PHYSICAL SENSING & PROCESSING – VI EDITION: PHYSICS FOR A BETTER PLANET

Laboratory for Brain Connectomics

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Tractography

3D modeling technique used to visually represent nerve tracts using data collected by diffusion MR.

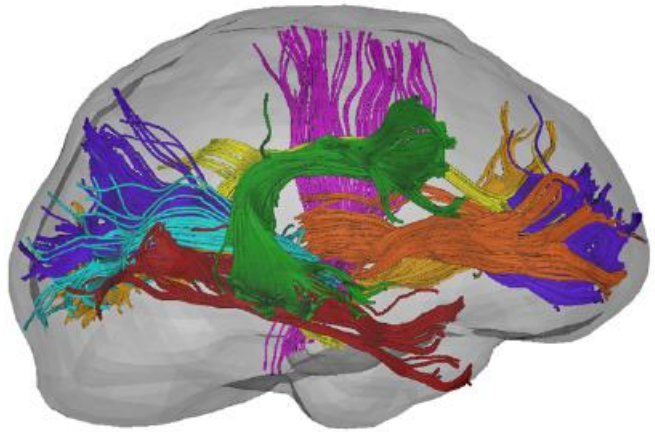
Starting from **diffusion MRI data** we can reconstruct the **brain pathways** by following the maximum direction of diffusivity within voxels. The result is a **coherent fibre bundle**.

What is Tractography?

FMRIB

Post-mortem dissection of some white matter fibre bundles (tracts)

Tractography
The post-imaging reconstruction of fibre bundles/ anatomical connections in the brain using a set of DW images. (in-vivo virtual dissection)



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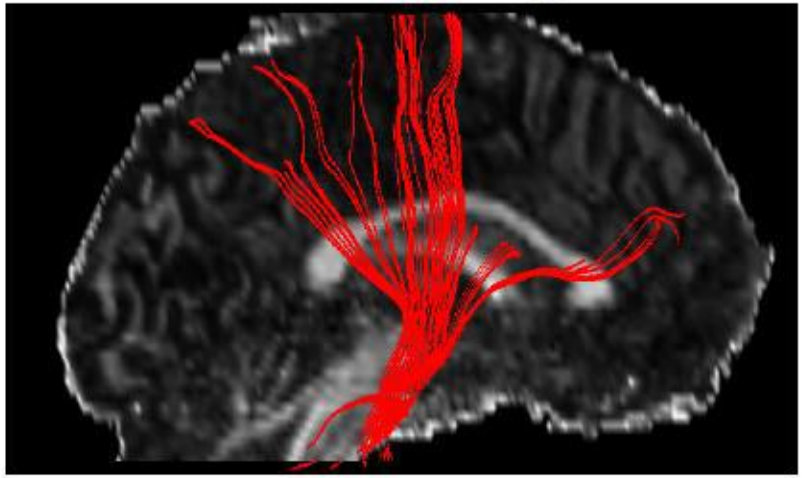
Laboratory for Brain Connectomics

Aim of the laboratory: reconstruct two different fibre bundles in two subjects.

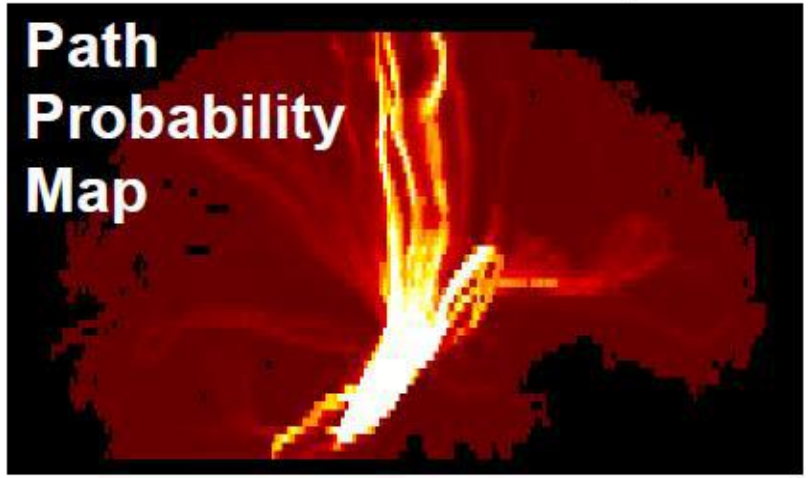
To do so we are going to use MRtrix3 which provides a set of tools to perform various types of diffusion MRI analyses.

