Morphometrics of the Superior Temporal Gyrus in the General Population

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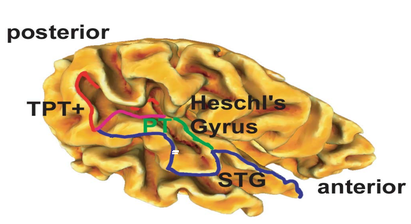

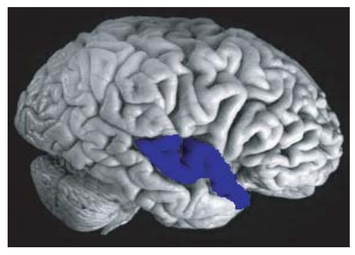

Figure 1: STG anatomy

Background

As the name suggests, the superior temporal gyrus (STG) is the most superior, or dorsal, gyrus of the temporal lobe. Its boundaries follow the Sylvian (lateral) fissure (SF) from the temporal pole to the anterior parietal lobe. Much of the supratemporal space is occupied by primary (Brodmann areas 41 and 42; Heschl's gyrus, HG) and secondary auditory cortices (Brodmann area 22, the PT). From a functional standpoint, the STG plays a significant role in phonological and auditory processing of language [1], musical rhythm perception [2], higher syntactic and semantic processes [3], and visual speech perception [4]. Additionally, gender [5] and laterality [6] differences have also contributed to functional differences in the STG.

Labeled Cortical Distance Maps (LCDM)

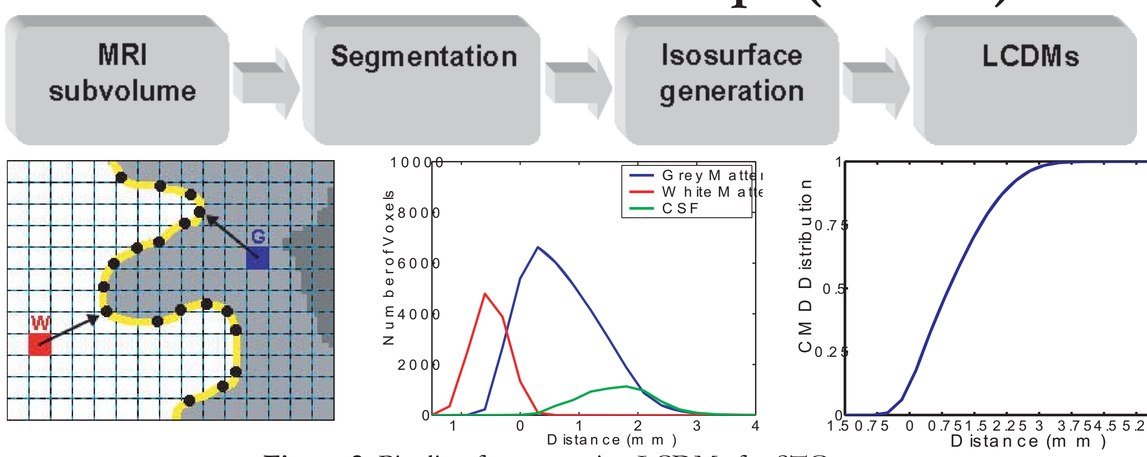

Figure 2: Pipeline for generating LCDMs for STG

The above flow chart describes the pipeline for generating LCDMs [7,8]. Bayesian segmentation of ROI masks of the STG classified image voxels as grey matter (GM), white matter (WM), and cerebrospinal fluid (CSF). Isosurfaces representing the 2D cortical sub-manifold were generated at the GM/WM interface. Anatomical boundaries of the STG were delineated by dynamic programming (DP) generation of principal curves such as gyri, sulci, and geodesics. The STG surface provides the natural local coordinates of the 2D manifold associated with the GM/WM surface with the third dimension described by the normal coordinates measuring distance of the GM voxel to the manifold. Distance maps profile the GM cortical mantle index by its distance along the normal axis to the GM/WM surface. LCDMs form a histogram consisting of labeled GM voxels as a function of distance from the GM/WM surface.

