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FMRI of the sensorimotor cortex by vibrotactile stimulation of the foot

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Purpose: The aim of the study was the development of a paradigm for the mapping of the sensorimotor foot region in functional magnetic resonance imaging (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 single shot echoplanar 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 a stimulus duration of 1 sec as a 2x2 design with a 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 of subjects with an uncorrected $p<0.001$ on a cluster level of $k>8$. **Results:** FMRI group data of the 10 subjects showed brain activity: 1. bilaterally within the secondary somatosensory cortex located in the inferior parietal lobule, 2. contralaterally to the stimulated side within the primary sensorimotor cortex overlapping the pre- and postcentral gyrus, 3. bilaterally within the supplementary motor cortex within the superior frontal gyrus and 4. on the right hemisphere within the anterior cingular gyrus. The present study supports an increasing stimulus-response relationship between vibrotactile stimuli and the amplitude of the BOLD response within the primary sensorimotor cortex SM to a single vibrotactile event. Stimulus frequency did not significantly influence BOLD amplitude. **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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