We use **probabilistic tractography: evaluates the probability of fibre direction voxel by voxel;** provide an estimate of all paths originating from the seed point(s) that are plausible given the data.

Streamlines from a single dataset



Map that shows where results across datasets overlap



Data folder overview

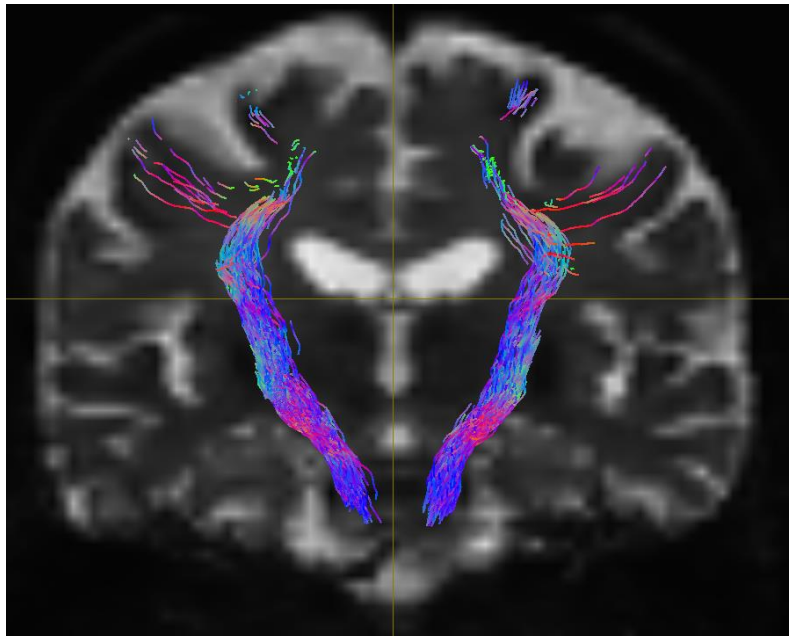
- **Two subjects**, each subject folder contains
  - **T1 weighted** image
  - **Diffusion data** “eddy_corrected_data”
  - **DTI fit results** FA and MD
  - **FOD**
  - **ROIs**
  - **bvals and bvecs**

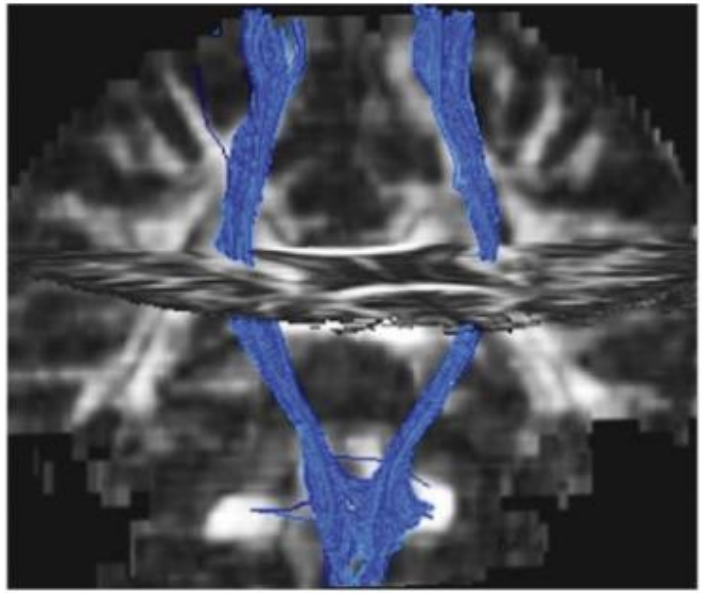
Corticospinal Tract (CST)

The Corticospinal tract (CST), is a white matter motor pathway, a collection of axons that carry movement-related information from the cerebral cortex to the spinal cord.