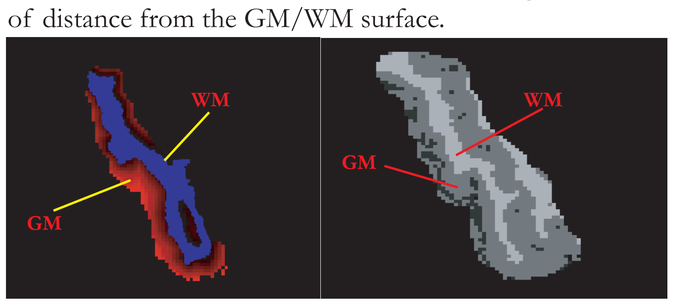

Figure 3: Distance (left) and segmentation (right) images of the STG

Methods

MPRAGE scans of 1mm^3 resolution from 20 healthy subjects were included in our study (10 males and 10 females, age: 36.5±11.2, mean±SD)

DP delineation of the STG was initiated with several landmarks. The posterior landmark of the STG boundary begins at the intersection of the angular gyrus (AG) and the STG at the most posterior extent of the lateral fissure (LF) [Figs. 4A, F, H]. The anterior landmark of the STG boundary is located at the superior portion of the temporal pole at the ascending ramus of the LF [Figs. 4A, B, E]. The inferior extent of the STG boundary follows from the posterior landmark along the superior temporal sulcus (STS) all the way to the anterior landmark [Figs. 4A, F, H]. The superior extent of the STG boundary follows from the anterior landmark along the LF to the posterior landmark [Figs. 4A, E, G].

Surface area was determined from the triangulated manifold while volume and cortical thickness were respectively derived from the total number of voxels and the 95th percentile distance from the LCDM histogram respectively. To account for the large size of the STG, cortical thickness and volume data were retrieved at censored distances of 4 mm, 4.5 mm, 5 mm, 5.5 mm, and 6 mm from the surface.

References:

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Results

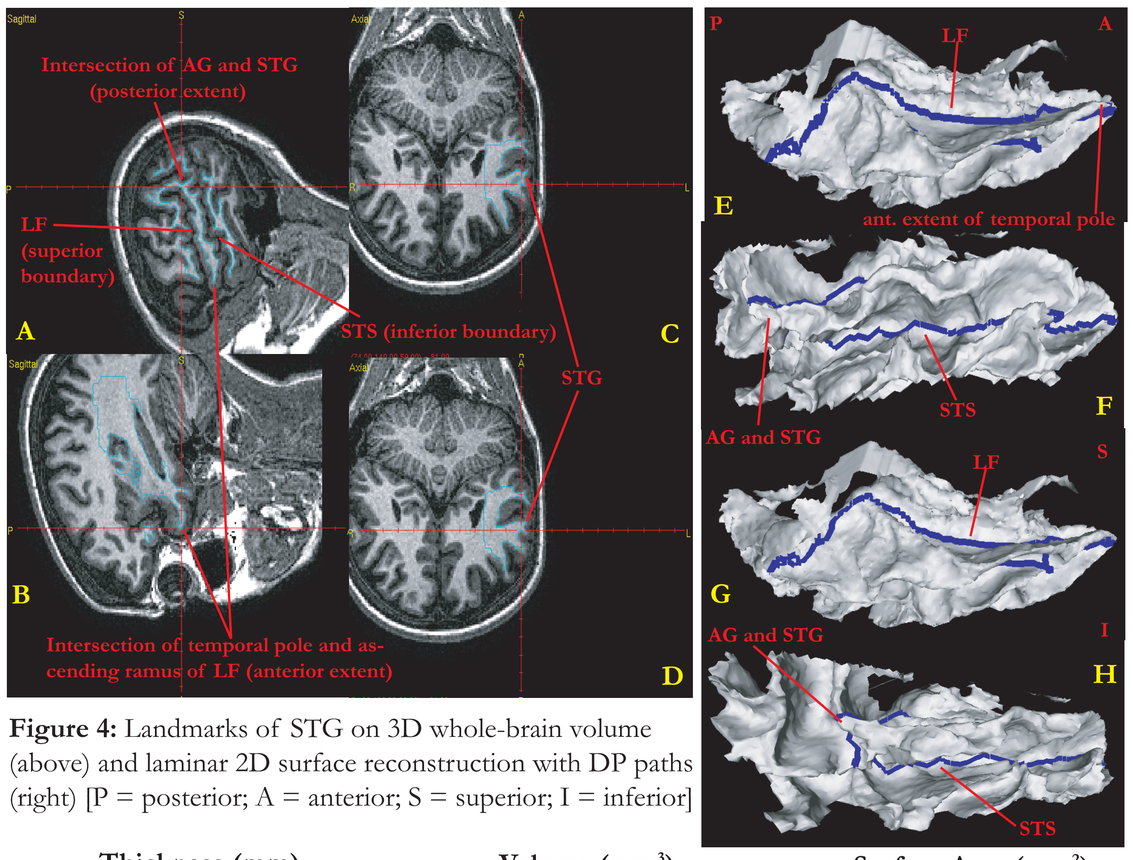

Figure 4: Landmarks of STG on 3D whole-brain volume (above) and laminar 2D surface reconstruction with DP paths (right) [P = posterior; A = anterior; S = superior; I = inferior]

