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Title:

Functional Magnetic Resonance Imaging of the sensorimotor cortex during vibratory stimulation of the hand

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Abstract:

PURPOSE Functional Magnetic Resonance Imaging studies of the sensorimotor cortex in stoke patients for monitoring of the poststroke rehabilitation and understanding of the mechanisms of poststroke motor recovery with active motor paradigms are often difficult to perform because of impairment of motor functions, hemiparesia or hemiplegia. Therefore, for the fMRI evaluation of stroke sensory stimulation would be of great importance, because the collaboration of the subject under examination is not needed. Sensory stimulation by vibration has already been performed in PET studies /2/, which have shown, that vibration stimulation activates the sensory as well as the motor cortex.

The aim of this fMRI study was to implement a vibratory stimulation paradigm within the environment of the MR-scanner which leads to a cortical response of the whole sensorimotor cortex as it is seen in active motor paradigms such as finger-to-thumb tapping and fist clenching to be applicable in patients after stroke with severe motor deficits.

MATERIALS AND METHODS All experiments were performed on a 1.5 Tesla whole body scanner (Magnetom VISION, Siemens, Germany) with a conventional circular polarised head coil (FoV=250mm). T2* weighted images were acquired with a single shot echo planar imaging (EPI) sequence /3/ allowing the simultaneous measurement of 15 slices within 2 sec (TE/α= 64ms/90°). To avoid artefacts due to involuntary head motion a special self developed head fixation device was used. The 15 image slices were positioned to cover the whole motor cortex, parallel to a line crossing the anterior and the posterior commissar. The vibratory stimulation paradigm was a 50 Hz vibratory stimulus with an amplitude of 2mm applied via pneumatic tube to the right and left palm. Series of 10 images during vibration (condition A) and 10 images without vibration (condition B) were alternatively acquired up to a total of 60 images (time series: ABABAB). The temporal resolution was 4 s. The vibrating device is an electromotor with 50 W performance and 6000 U/min, which rotates two excenters pumping simultaneously via two circular rubber membranes air into a pneumatic tube, which is fixed onto the palm of the right and left hand above the basic joints of the fingers I-V.

A single examination consisted of two fMRI measurements, where the right and the left palm were vibrated. The whole study was performed in six healthy, right handed male and female volunteers (age range 25 - 45 years), who signed the written consent form. The study protocol was approved by the local ethic committee. Prior to statistical analysis the image data sets were corrected for involuntary subject motions based on the Woods algorithm /4/. For the calculation of the activation maps, we used the cross correlation analysis with a threshold of 0.5 and a pixel cluster size of ≥ 4 /5/. For anatomical location of the activated areas we transformed the functional data into Talairach space.

RESULTS Vibratory stimulation of the right and left palm revealed contralateral activation of the primary motor cortex (MI), the primary and secondary somatosensory cortex (SI and SII) and the frontal cortex ventral to the MI area, which can be associated with a premotor area (PM). The supplementary motor area (SMA) within the frontal lobe was bilaterally activated. An ipsilateral activation foci was seen within the gyrus frontalis superior near the interhemispheric fissure, within the PM and the SI and SII. The strongest activation was found within the SI and SII followed by the MI. The PM and the SMA showed only weak activation. Patient 6 had activation only within the somatosensory cortex without motor activation, probably due to not properly applied vibratory stimulus.

CONCLUSIONS We have demonstrated by fMRI, that passive sensory stimulation by a vibratory stimulus to the right and left palm can lead to an activation response not only of sensory cortex, but also to an activation response of the motor cortex like in active motor paradigms as finger-to-thumb tapping or fist clenching. Obviously, our vibratory stimulus elicited the vibratory tonic reflex, which involves the cortical motoneurons. This holds promise for vibratory stimulation as an alternative to active motor paradigms in stroke patients with severe motor deficits to study motor cortex functions and to monitor poststroke rehabilitation.

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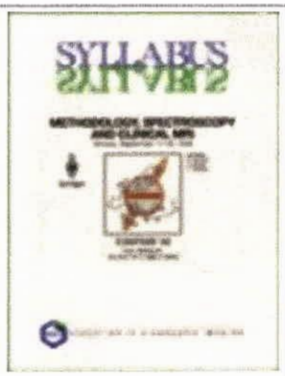

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