Cortical activation associated with tactile movement in attentive subjects

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Introduction

In this study, moving tactile stimuli were generated by a non-magnetic array stimulator[1]. This was placed directly under the index finger of the right hand to produce virtual touch sensations during fMRI[1]. The array comprises 100-elements (Fig 1), each driven by a piezoelectric bimorph cantilever, under individual software control. The two dimensional array of contactors is capable of producing spatiotemporal patterns of mechanical disturbance on the skin of the fingertip, at a comfortable sensation level. The present study compares activation from moving and stationary tactile stimuli, with a view to identifying the cortical activation associated with tactile movement. In contrast to a previous study[2], subjects in the present study were required to attend to the stimuli.

Methods

Subjects: Eight right-handed subjects (F/M=1/7, age 33-57) were scanned using a clinical 1.5-T Philips Intera system (Philips Medical Systems, Best, the Netherlands). The head was held in place with a strap and padding. Functional scanning was performed using a one-shot EPI sequence (TR/TE = 3000/50 ms; flip angle = 90^0; FOV = 230 mm; slice thickness = 4 mm; 64×64×32 matrix).

Stimuli: Moving stimuli were produced by sequentially vibrating the ten adjacent rows of the array, with 9 "sweeps" over the 12 s stimulus block. For stationary stimuli, all rows of the array were vibrated simultaneously, using a similar timing pattern. Stimuli produced by vibration at 40 Hz and stimuli produced by vibration at 320 Hz were tested in separate sessions.

Tasks: Subjects were required to attend to the stimuli and make a decision on whether each stimulus was "stationary" or "moving" by pressing a corresponding key.

Experiment Design: The subjects were divided into two groups. For the first group, the 40 Hz stimuli were presented in the first session and the 320 Hz in the second session whereas, for the second group, the 320 Hz stimuli were presented in the first session and the 40 Hz in the second session. Each session consisted of a unpredictable sequence of stationary and moving stimuli and lasted for 14.7 minutes (288 scans). The stimulus ON period of 12 s was followed by a resting OFF period of 33s.

Data Analysis: The fMRI data were analyzed using SPM2 (Wellcome Department of Cognitive Neurology, London, UK). The standard MNI brain template was used. A random effect model was applied with the height threshold p = 0.05 (corrected) and a spatial extent k = 50 voxels. A one sample t-test was conducted to examine the stimulus specific activation (moving or stationary) at each of the two stimulus frequencies. Paired t-tests were also done to compare activations between moving and stationary stimuli, again at each of the two stimulus frequencies.

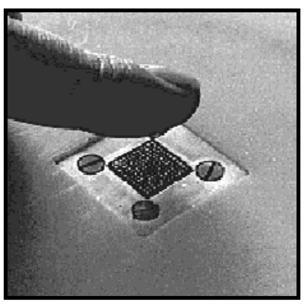

Fig 1: Array stimulator with 100 independent contactors.

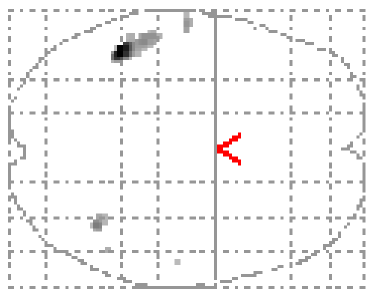

Fig 2: Group analysis for contrast between stationary vs moving stimuli at 320 Hz, $p_{corrected} = 0.05$.

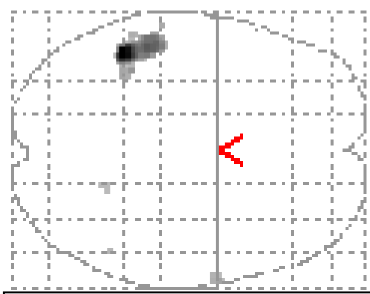

Fig 3: Group analysis for contrast between stationary vs moving stimuli (pooled 40 Hz and 320 Hz data), $p_{corrected} = 0.05$.

Results and Discussion

The activity due to vibrotactile stimuli is clearly recorded in the somatosensory cortex and motor cortex, throughout all the subjects. Both the moving and stationary tactile stimuli produce significant activation of SI, SII and the posterior parietal cortex, in agreement with previous studies of vibrotactile stimulation[2, 3, 4]. Figure 2 shows that, for 320 Hz stimuli, activation is significantly enhanced for moving stimuli, compared to stationary stimuli (p = 0.05, corrected), predominantly in a region corresponding to Brodmann area 40 (contralateral). Figure 3 shows a similar result from analysis of data pooled over 40 Hz and 320 Hz stimuli (p = 0.05, corrected). For 40 Hz stimuli (not shown) a similar result was obtained at a lower significance level of p = 0.001(uncorrected) but not at p = 0.05 (corrected). These observations are in contrast to results from the previous study[2], where moving *vs* stationary comparison indicated bilateral involvement of MT/V5. It is possible that involvement of Brodmann area 40 is associated with the attentional aspect of the task.

Reference

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