It originates from the cerebral cortex, and it terminates on lower motor neurons in the spinal cord, **controlling movements of the limbs and trunk.**

The primary purpose of the corticospinal tract is for **voluntary motor control** of the body and limbs.





How to reconstruct the CST

We use an **ROI** approach

MRtrix3 provides two functions to correctly reconstruct the tract

tckgen FODs/FOD_wm.nii.gz **-fslgrad** bvecs.bvec bvals.bval **-seed_image** ROIs/PLIC_R.nii.gz **-mask** Corrected_diffusion_data/B0_brain_mask.nii.gz **-force** Corticospinal_tract/CST_R_no_include.tck

tckgen FODs/FOD_wm.nii.gz **-fslgrad** bvecs.bvec bvals.bval **-seed_image** ROIs/PLIC_L.nii.gz **-mask** Corrected_diffusion_data/B0_brain_mask.nii.gz **-force** Corticospinal_tract/CST_L_no_include.tck

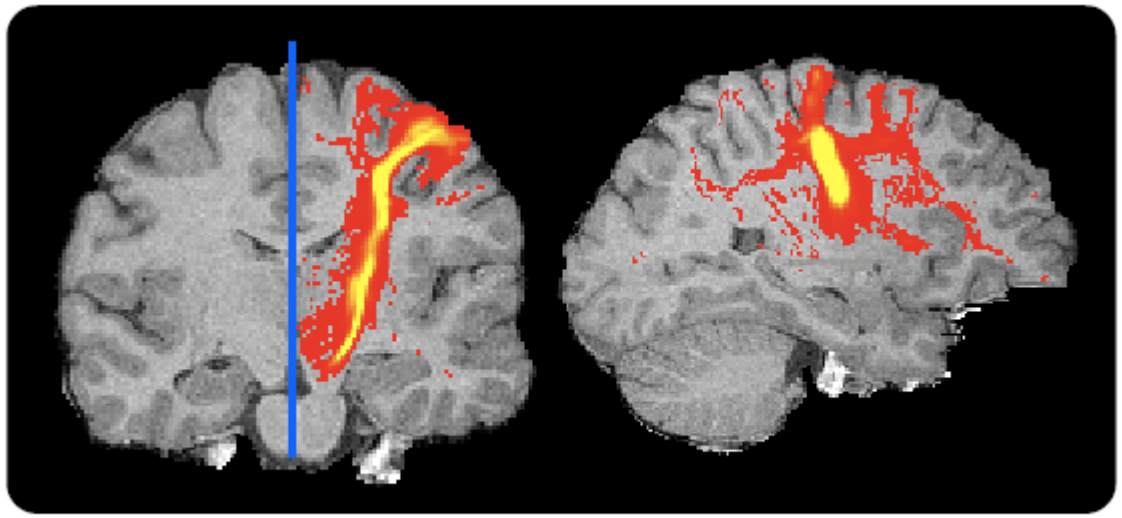
How to reconstruct the CST

We use an **ROI** approach

MRtrix3 provides two functions to correctly reconstruct the tract

tckgen FODs/FOD_wm.nii.gz **-fslgrad** bvecs.bvec bvals.bval **-seed_image** ROIs/PLIC_R.nii.gz **-exclude** ROIs/midsagittal_to_DWI.nii.gz **-mask** Corrected_diffusion_data/B0_brain_mask.nii.gz **-force** Corticospinal_tract/CST_R_no_include.tck

tckgen FODs/FOD_wm.nii.gz **-fslgrad** bvecs.bvec bvals.bval **-seed_image** ROIs/PLIC_L.nii.gz **-exclude** ROIs/midsagittal_to_DWI.nii.gz **-mask** Corrected_diffusion_data/B0_brain_mask.nii.gz **-force** Corticospinal_tract/CST_L_no_include.tck



