A Whole-Brain Voxel-Based Morphometric Study of Early-Blind Chinese Adults

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Introduction Numerous previous studies have demonstrated that the visual and sensorimotor cortices of congenital and early blind (EB) show striking functional plasticity. For example, the primary visual cortex and the visual association areas of the congenital blind and the EB are activated by various tactile tasks [1,2], and somatosensory representation of the fingers is topographically disordered in certain blind population [3]. However, few studies have addressed the question whether such functional plasticity is associated with macroscopic alterations of anatomical structures in the corresponding brain regions [1,4]. In this study, voxel-based morphometry (VBM) analysis was performed in a group of Chinese EB subjects and controls to investigate the anatomical changes, if any, in the brain of the EB subjects, presumably resulted from development-related and learning-related plasticity after early sensory deprivation and long-term living in an environment with no visual input.

Materials and Methods Eight EB subjects (18-50 years of age, 4 females) and 11 age-matched control subjects (SC, 20-45 years of age, 5 females) participated the study. All subjects are Chinese natives and right-handed. All EB subjects lost their sights at ages <2.5 years and are practiced Braille readers. Volumetric images across the whole brain were acquired on a 1.5-T Philips (Eclipse) MRI scanner using a 3D T_1-weighted RF-FAST sequence (TR 11 ms, TE 4 ms, flip angle 90°, matrix size 256×256, FOV 240 mm × 240 mm, 125 slices, slice thickness 1.2 mm). Modified VBM tools provided in SPM2 were used for data analysis [5]. An anatomical template was created by averaging the data from all subjects, including both EB and SC. The subject images were then resampled and non-linearly normalized to the template with a resultant cubic voxel size of 1 mm^3, and segmented into gray matter (GM) and white matter (WM) images using an optimized VBM procedure [5]. The GM and WM images obtained were smoothed with a 12-mm FWHM kernel before statistical analyses, which were carried out by voxel-wise comparisons in SPM2 using the general linear model after covarying for global gray matter intensity.

Results The parametric maps (color scale indicates Z scores, which correlate with the significance of the change) obtained from statistical analyses are superimposed on three orthogonal MNI-spaced T_1-weighted average images (Figs. 1 and 2). Relative to the SC subjects, the EB subjects showed decreased WM volume (Fig. 1) in bilateral optic radiation (x = -36, y = -65, z = 11 and x = 31, y = -57, z = 11) and reduced GM volumes (Fig. 2) in bilateral primary sensorimoter areas (x = 42, y = -15, z = 61 and x = -49, y = -16, z = 51).

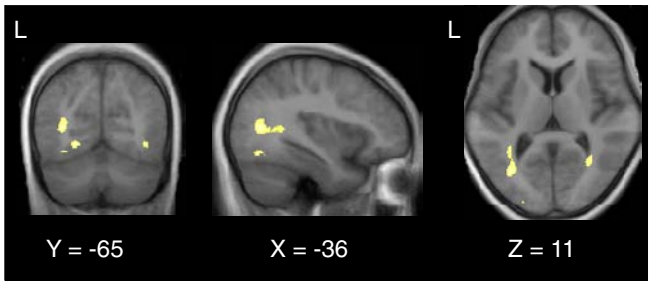

Figure 1 Changes of WM volumes in the EB subjects (EB<SC, Z>3.65, p<0.001, uncorrected).

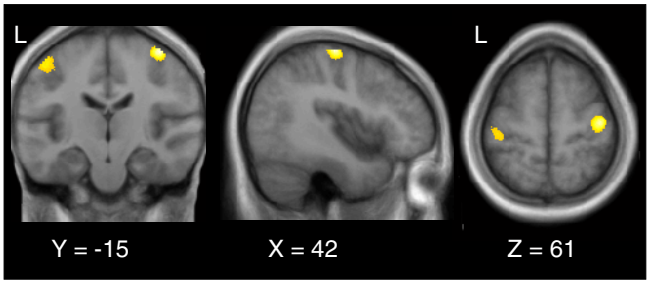

Figure 2 Changes of GM volumes in the EB subjects (EB<SC, Z>4.65, p<0.0001, uncorrected).

Discussion The observation that the EB subjects show atrophy of the optic radiation agrees well with the results of Noppeney et al [4]. However, these authors also showed that GM volume in the early visual areas of the EB subjects is reduced relative to control, a result that was not reproduced in this study. This could simply be due to the reason that smaller number of SC subjects was used in this study so that the statistical power of the study was somewhat lower. Our results, however, are consistent with the findings in congenitally deaf subjects, who reportedly show preserved GM volume and reduced WM volume in the superior temporal gyrus in the early auditory regions [6]. In contrast to the results of Noppeney et al [4], we found preserved WM volumes and decreased GM volumes in the primary senserimotor areas of our EB subjects. This result is surprising given that learning- and/or overuse-induced plasticity in the brain is often associated with increases, rather than decreases, of GM volumes, in the brain regions involved [7,8]. We postulate that this might have something to do with the special working experience of our EB subjects, most of whom (7 out of 8) started to work as professional massage technicians, as a tradition in the Chinese society, since they were teenagers.

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