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Visualizing Cortical Thickness on the Gray/White Cortical Surface

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Introduction

Ante-mortem neuroimaging studies as well as post-mortem studies suggest that neuroanatomical abnormalities of the cerebral cortex are common in neurodegenerative and psychiatric diseases. So that cortical abnormalities can be characterized precisely in subjects with such diseases, methods to more fully investigate the neuroanatomical features of the cerebral cortex in living human beings are needed. In particular, the capacity to measure cortical thickness, which may reflect neuronal organization better than cortical volume in some cortical regions, may be critical for studies of neuropsychiatric and auditory disorders. Cortical thickness varies locally across the brain from 1.3mm to 4.5mm. For example, cortical thickness in the anterior segment of the cingulate is generally thicker than that in the posterior and the left planum temporale is thinner than the right in general.

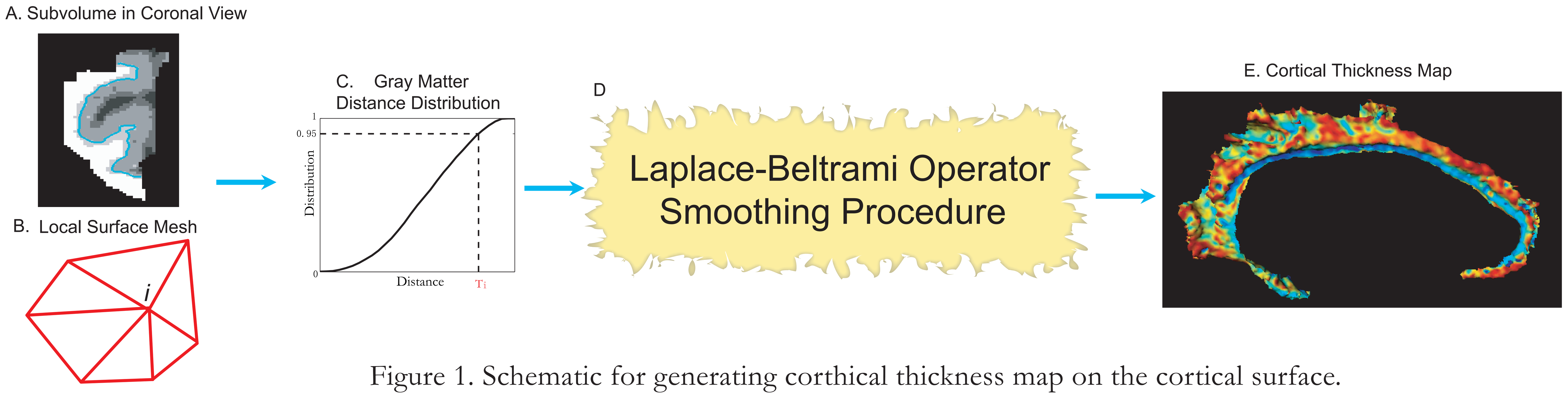

Figure 1. Schematic for generating corthical thickness map on the cortical surface.

Method

Specific tools have been developed to visualize and quantify the variability of cortical thickness in a specific region of the brain (i.e., cingulate gyrus and planum temporale). The boundary between gray and white matter (i.e., the gray/white matter surface) was used as a reference manifold. By using automated Bayesian segmentation of the cortex and the generation of a gray/white matter surface composed of a fine triangulated mesh of points, each voxel was labeled as gray, white, or CSF as a function of distance from the gray/white matter surface. This method is named as labeled cortical mantle distance mapping (LCMDM) method in the previous study[1]. In the present study, LCMDM was used to augment the information available for each voxel by determining the distance between the voxel and the closest vertex on the gray/white surface. For each vertex on the gray/white surface (e.g. vertex i in Figure 1B) , all gray matter voxels that belonged to it and its neighbors were found. The distribution of the distances (Figure 1C) from the surface to the voxels allowed for the direct calculation of the statistics of cortical thickness and variation as a function of position on the surface. Cortical thickness was then defined using the 95th percentile of these distances and the thickness measure was superimposed onto a map of the gyrus gray/white surface. Finally, the cortical thickness map was smoothed using harmonics of the Laplace-Beltrami operator on the surface[2].

