Joint modelling of diffusion MRI and histology indicates variation in axial and radial diffusivities across the brain.

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Introduction: Microstructural features such as axonal diameter, packing and density affect the diffusion MRI (dMRI) signal and vary considerably across white matter. However, spherical deconvolution-based approaches generally assume these to be constant in order to model the fibre orientation distribution function (ODF) at each voxel. Here we combine dMRI data and histological sections from the same tissue sample into a joint model to investigate how the diffusion profile of a single-fibre (modelled as an axially-symmetric diffusion tensor) varies in the human brain. By constraining both the fibre orientation and amount of dispersion in each MRI voxel using histological data, we can estimate the diffusivities both parallel (axial) and perpendicular (radial) to the fibre.

Method: Details of both the data acquisition [1] and joint model [2] have been reported previously. Here we compare estimates of both axial and radial diffusivity across the entire tissue sample which anatomically includes parts of the corpus callosum (CC), centrum semiovale (CS), cortico-spinal tract (CST) and cingulum bundle (CB) [1]. The ROIs are shown in the blue circle of Figure 1.

Results: From Figure 1 we see how the axial (top) and radial (bottom) diffusion coefficients vary across the tissue sample, with particularly low diffusivities found in the corpus callosum. Figure 2 shows how this variation has significant impact on the resultant fibre response function (FRF).

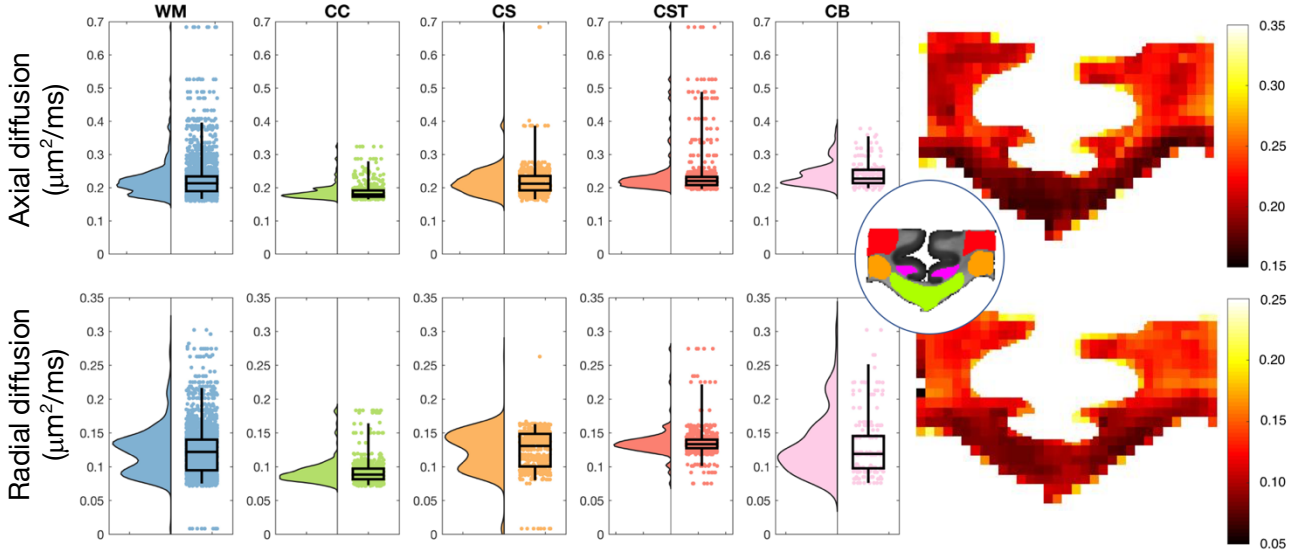

Figure 1: Raincloud plots (left) and heat maps (right) show how the axial and radial diffusivities vary across the white matter (WM). We find notably lower values in the corpus callosum compared to other WM tracts.

Discussion and conclusion: By combining dMRI and histology into a joint model we have shown how the diffusion profile of a single fibre varies across the brain. In particular, our results suggest that both the axial and radial diffusivities are considerably lower in the CC when compared to other white matter tracts. This may have implications for spherical deconvolution-based approaches, where a 'brain-wide' fibre response function is typically estimated from voxels in the CC. Future work will look at both inter- and intra-subject variability of the diffusion profile in three tissue samples.

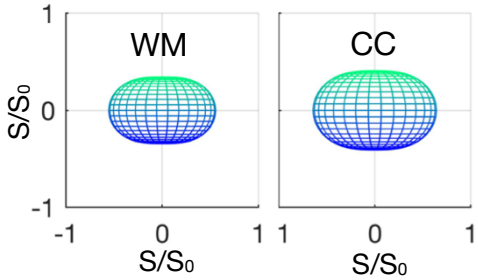

Figure 2: The fibre response function when defined by the mean diffusion coefficients of all white matter voxels in our sample (left), or only those in the corpus callosum (right).

References: [1] Mollink *et al.* (2017) NeuroImage, 157, 561-574. [2] Howard *et al.* (2018) 26th ISMRM-ESMRMB, accessed via: cds.ismrm.org/protected/18MPresentations/abstracts/0740.html