Training-related cortical thickness changes

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Abstract

Evidence for training-related gray matter changes has been reported in several studies [1,2,3]. However, changes detected with gray matter VBM can potentially be due to global or local intensity changes, alignment issues, lesions, morphological changes, and/or thickness changes. Here we specifically test for changes in cortical thickness over time taking advantage of the longitudinal processing stream of FreeSurfer.

Methods

Subjects: Twenty-four naive subjects were given instructions on how to learn juggling. Every subject received a diffusion scan on three occasions: before training, after a 6-week period of daily juggling training, and after a subsequent 4-week period of juggling abstinence. *Image Acquisition:* At each time point one T1-weighted anatomical image was acquired using a FLASH sequence (TR = 11.2 ms; TE = 4.7 ms; flip angle = 8°, voxel size = 1×1×1mm3). *Analysis:* Longitudinal cortical thickness analysis was carried out in Freesurfer (v5.1) [4]. Thickness maps were smoothed with a FWHM 15 mm kernel. Changes of subcortical and cortical areas were then investigated with a repeated measures ANOVA with dependent variable (subcortical volume/cortical thickness) and within subject factors time and area (45 subcortical segments, 72 cortical parcels). In addition a linear regression model was fitted to all three time points at every vertex for each subject. The significance of the slope of the fit was then determined using a one-sample t-test.

Results

For cortical thickness (and subcortical volume) no significant effect of time $p>0.50$ ($p> 0.69$) nor interaction between time and area $p>0.99$ ($p>0.88$) was found. Vertex-wise analysis found 3 clusters of significant change in the left hemisphere (Figure 1). Decreases in frontal areas averaged at 0.5% during the training period and 1.8% during the training abstinence period (Figure 2a). Increases in occipital areas averaged at 1.6% and 3% respectively (Figure 2b). No significant changes were found in the right hemisphere. Lowering the threshold to $p>0.05$ revealed two clusters of increases in occipital areas.

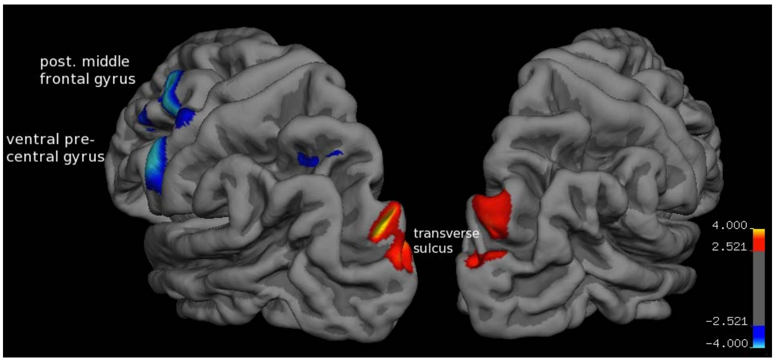

Figure 1: Cortical thickness changes over 3 time points. t-values thresholded at $p>0.001$, uncorrected. (red, increase; blue, decr.)

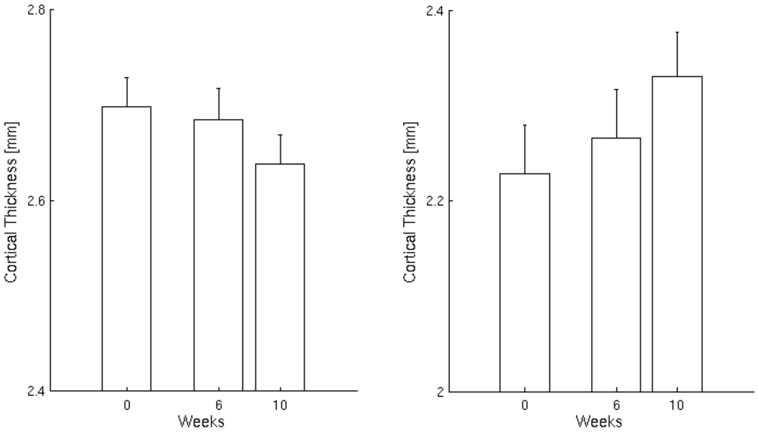

Figure 2: Cortical thickness changes over time averaged over clusters, $p>0.001$, uncorrected. A ventral M1. B transverse sulcus.

Discussion

The occipito-parietal areas where the cortical thickness increase occurred have been shown to be involved in attention and visuo-motor transfomation -- skills that are important for successful juggling. These results demonstrate that the human brain retains a remarkable degree of plasticity even until adulthood. Finally, these findings suggest that cortical thickness estimates are robust enough to detect relatively small cortical changes over time. This might be a potentially useful marker in diagnosing patients recovering from brain injury.

References

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