Results and Conclusion

Figure 2 shows the cortical thickness and curvature maps on cingulate and planum temporale surfaces. For each subject, the top row illustrates the geometry of the cortical surface by curvature map and the bottom row shows the cortical thickness map; the left and right columns are the left and right cortical surfaces, respectively. From observation, the anteior cingulate is thicker than the posterior cingulate, which is consistent with the cytoarchitectonic study of the human brain[3]. Furthermore, combining the curvarure information allows us to investigate how the cortical thickness is variable relative to the convoluted cortical geometry, namely the cortical thickness in the gyrus region (bright color in the curvature map) is thicker than the one in the sulcus region (dark color in the curvature map). Such information may be important to study the cingulate structure in neuropsychiatric diseases and the structure of planum temporale in auditory disorders.

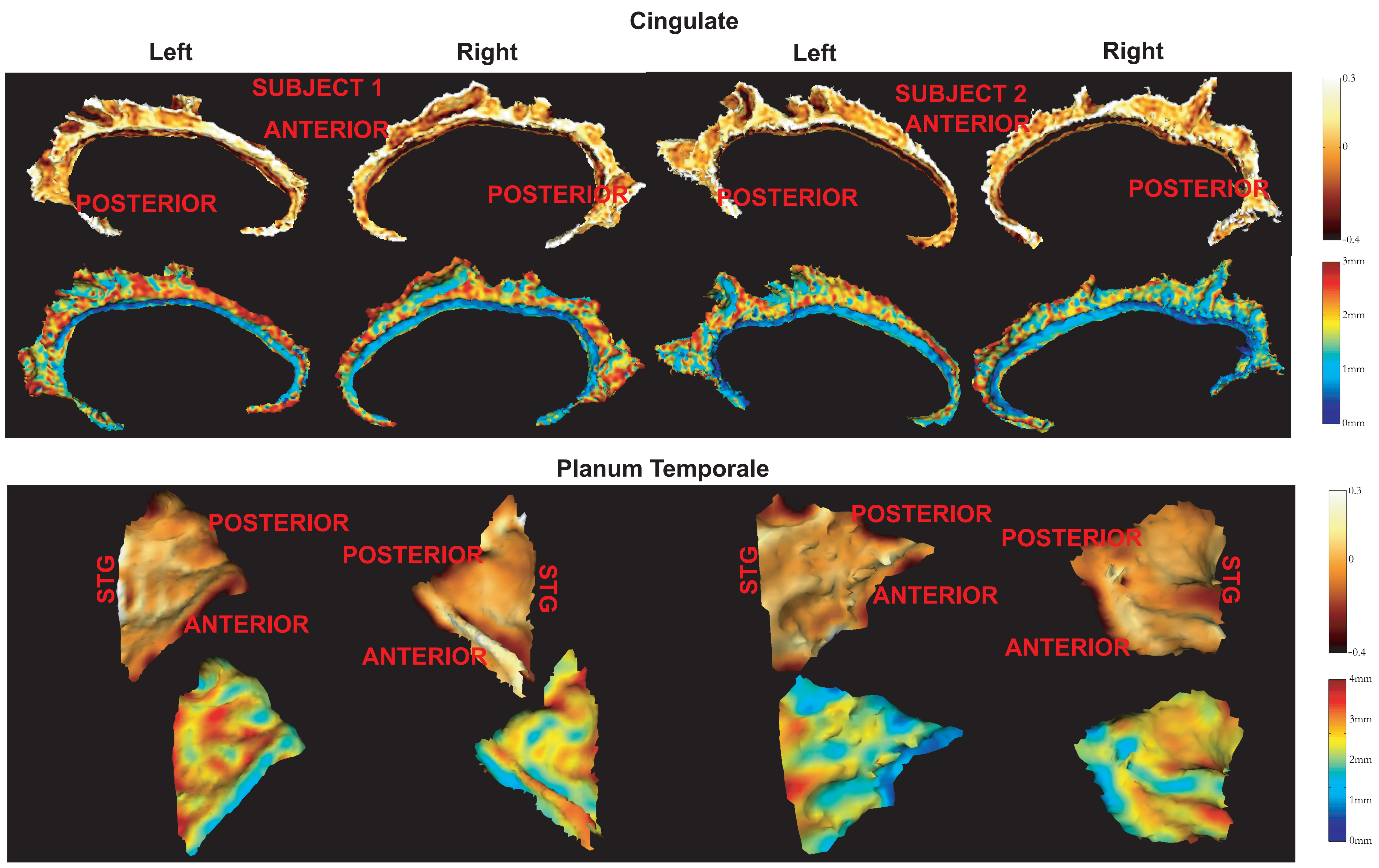

Figure 2. Curvature and Cortical Thickness Maps on the Cingulate and Planum Temporale.

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