Exclusion: Mid-Sagittal plane

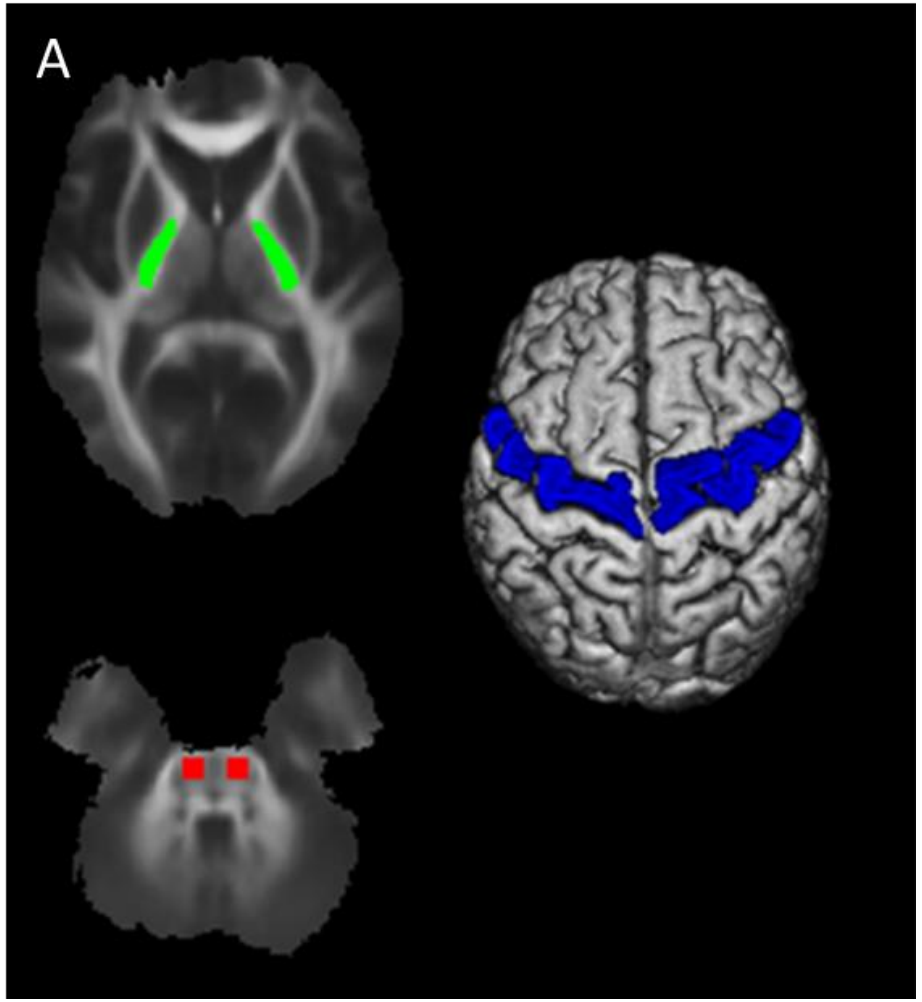
How to reconstruct the CST

We use an **ROI** approach

MRtrix3 provides two functions to correctly reconstruct the tract

tckgen FODs/FOD_wm.nii.gz **-fslgrad** bvecs.bvec bvals.bval **-seed_image** ROIs/PLIC_R.nii.gz **-include** ROIs/precentral_R_DWI.nii.gz **-include** ROIs/pons_R.nii.gz **-exclude** ROIs/midsagittal_to_DWI.nii.gz **-mask** Corrected_diffusion_data/B0_brain_mask.nii.gz **-force** Corticospinal_tract/CST_R.tck

tckmap -template DTI_results/DTIFit_FA.nii.gz Corticospinal_tract/CST_R.tck **-force** Corticospinal_tract/CST_R.nii.gz