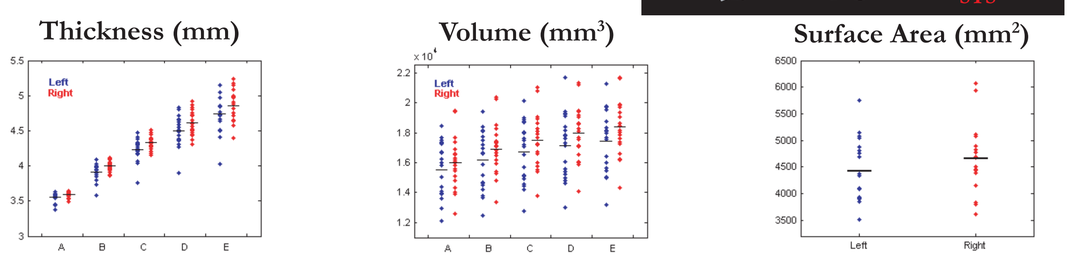

Figure 5: Laterality plots of thickness, volume, and surface area of right and left STG (A = 4 mm; B = 4.5 mm; C = 5 mm; D = 5.5 mm; E = 6 mm)

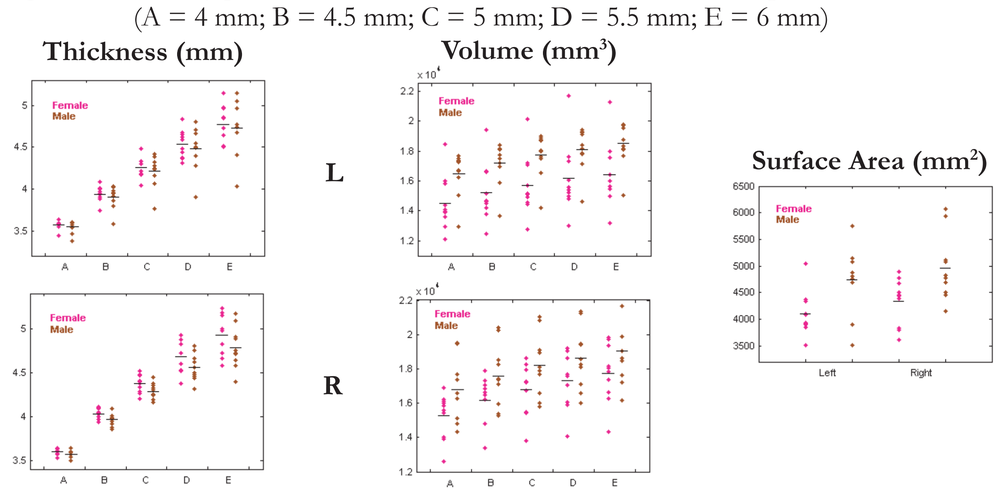

Figure 6: Gender plots of thickness, volume, and surface area of right and left STG (A = 4 mm; B = 4.5 mm; C = 5 mm; D = 5.5 mm; E = 6 mm)

Thickness	4 mm	4.5 mm	5 mm	5.5 mm	6 mm
Gender	0.2135	0.2294	0.2027	0.2358	0.3518
Laterality	0.0053	0.0021	0.0068	0.0233	0.0773
Volume	**4 mm**	**4.5 mm**	**5 mm**	**5.5 mm**	**6 mm**
Gender	0.0096	0.0104	0.0119	0.0194	0.0136
Laterality	0.2222	0.1422	0.1121	0.1328	0.0865
LCDM	**4 mm**	**4.5 mm**	**5 mm**	**5.5 mm**	**6 mm**
K-S test, Left STG,F-M	1.08E-12	1.80E-15	6.90E-19	0.000534	1.98E-20
K-S test, Right STG, F-M	3.12E-21	2.88E-32	4.09E-46	3.27E-60	8.95E-71
K-S test, Female, L-R	7.12E-45	1.02E-45	2.37E-46	3.89E-41	3.50E-57
K-S test, Male, L-R	1.90E-63	2.70E-62	2.36E-61	1.66E-60	1.60E-59

Table 1: p-values of MANOVA and Kolmogorov-Smirnov test statistics

Discussion

-The right STG was significantly thicker than the left STG for both females and males.
-Males had significantly larger STG volumes than females.
-Laterality and gender do not play a significant role in the surface area of STG.
-K-S test results show that distributions are not the same for each thickness category.
-Effect of censoring for thickness is most apparent at 4.5 mm; censoring does not affect volume or surface area calculations.
-A new problem arose when comparing measured thickness values from LCDMs with laminar approximation (e.g. volume divided by surface area), thereby suggesting that estimates of measured and calculated mean thickness values can have different laminar variabilities.

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