Attention Modulation of S1 Activation in Blind and Sighted Subjects: A pilot study

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Background

The adult human brain retains the ability to reorganize its circuits in response to both, injury and increased use. In particular the latter phenomenon, use-related plasticity, has given rise to the idea that organotopic maps in primary sensory areas are continually reconfigured to reflect the amount of behaviorally relevant sensory input. One example for such use-related adaptations in blind subjects. By the nature of their disability, blind individuals are forced to depend on non-affected modalities for information about their external environment. Such increased demand on the remaining senses is reflected in a substantial enlargement of primary sensory representations ([1-3]). However, enlarged representations cannot fully account for all perceptual phenomena observed in the blind. We therefore propose that the "qinput-model" alone may not be exhaustive, and that processes of use-related plasticity may also modulate higher cognitive functions, such as memory and attention. Based on this idea, the present experiment explored (1) the extent of S1 activation and (2) its modulation by attention, in blind and sighted persons. We predicted that top-down processing mechanisms lead to substantial differences in S1 activation between attended and ignored conditions in both groups. We further assume that in the blind use-related plasticity processes result in enhanced attentional modulation.

METRHODS

Subjects: So far 10 sighted and 8 blind subjects participated in the study. All volunteers were right-hand dominant and did not suffer from any disease affecting the central nervous system. Blind participants had all learned to read Braille and used the tactile language in everyday life.

Stimuli & paradigm: Tactile stimuli were presented to the midvolvar surface of the middle phalanx of the right index finger. An electronically-controlled device was used to deliver prodding events that activated the mechanoreceptors in their physiological range (Figure 1). The experiment comprised three conditions, (1) attend tactile stimuli, (2) ignore tactile stimuli, and (3) an active control condition. The experimental runs (attend/ignore condition) employed an oddball paradigm (standards: 813 ms SOA, deviants: 640 ms SOA; 0-2 deviants/ run). In the attend condition, subjects were asked to silently count the deviants; in the ignore condition a mental arithmetic task had to be performed. In the active control condition, no tactile stimulation was given while participants performed the arithmetic task. Participants were blindfolded during the experiment.

Recording: Imaging data was collected with a 1.5 T GE (LX/Nvi Neuro-Optimised) MRI system. BOLD contrast was obtained from T2*-weighted EPI encompassing the whole cerebrum [TR 3s; TE 40ms; flip angle 90degs; FOV 24 cm, slice thickness 5 mm, 22 slices], and superimposed on a T1-weighted 3D image for anatomical localisation. 100 EPI volumes per condition were acquired in a 10-cycle boxcar design with 15s ACTIVE/15s REST. Conditions were counterbalanced across participants. Data were analysed with SPM99. Group conjunction analysis ($p<0.001$) were performed, and the number of supra-threshold voxels and the % signal change in ROI S1/M1 (ipsi & contralateral) served as dependent variables.

RESULTS

Contralateral hemisphere: In both groups, the number of activated voxels and % signal change in the contralateral S1/M1 were much greater when subjects attended the tactile events as compared to the ignore condition (Figure 1). Thereby, the group difference for the attend condition was minimal (218 vs 208 voxels). For the ignore condition, however, activation in the blind was much stronger (138 voxels) than the sighted (7 voxels). Ipsilateral hemisphere: In the attend and the ignore condition, blind persons showed no S1/M1 activation. In the sighted, however, both conditions induced S1/M1 activity (attend = 19 voxels, ignore = 56 voxels).

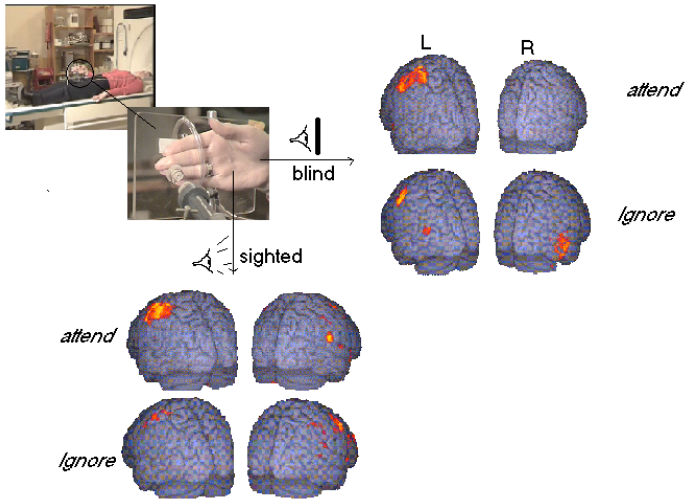

Figure 1

CONCLUSION

In both groups attention substantially modulates activation of the primary somatosensory area SI: even though the same subset of mechanoreceptors is stimulated, the extent of neuronal activation is larger when the attentional focus is placed on the tactile domain. This effect is particularly striking in the sighted, where SI activation increases nearly 30 times with attention.The group comparison further indicates a substantial difference in the way a blind person process tactile information when it is irrelevant, i.e. the attentional focus is placed on a non-tactile task. In the blind, ignored tactile stimuli activate a much greater region (~20 times) within SI than in the sighted. This finding suggests that tactile stimulus processing is enhanced in the blind. In line with previous evidence adaptational benefits are not generalised but differential for particular aspects of information processing.

References:

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