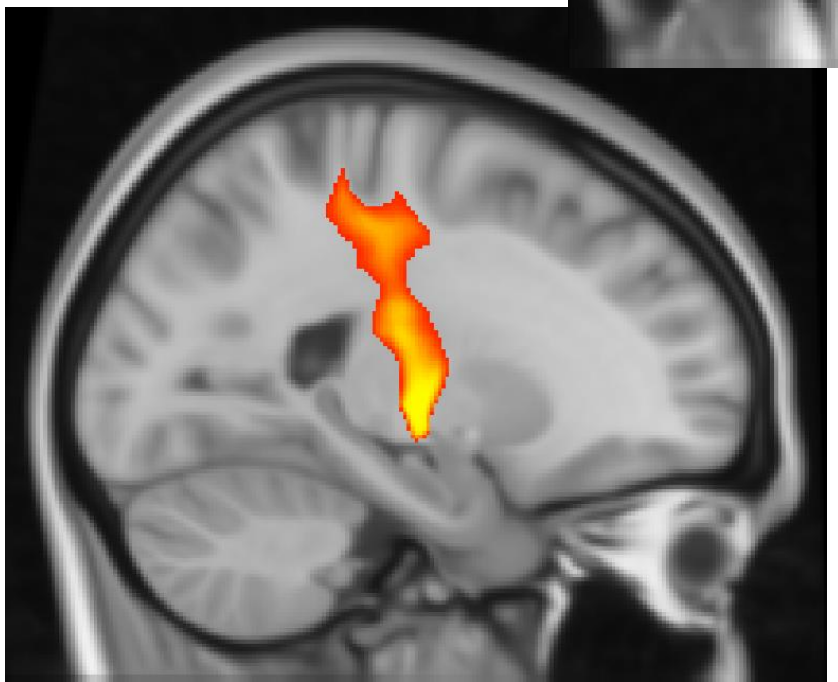
How to reconstruct the CST

We are not there yet, now we have to cut the originated tracts to reduce as much as possible the false positives.

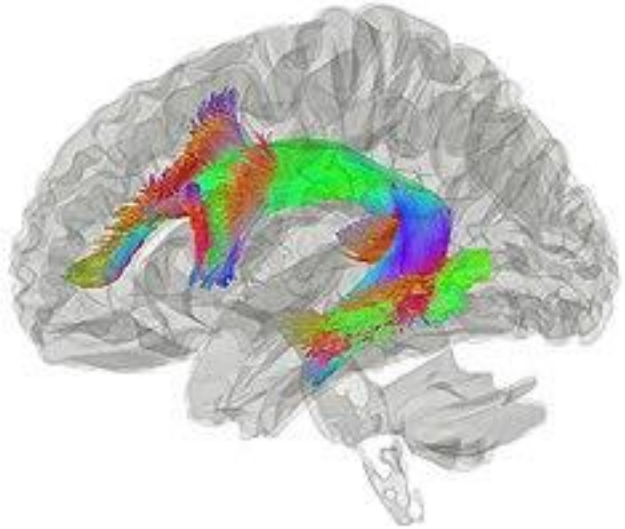
To do so we use a pre-designed mask, and we edit the streamlines

tckedit Corticospinal_tract/CST_R.tck Corticospinal_tract/CST_R_cropped.tck **-mask** ROIs/Mask_CST_R_DWI.nii.gz **-force**

tckmap -template DTI_results/DTIFit_FA.nii.gz Corticospinal_tract/CST_R_cropped.tck **-force** Corticospinal_tract/CST_R_cropped.nii.gz



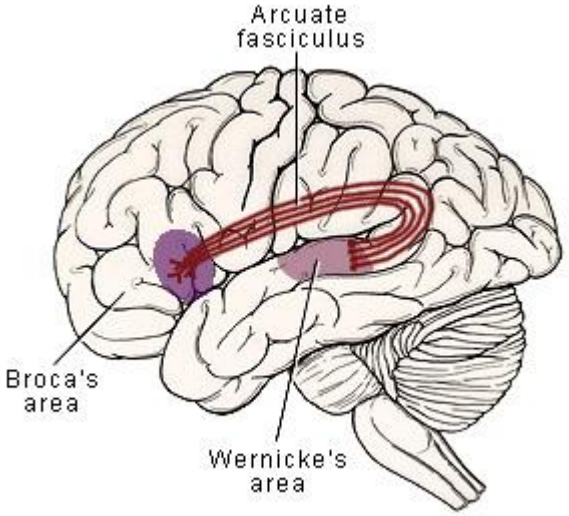
Arcuate Fasciculus (AF)



