

Probabilistic mapping of brain connectivity in the IIT Human Brain Atlas

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TARGET AUDIENCE: Researchers investigating brain connectivity or using brain atlases in clinical applications.

PURPOSE: The IIT Human Brain Atlas project is in the 4th year of development^{1,2} (www.nitrc.org/projects/iit2). The latest version of the atlas (v.3) contains high-quality artifact-free anatomical, DTI, HARDI templates, and probabilistic gray matter labels of the adult human brain in ICBM-152 space. The current phase of the project is focusing on the development of a probabilistic white matter atlas that is complementary to the gray matter atlas, by performing tractography in the state-of-the-art HARDI template using the labels of the gray matter atlas as seeds. The purpose of the present work was twofold: a) evaluate the anatomical validity of tractography results in the HARDI template, and b) generate probabilistic connectivity maps for pairs of gray matter labels.

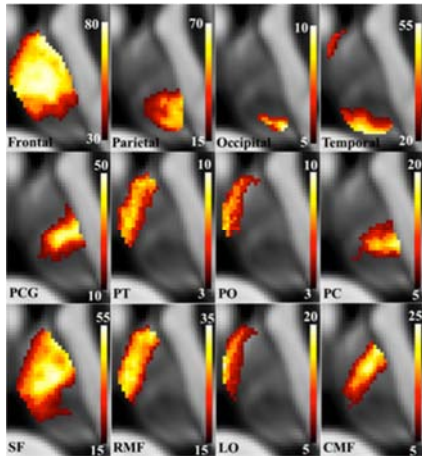


Figure 1. Connectivity of the thalamus to cortical gray matter labels allowed segmentation of the thalamus for validation purposes. Top row shows probability maps for connectivity between the thalamus and lobes. The middle and bottom rows show probability maps for connectivity of the thalamus to 8 of the labels within the frontal lobe: precentral gyrus (PCG), pars triangularis (PT), pars orbitalis (PO), paracentral lobule (PC), superior frontal gyrus (SF), rostral division of the middle frontal gyrus (RMF), lateral division of orbitofrontal cortex (LO), caudal division of the middle frontal gyrus (CMF). The color bar represents probability as % of the total number of fibers originating from the thalamus and penetrating that voxel.

and connecting the seed region to the target label over the total number of fibers originating from the seed region and penetrating that voxel.

RESULTS & DISCUSSION: The resulting maps of connectivity between the thalamus and the frontal, temporal, parietal and occipital lobes were in agreement with published results⁶ (Fig.1). In addition, detailed maps of connectivity between the thalamus and gray matter labels within each of the lobes were also generated (Figs.1,2). Connectivity between the corpus callosum and the frontal, temporal, parietal and occipital lobes was in agreement with published research⁷ (Fig.3). Maps of the connectivity between the corpus callosum and different gray matter labels within each lobe were also generated (Fig.3). Track density⁸ maps have been generated for a large number of pairs of gray matter labels (Fig.2). However, this process is ongoing.

CONCLUSION: The probabilistic white matter atlas currently under development will complement the already available high-quality templates and gray matter atlas (all located in ICBM-152 space). The resulting set of tools is expected to enhance the accuracy and level of detail in a number of neuroimaging efforts.

REFERENCES: [1] Zhang S et al., ISMRM 2013, p.2129. [2] Varentsova A et al., ISMRM 2011, p.1928. [3] Tournier JD et al., Neuroimage. 2007;35:1459-72. [4] Fischl B, Neuroimage. 2012;62:774-781. [5] Tournier JD et al., Int J Imag Syst Tecah. 2012;22(1):53-66. [6] Behrens TE et al., Nature Neurosci. 2003;6(7):750:57. [7] Park HJ et al., HBM. 2008;29:503-16. [8] Calamante F et al. Neuroimage. 2010;53(4):1233-43.

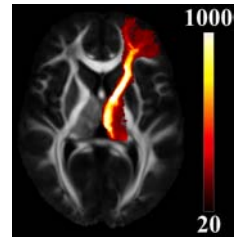


Figure 2. Example of track density map of thalamic connections to the rostral division of the middle frontal gyrus (RMF).

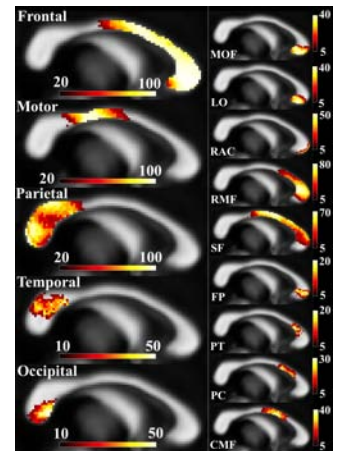


Figure 3. Connectivity through the corpus callosum (CC) allowed segmentation of the CC for validation purposes. CC was used as a seed here. Left column shows probability maps for connectivity of the CC seed region to lobes and the primary motor cortex. The right column shows probability maps for connectivity of the CC seed region to 9 labels within the frontal lobe: medial division of orbitofrontal cortex (MOF), rostral anterior division of cingulate cortex (RAC), frontal pole (FP), (PT), (PC), (SF), (RMF), (LO), (CMF) (for acronyms see Fig.1 legend). The color bar represents probability as % of the total number of fibers originating from the corpus callosum seed region and penetrating that voxel.