3D pattern of brain changes in deaf subjects using Tensor-Based Morphometry

Natasha Leporé[1], Patrick Vachon[2], Franco Lepore[2], Yi-Yu Chou[1], Patrice Voss[2], Caroline Brun[1], Agatha D. Lee[1], Arthur W. Toga[1], and Paul M. Thompson[1]

[1] Laboratory of Neuro Imaging, Department of Neurology, David Geffen School of Medicine at UCLA, Los Angeles, CA 90095 USA
[2] Centre de Recherche en Neuropsychologie et Cognition, Université de Montréal, Montréal, Québec, Canada

INTRODUCTION: In the congenital deaf, functional reorganization is known to occur throughout brain regions normally associated with hearing. However, the anatomical correlates of these changes are not well understood. Here we perform the first tensor-based morphometric analysis of voxelwise volumetric differences in congenitally deaf subjects, compared to hearing controls.

METHOD: We obtained 3D T1-weighted brain MRI scans for 14 congenitally deaf but otherwise healthy subjects (median age 29.5 years old, 7 men, 7 women) and 16 age and gender matched controls. Extracerebral tissues were removed and the resulting images were 9-parameter registered (3 scales, 3 rotation and 3 translations) to the ICBM-53 template. We used a fluid registration algorithm [1] to map each image to that of one of the control subjects. The determinant of the Jacobian J of the resulting deformation field was computed. In order to eliminate any effect of age and gender on the statistics, we first covaried the logarithms of the determinants at each voxel with these variables. The new adjusted statistic, J_{cov} was found by fitting the following general linear model to the data:

$$\log(J) = \beta_0 + \beta_1 * age + \beta_2 * sex + \beta_3 * diagnosis, \quad (1)$$

where $\log(J)$ is the logarithm of the Jacobian determinant, the β_i are estimated parameters, and sex and diagnosis are coded as binary dummy variables, 0 or 1, so that $J_{cov} = \log(J) - \beta_0 - \beta_1 * age - \beta_2 * gender$. A t-test was performed at each voxel in order to determine areas significant volume of differences between the two groups of subjects.

RESULTS AND DISCUSSION: The top panel shows voxelwise volume ratio between deaf subjects and controls for the scaled dataset. Voxelwise p-values from a positive one-tailed t-test on the determinant of the Jacobian are shown in the bottom panel. The global p-value from permutations is $p = 0.014$. Surprisingly, negative changes were not significant from a one-tailed permutation tests over the whole brain volume, including the temporal lobes. An increase in white matter volume is seen in the frontal lobes, and is possibly related to an

increased reliance on visual working memory processes, as the deaf individuals can no longer benefit from auditory input.

References

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