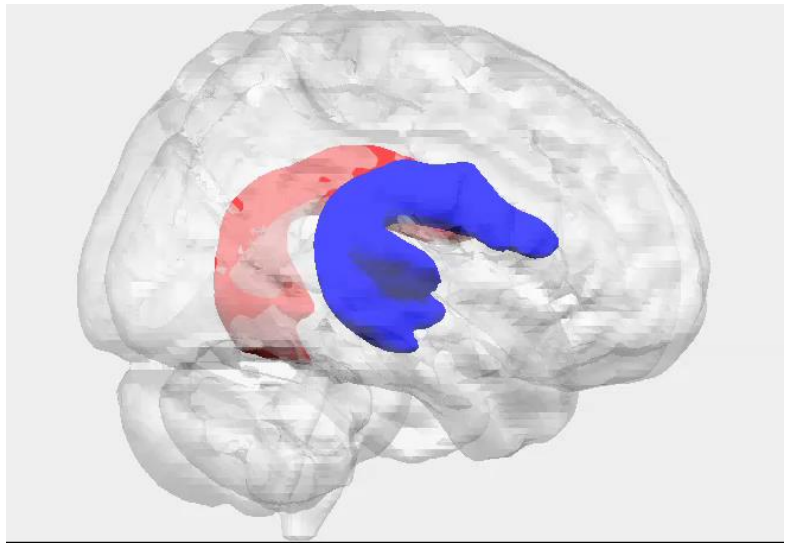
The arcuate fasciculus connects two important areas for **language use**, Broca's area and Wernicke's area.

Wernicke's area: comprehension of written and spoken language

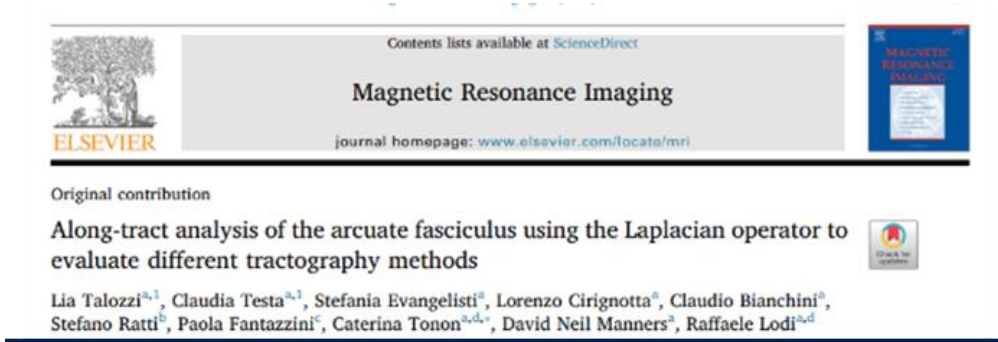
Broca's area: production of language



It has an important role in **syntax,** a set of rules by which we order words within a language. Lesions in the arcuate fasciculus often result in difficulties with syntax.



