Gender Effects on Cortical Thickness

Luders E[1], Narr KL[1], Thompson PM[1], Rex DE[1], Woods RP[2], DeLuca H[1], Jancke L[3], and Toga AW[1]

[1]Laboratory of Neuro Imaging, Department of Neurology, UCLA Geffen School of Medicine Los Angeles, USA
[2]Ahmanson-Lovelace Brain Mapping Center, Department of Neurology, UCLA Geffen School of Medicine, Los Angeles, USA
[3]Department of Neuropsychology, University of Zurich, Zurich, Switzerland

Introduction

Empirical examinations of gender effects on the thickness of the cortex are rare and existing findings are inconsistent. Using MRI to resolve cortical anatomy at high-resolution in living subjects, we computed cortical thickness across the entire lateral and medial cortices in a large and well-matched sample of young and healthy men and women (N = 60). The influences of spatial normalizations on gender differences in morphological features have been largely neglected in previous analyses. Thus, we further aimed to establish the presence and direction of gender differences in cortical thickness using both scaled (after transforming images into standard ICBM-305 space using 12-parameter transformations) and unscaled data (after applying 6-parameter rigid-body transformations).

Methods

Image volumes passed through a number of manual and automated preprocessing procedures including: (1) affine or rigid-body transformations into ICBM-305 space; (2) removal of non-brain tissue; (3) signal inhomogeneity correction; (4) cortical surface extraction; (5) cortical pattern matching; and (6) tissue segmentation. Cortical thickness, defined as the 3D distance (in mm) between inner GM/WM border and the closest point on the outer CSF/GM boundary, was calculated using the Eikonal fire equation and the tissue segmented brain volumes. Cortical thickness was estimated voxel by voxel and projected as a local value (mm) onto the cortical surface, where a 15mm smoothing kernel was used to average thickness measures at 65 536 cortical surface points. The mean values for cortical thickness obtained at each cortical surface point were calculated to provide maps of average cortical thickness across the cortex in scaled and unscaled imaging data. Thickness values were then compared statistically between men and women at each 3D cortical surface location.

Results

Statistical analyses revealed significant regional increases in cortical thickness across the lateral and medial cortex in women compared to men, after individual differences in brain size had been removed (scaled data). No regions showed significantly increased cortical thickness in males. Similarly, when the brain sizes of men and women were preserved (unscaled data), the same pattern and general direction of gender differences in cortical thickness were observed, albeit significance was much less pronounced. Moreover, a small cortical region in the lateral temporal lobes showed increased thickness in males.

Conclusion

Our gender-specific findings support a dimorphic organization in male and female brains that appears to involve the architecture of the cortical mantle. We detected significantly greater cortical thickness in women compared to men, complementing previous findings of larger cortical volumes relative to cerebrum size, regionally increased concentration of cortical gray matter, and a more pronounced cortical complexity in females. This sexual dimorphism favoring women, even without correcting for brain size, may have functional significance and possibly account for gender-specific abilities and/or behavioral differences between sexes. Although gender-specific results were similar in scaled and unscaled data, spatial

normalizations were shown to influence results suggesting these issues require attention in future studies.