Probabilistic atlases of white matter pathways underlying auditory, language, sensorimotor, and visual networks

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Background: Despite the popularity of functional connectivity analyses and the well-known topology of several intrinsic cortical networks, relatively little is known about the white matter regions (i.e., structural connectivity) underlying these networks. Therefore, in the current study, we have performed fMRI-guided DTI tractography to create probabilistic white matter atlases for five previously identified functional brain networks, including the: Auditory Network (AN), Language Network (LN), Sensorimotor Network (SmN), and both the Primary and Higher Visual Networks (PVN and HVN).

Methods: Whole-brain DTI data (30 diffusion directions, plus 5 b=0 s/mm² images) were acquired at 3T from 32 healthy volunteers (16 male). Initial preprocessing included coregistration of the diffusion-weighted images, fitting the diffusion tensor, skull stripping, and two-stage, high-dimensional, non-linear spatial normalization to the ICBM template. Deterministic tractography, with a fractional anisotropy (FA) cutoff of 0.15 and deviation angle < 50°, was then performed using the Fiber Association by Continuous Tracking (FACT) algorithm, and a multi-ROI approach to identify tracts of interest. ROIs for each of the five networks were taken from a pre-existing atlas of functionally defined regions (Shirer et al., 2012) to explore all ROI-ROI connections within each network, and all resulting streamlines were saved as binary masks to create probabilistic atlases for tracts between each ROI-ROI pair.

Results: The resulting functionally-defined white matter atlases (i.e., for each tract and each network as a whole) have been computed in stereotaxic coordinates. After aligning to both the SPM8 and MRISStudio coordinate systems, the resulting probabilistic maps have been saved as NIfTI images that, upon final publication, will be added to the UManitoba-JHU Functionally-Defined Human White Matter Atlas (http://www.nitrc.org/projects/uofm_jhu_atlas/).

Conclusions: The current atlases build on previous work in which we identified functionally-defined white matter regions of the dorsal and ventral Default Mode Networks, the left and right Executive Control Networks, and the anterior and posterior Salience Networks. To the best of our knowledge, this work represents the first attempt to identify white matter regions underlying the AN, LN, SmN, PVN, and HVN; and as a result, the ensuing probabilistic atlases offer the first principled method to ascribe voxel-wise or ROI-based changes (i.e., in DTI or other quantitative white matter imaging signals) to these functional brain networks.