How to reconstruct the AF



Contents lists available at ScienceDirect

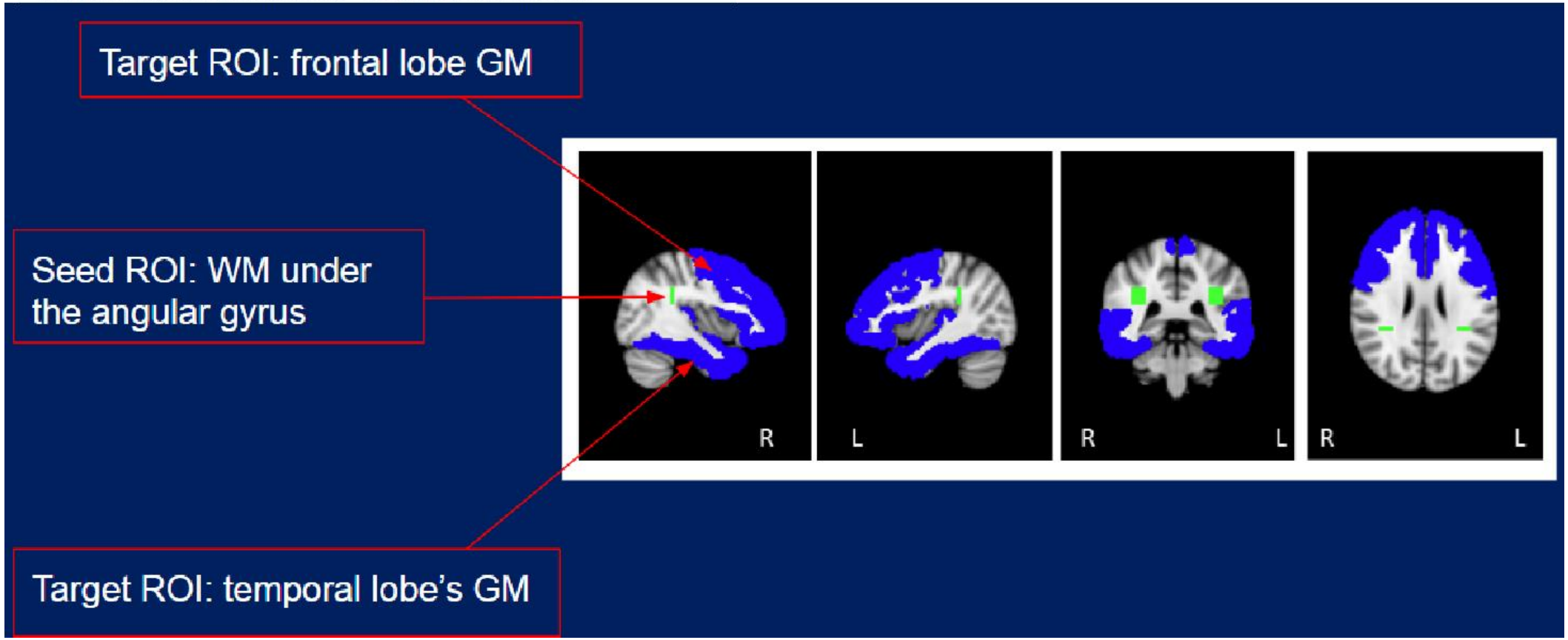
Magnetic Resonance Imaging

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

Original contribution

Along-tract analysis of the arcuate fasciculus using the Laplacian operator to evaluate different tractography methods

Lia Talozzi[a,1], Claudia Testa[a,1], Stefania Evangelisti[a], Lorenzo Cirignotta[a], Claudio Bianchini[a], Stefano Ratti[b], Paola Fantazzini[c], Caterina Tonon[a,d,*], David Neil Manners[a], Raffaele Lodi[a,d]



