A Template and Probabilistic Atlas of the Human Sensorimotor Tracts using Diffusion MRI

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Introduction and Methods

The purpose of this study was to develop a high-resolution sensorimotor area tract template (SMATT) which segments corticofugal tracts based on 6 cortical regions in primary motor cortex, dorsal premotor cortex, ventral premotor cortex, supplementary motor area (SMA), pre-supplementary motor area (preSMA), and primary somatosensory cortex using diffusion tensor imaging. Individual probabilistic tractography analyses were conducted in 100 subjects using the highest resolution data currently available. Tractography results were refined using a novel algorithm to objectively determine slice level thresholds that best minimized overlap between tracts while preserving tract volume.

Results and Discussion

Consistent with tracing studies in monkey and rodent, our observations show that cortical topography is generally preserved through the internal capsule, with the preSMA tract remaining most anterior and the primary somatosensory tract remaining most posterior. We combine our results into a freely available white matter template named the SMATT. We also provide a probabilistic SMATT that quantifies the extent of overlap between tracts. Finally, we assess how the SMATT operates at the individual subject level in another independent data set, and in an individual after stroke.

Conclusions

The SMATT and probabilistic SMATT provide new tools that segment and label sensorimotor tracts at a spatial resolution not previously available.

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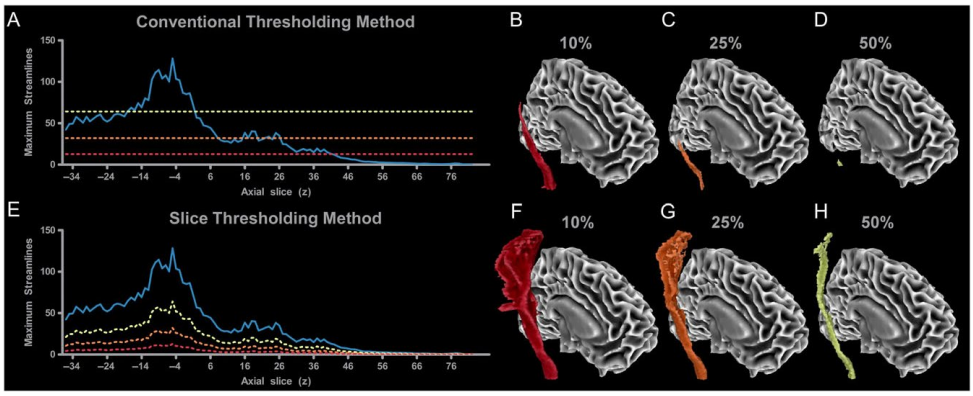

Figure 1. Tract level thresholding versus slice level thresholding in the M1 tract. (A) When performing probabilistic tractography from M1 to the CP, the number of streamlines per slice varies (blue line), in which there is a peak number of streamlines at z=−5. Conventional tract level thresholding calculates the maximum number of streamlines within the profile and bases the threshold on a percentage of this value. Thresholds can be arbitrarily set at 10% (red line), 25% (orange line), or 50% (yellow line) of the peak value. Higher thresholds lead to a reduction in tract volume (B–D). Blue lines that fall below the threshold line would be excluded from the final results. Therefore, a threshold of 10% results in some loss of cortical volume (z>40 eliminated), while a 25% threshold results in additional loss of volume in the cortex (z>8 eliminated). At 50%, the only slices which remain are within the PLIC (z=−16 to 0 remain). (E) By splitting the tract into individual slices, each slice can be thresholded independently. A benefit of this method is that it does not result in any excluded slices within the tract. At 10%, tract volume is high. At 25% and50% the volume of the tract decreases but volume is maintained in every slice of the tract (F–H).