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A new pneumatic vibrator for Functional Magnetic Resonance Imaging of the human sensorimotor cortex

S. Golaszewski [1,3], C. Siedentopf [1], S. Lechner-Steinleitner [2], M. Berger [2], S. Felber [1], F. Gerstenbrand [2,4]

[1]Department of Magnetic Resonance and [2] Institute for Space Neurology, University of Innsbruck, Austria
[3]Department of Neurology, University of Graz, Austria
[4]Ludwig-Boltzmann-Institute for Restorative Neurology and Neuromodulation, Vienna, Austria

PURPOSE: Functional diagnosis of the sensorimotor cortex is of increasing importance for the planning of neurosurgical intervention in patients with brain tumor or for the planning or monitoring of poststroke rehabilitation. Within these patients, active motor paradigms such as finger-to-thumb tapping or fist clenching are often difficult to perform because of severe motor deficits. Therefore, paradigms which do not need the collaboration of the patient under investigation are needed. The aim of the study was to implement a vibrotactile stimulation paradigm within the MR environment and to compare the results with the finger-to-thumb-tapping paradigm.

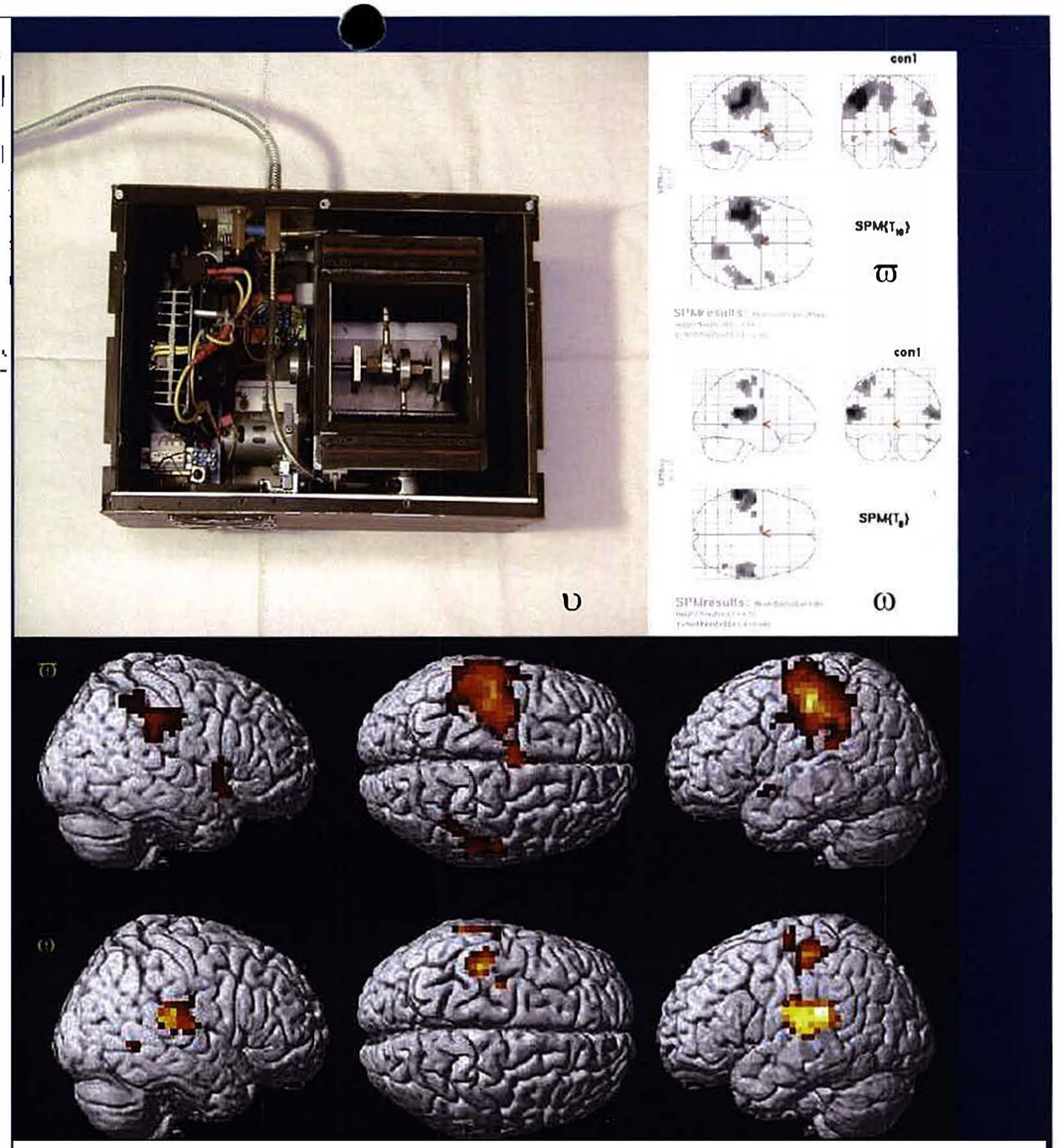
METHODS: 10 healthy, right-handed male volunteers performed a finger-to-thumb-tapping paradigm with the right hand. In a second experimental run, the subject's palm of the right hand was vibrated with a pneumatic vibrotactile stimulus produced by a self developed MR compatible vibration device. Prior to the second measurement, we performed a test vibration procedure with a 50 Hz vibrotactile stimulus to the right hand palm and the tonic vibratory reflex (TVR) in the bellies of the forearm flexors, the thenar and the hypothenar muscles was constantly elicited which was recorded by EMG. The vibration device is based on a dual membrane pump driven by an DC motor (12 V, 100 W, max. 6000 rpm) which pumps air in a latex tube. This tube was fixed onto the palm of the right hand above the basic joints of the fingers I – V.

