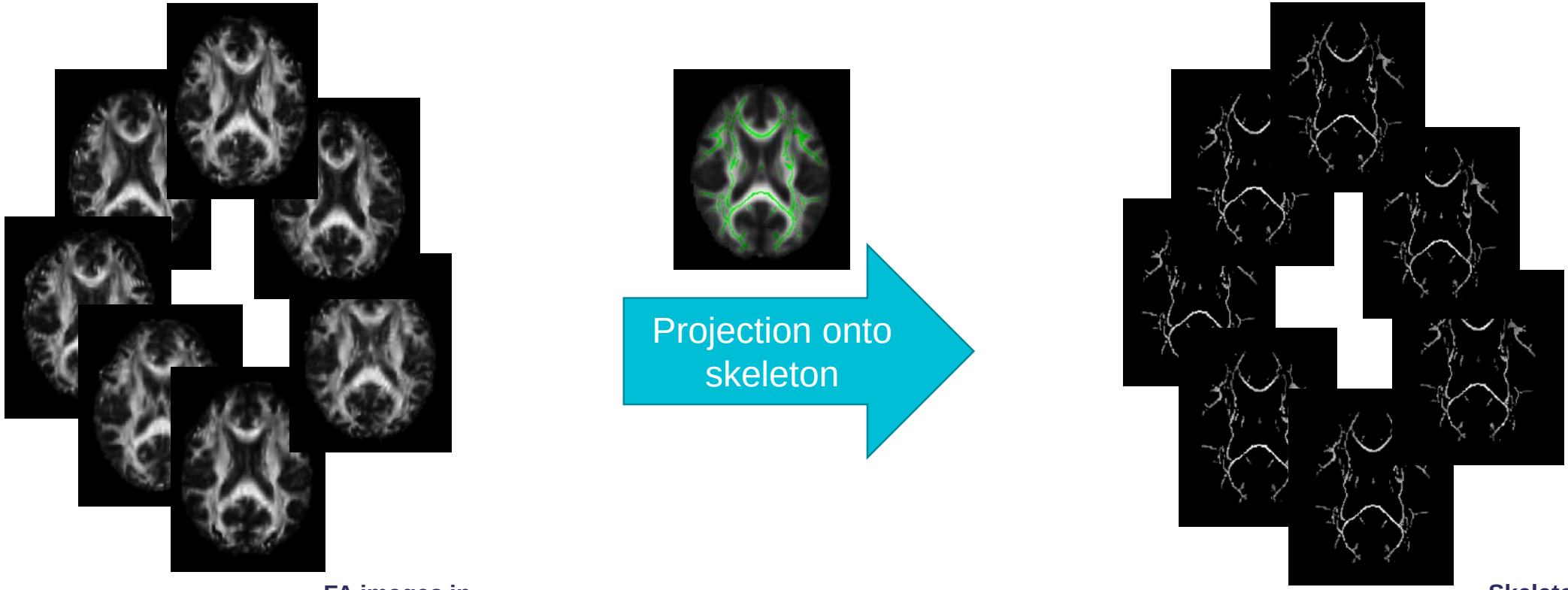


FA skeletonisation



TBSS: Group Analysis of DTI data

4. Projecting each subject's FA map onto the skeleton:



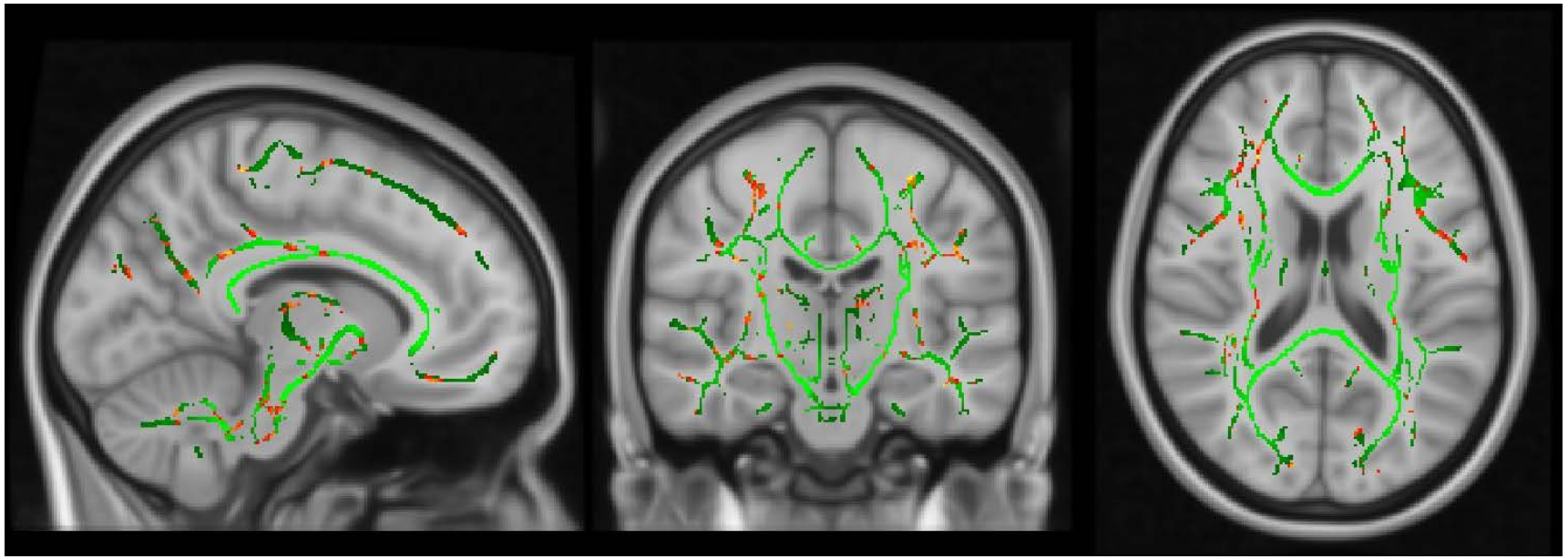
FA images in template space

Skeletonised FA images

VBM using FSL tools

5. Statistical analysis:

- Create the design matrix
- Use **randomise** for non-parametric inference



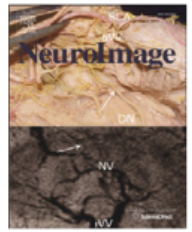
Interpretation of results

- FA skeleton does not represent the center of a specific WM tract.
- Significance maps should be interpreted with care: post-registration misalignments and voxel misassignments may confound the FA values from structures in close proximity.
- Choice of parameters, e.g. the registration target, can lead to large variation in the FA skeleton and subsequently the statistical results.

Contents lists available at ScienceDirect

NeuroImage

journal homepage: www.elsevier.com/locate/ynimg



Methodological considerations on tract-based spatial statistics (TBSS)

Michael Bach [a,b], Frederik B. Laun [a,b], Alexander Leemans [c], Chantal M.W. Tax [c], Geert J. Biessels [d], Bram Stieltjes [a], Klaus H. Maier-Hein [a,e,*]

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Questions?