FMRI Mapping of the sensorimotor cortex of the foot

by vibrotactile stimulation

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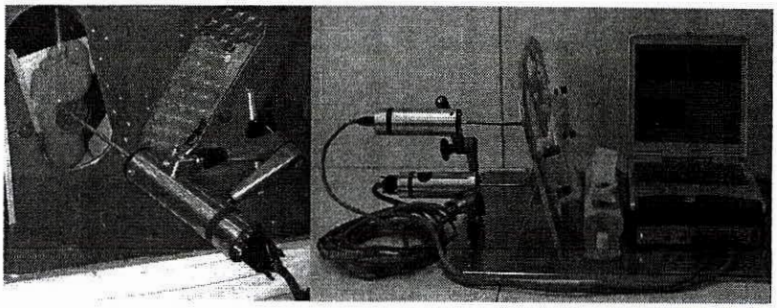
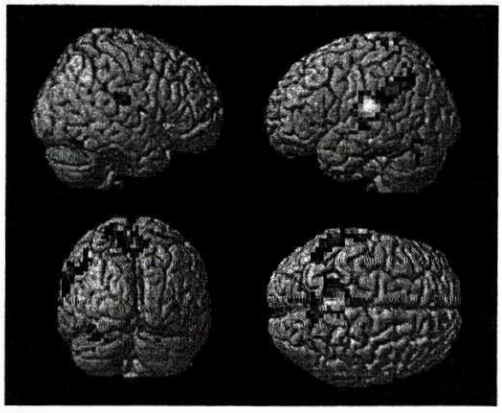
PURPOSE: The aim of the study was to develop a paradigm for the mapping of the sensorimotor foot region in fMRI with vibrotactile stimulation. Therefore, a proper vibrotactile stimulus was developed and the elicited brain activation pattern was analyzed to find best vibration parameters and an optimized experimental protocol for the applicability of the developed paradigm in clinical functional diagnosis of the brain.

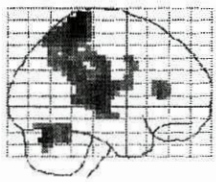
METHODS: 10 healthy male subjects (25–45yrs) were stimulated with a vibrotactile stimulus within the arch of the right foot. The stimulus was delivered through a fully automated moving magnet actuator with frequency (0-100Hz) and amplitude (0-4mm) control. To avoid adaptation phenomena a stimulus wave form was formed as the product of a fixed vibration carrier signal and a modulation term which varied sinusoidally. The carrier frequency was held constant at 100 Hz at a fixed modulation frequency of 25Hz and a fixed stimulus intensity of 0.05N throughout the fMRI run.

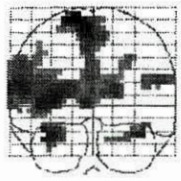


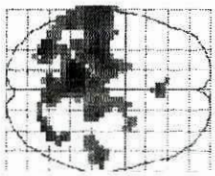
Experiments were performed on a 1.5Tesla MR-scanner. For fMRI, we employed T2*-weighted EPI sequences (TR/TE/α=0, 96ms/66ms/90°, matrix=64x64, acquisition time: 2sec, voxel dimension=4x4x4mm). Twenty-four slices parallel to the bicommissural plane were simultaneously acquired in an event related design with randomized stimulus presentation with stimulus duration of 1 sec as a 2x2 design with vibration amplitude of 0.5 and 1 mm and a vibration frequency of 25 and 50 Hz. A total amount of 120 volume images was acquired during a single fMRI run. The scan repetition time for the stimulus on/off conditions was 3s. Post-processing was performed offline with SPM99. A statistical parametric activation map was calculated for each of the 10 subjects and for the group. Clusters are reported as being significant if they passed an uncorrected threshold of $p<0.001$ with corrected p-value on cluster-level of less than 0.05.

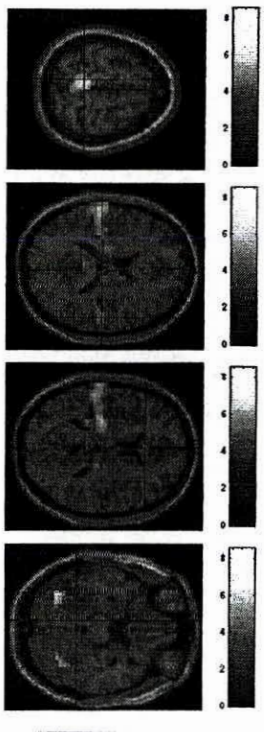
RESULTS: Comparing stimulation condition with baseline condition (no stimulation) brain activation was observed bilaterally within: the secondary somatosensory cortex SII within the inferior parietal lobule (BA 39, 40, 43), the superior parietal lobule (Precuneus; BA 5, 7), the anterior and posterior cingular gyrus (BA 23, 24, 29, 31), and the posterior insula (BA 13). Additional activation was observed bilaterally within the fusiform gyrus (BA 19, 37), the thalamus and caudate nucleus as well as the anterior (Culmen) and posterior (Declive) cerebellar lobe. Acitvation within the thalamus included the pulvinar, the lateral dorsal nucleus, the lateral posterior nucleus, the midline nucleus, the ventral posterior lateral nucleus, the ventral posterior medial nucleus and the ventral lateral nucleus. Contralaterally to the stimulated foot, responses within the primary sensorimotor cortex including the pre- and postcentral gyrus (SM1; BA1, 2, 3a,3b, 4), the lentiform nucleus and the Putamen were seen.











CONCLUSION: In the present study, an fMRI paradigm for vibrotactile stimulation of the foot could be implemented within the MR environment. The vibrotactile stimulus can be well defined and frequency and amplitude can be controlled. The stimulus with a modulation frequency of 25Hz is able to elicit brain activation within main centers of the sensorimotor cortex for the right foot within a group of 10 subjects. The described fMRI map by vibrotactile stimulation of the foot hold promise for the applicability in preoperative functional diagnosis of patients with brain tumors, in prognostic investigations for patients after head injury or within vegetative state as well as in the planning and functional monitoring in neurorehabilitation.

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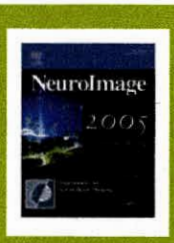

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