All experiments were performed on a 1.5 Tesla MR scanner (Magnetom Vision, Siemens, Erlangen Germany) using a circular polarised head coil with a field of view of 250 mm. T2* weighted images were obtained with a single shot echoplanar imaging (EPI) sequence (TR/TE/α 3.96ms/66ms/90°, matrix 128x128, acquisition time 6 sec). This sequence is able to acquire simultaneously 35 transversal slices parallel to the AC-PC line covering the whole brain. The resulting voxel size was 1.95 mm x 1.95 mm x 3.8 mm. In order to minimise motion artefacts, a home made fixation device was used.

Post-processing was done offline on a dual Pentium III computer workstation with software SPM99 [1]. A statistical parametric activation map was calculated for the whole subject group as well as single subject analysis was performed using a p value of 0.001 and a cluster size of 4. Data processing included motion correction, normalisation and transformation of the data into the Talairach space, spatial smoothing with a Gauß filter (FWHM 12x12x12 mm³), a high pass filter (cut-off: 0.001 Hz) and a low pass filter (cut-off: 0.1 Hz) for elimination of respiration and liquor pulsation related motion artefacts.

RESULTS: Group analysis over the 10 subjects shows

- For the finger-to-thumb paradigm (FTP) in contralateral cortical brain activity within Gyrus precentralis (GPrC, MI), Gyrus postcentralis (GPoC, SI), Lobulus parietalis inferior (LPi, SII), Gyrus frontalis medius (GFd) and Gyrus cinguli (GC). Ipsilateral brain activation could be detected within LPi, GPoC, GPrC and LPs.
- For the vibration paradigm (VPD) a similar brain activation pattern could be elicited. Contralateral GPrC, GPoC, LPi, GC, Gyrus temporalis superior (GTs). Ipsilateral LPi, LPs, Gyrus temporalis medius (GTm).



CONCLUSION: Our results hold promise for the application of the pneumatic vibrotactile stimulus for the functional diagnosis of the sensorimotor cortex in patients with brain tumor for the planning of the neurosurgical intervention or in patients with motor deficits for instance in stroke or spinal cord injury. A pneumatic vibrotactile stimulus can be lead easily into the magnet of the MR scanner. Further it can be applied easily to each site of the body, because the flexible plastic tube can be easily attached with velcro strap. Disadvantage of our system at the moment is the not yet exactly defined vibration amplitude because of the compressibility of the air. Further studies are needed to optimize the pneumatic vibrotactile stimulus for functional diagnosis of the brain an to define precisely vibration displacement.

References:

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