How to reconstruct the AF

Reconstruct the tracts

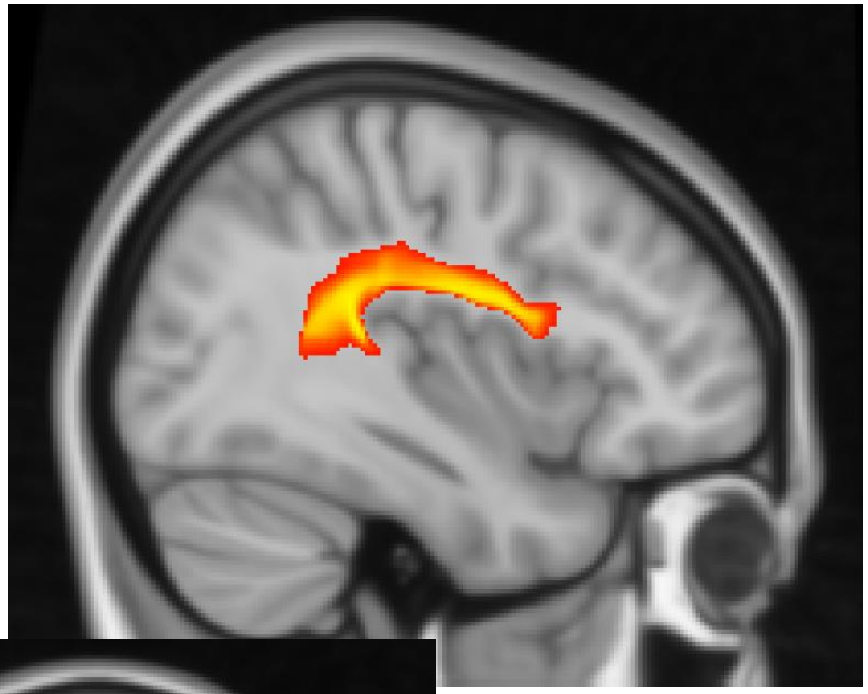
tckgen FODs/FOD_wm.nii.gz **-fslgrad** bvecs.bvec bvals.bval **-seed_image** ROIs/AF_Seed_R_DWI.nii.gz **-include** ROIs/Frontal_Lobe_DWI.nii.gz **-include** ROIs/Temporal_Lobe_DWI.nii.gz **-exclude** ROIs/midsagittal_to_DWI.nii.gz **-mask** Corrected_diffusion_data/B0_brain_mask.nii.gz **-force** Arcuate_Fasciculus/AF_R.tck

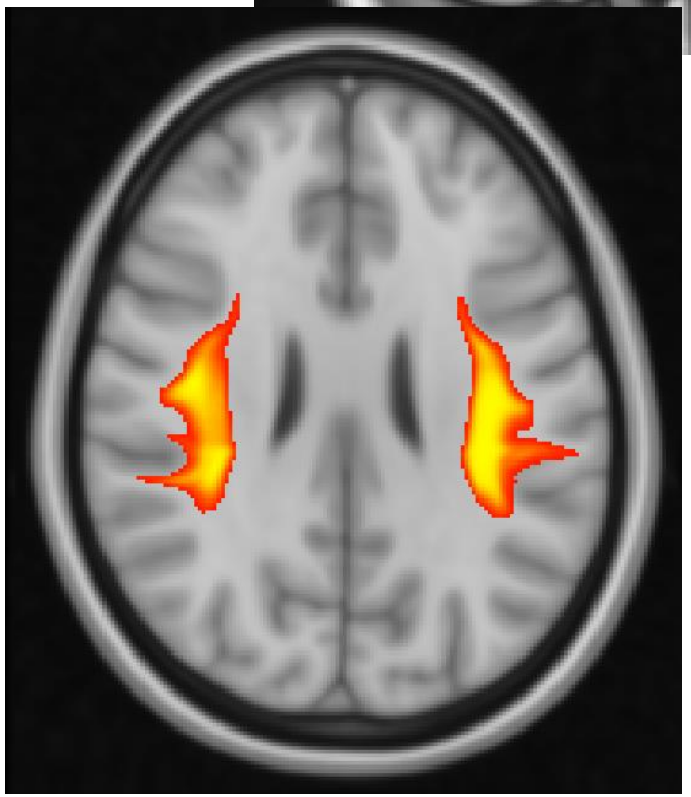
tckmap -template DTI_results/DTIFit_FA.nii.gz Arcuate_Fasciculus/AF_R.tck **-force** Arcuate_Fasciculus/AF_R.nii.gz

Cut the tracts

tckedit Arcuate_Fasciculus/AF_R.tck Arcuate_Fasciculus/AF_R_cropped.tck **-mask** ROIs/Mask_AF_R_DWI.nii.gz **-force**

tckmap -template DTI_results/DTIFit_FA.nii.gz Arcuate_Fasciculus/AF_R_cropped.tck **-force** Arcuate_Fasciculus/AF_R_cropped.nii.gz





Now it’s your turn

Now it’s your turn to work on **subject 2**

- **<u>Looking at the images is always a good starting point</u>**
- Start with the T1 to have an idea of the structure of the subject’s brain: do you notice something? What do you think it is?

- Reconstruct the Corticospinal tract and the Arcuate Fasciculus. How are they influenced by the presence of what you saw on the T1 image?

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