

Adaptations in cortical activations in early, late blind individuals reading Braille

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Introduction: Braille converts simple tactile information into meaningful patterns that have lexical and semantic properties which may be mediated by the somatosensory system in the visually impaired subjects. Visual letter identity is accomplished within the visual system in sighted people as opposed to visual perception. Functional MRI is carried out to study the tactile and spatial perception during Braille reading.

Material and method: Ten right handed subjects in the early blind group (mean age \pm SD 15.1 \pm 3.6 years) and late blind group (mean age \pm SD: 12.9 \pm 1.3 years), each from the clinics of our institute and six sighted controls were recruited. Standard diagnostic and exclusion criteria were followed. BOLD scans were conducted on 3T MR scanner (Achieva 3.0T TX, Philips, Netherlands) using 32-channel head coil. For Braille semantic task of reading processing, patients were presented with noun pairs (antonyms), with four options written on Braille paper mounted on Braille base plate fitted on patient abdominal region and the cues were presented by using E-prime software (for changing plates). Single-shot echo planar imaging sequence was used for the BOLD studies (number of slices: 30, slice thickness 4.5 mm; TR: 2000 ms, TE: 30 ms, FOV: 231.7 mm, flip angle: 90°, number of dynamics: 192, resolution: 64 x 64). Pre- and post-processing was carried out using SPM8 (Wellcome Department of Cognitive Neurology, London, UK). One sample t- test ($p < 0.001$, cluster threshold 10) was used for group analysis.

Results: During the semantic task in **early blind** subjects, BOLD activation was observed in bilateral inferior temporal gyrus and inferior parietal lobule, left hemispheric cerebellum, somatosensory association cortex, premotor cortex and supplementary motor cortex and primary somatosensory cortex, right cerebral dorsolateral prefrontal cortex, pars opercularis, part of Broca's area, and superior frontal gyrus. In **late blind** subjects, activation was observed in bilateral inferior frontal cortex, left secondary visual cortex (V2), primary somatosensory cortex, premotor cortex and supplementary motor cortex, along with right pars triangularis Broca's area, and associative visual cortex (V3, V4, and V5), with dominant activation in left hemisphere. Though controls had not learnt Braille, the study was carried out in them to observe the tactile perception. In **controls**, the BOLD response to the task was in bilateral inferior frontal gyrus and inferior parietal lobule, right hemispheric dorsolateral prefrontal cortex, insula and claustrum and left hemispheric post-central gyrus and the most rostral superior frontal gyrus. Both hemispheres were active in sighted controls while dominant activation was observed in left hemisphere after analysis in late and early blind participants during the semantic task.

Discussion: The visual cortex of blind subjects is functionally relevant to Braille reading, suggesting that the brain shows remarkable plasticity that potentially permits the additional processing of tactile information in the visual cortical areas. Inferior parietal lobule in BA 40 is involved in meaning and phonology [1]. Consistent with this possibility, sighted and blind participants alike manifested higher responses in premotor and prefrontal cortex during the semantic task for inferring the tactile reference [2]. Late blind subjects showed significant activation in extrastriate area of visual cortex, whereas such activation was absent in early blind subjects [3]. Activation of the cerebellum in early blind suggests its role in tactile discrimination and motor control [4]. Activity in secondary visual cortex (V2) and associative visual cortex (V3, V4, V5) during Braille tasks may indicate a shift in modality selectivity of those areas, enabling them to contribute directly to perception rather than visual.

References

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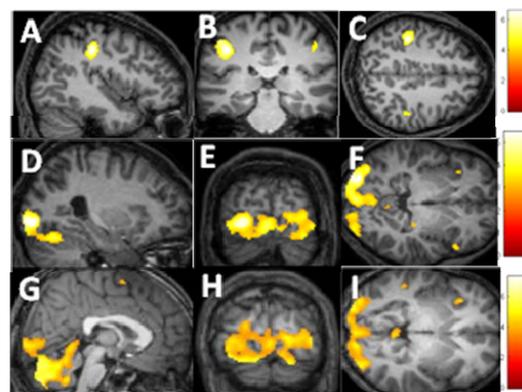


Figure 1. BOLD activation in (A,B,C) Controls, (D,E,F) Early blind and (G,H,I) in Late blind response to Braille reading task

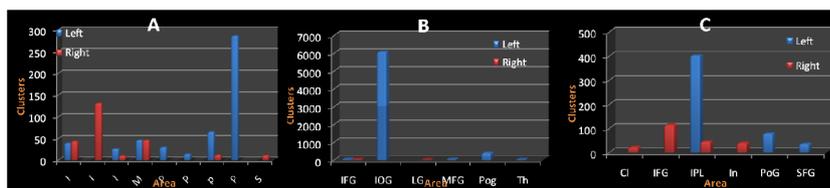


Figure 2. BOLD clusters in (A) Early blind, (B) Late blind and (C) Controls in response to Braille reading task (One sample t-test, $p_{\text{uncorrected}} < 0.001$, voxel threshold: 10, 1 voxel: $2 \times 2 \times 2 \text{ mm}^3$)