A fMRI compatible thumb actuator for stroke patients

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Purpose/Introduction

Stroke is a major cause of disability in all age groups, and many of the survivors are left with some disability .[2] One of consequences of stroke is partial paralysis usually in one half of patient‘s body. The diagnostic value of self-paced fMRI of brain motor areas of such patients can be questioned due to variability in the subject performance [1]. In order to overcome these limitations we propose a system helping disabled patients execution of thumb movements during neuroscience experiments. We demonstrated an application of the proposed system in the stroke recovery rehabilitation monitoring.

Subjects and Methods

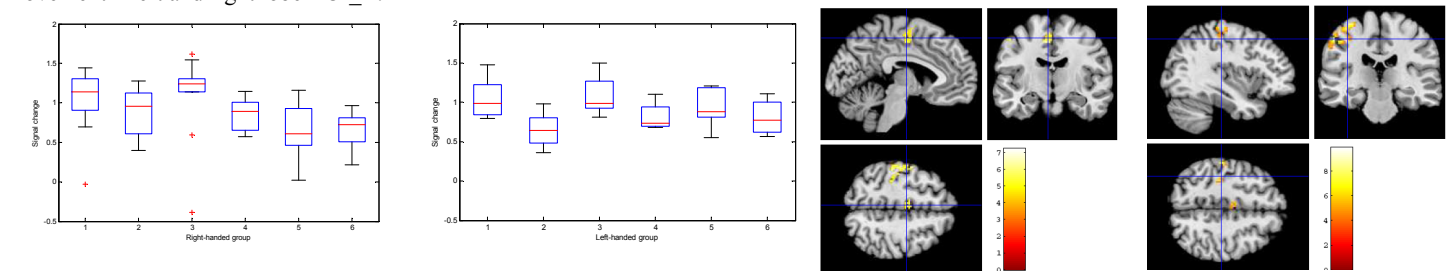
The main part of the system is a mechanical actuator fitted to the patient‘s hand. All supporting parts were made from paramagnetic materials: aluminum, stainless steel and brass. A small microprocessor system controls two, operating in simple on-of mode, electric valves one for each thumb actuator. The pneumatic system is powered by an air compressor located in operator’s room. Initial testing a group of 17 volunteers healthy subject (10 right-handed, 7 left-handed) and one patient after stroke actually during intensive rehabilitation was examined on 3T TRIO scanner in Bioimaging Research Centre (IPPH Poland). Both T1-weighted anatomical and functional images were collected in the transverse (axial) plane, with in-plane resolution of 1mm×1mm for the anatomical scan; and for fMRI, resolution was 3mm×3mm, repetition time was (TR) = 3 s, echo time was (TE) = 30ms, and flip angle was 90◦.

For each of the subject 6 functional runs were collected (EPI sequence): for each thumb free and paced movement (4 runs), both thumb movement free and paced (2 runs). Two blocks of rest and movement were repeated 5 times, with one final rest period at the end. The movements were performed 1 time per s.

Data analysis was performed using the Statistical Parametric Mapping (SPM5) package (Wellcome Department of Imaging Neuroscience at University College London, UK). Regions of interest (ROIs) were identified using SPMsoftware (wfu_pickatlas, Anatomy Toolbox). The following ROIs were studied: premotor cortex (Area 6), motor cortex (Areas 4a and 4p), primary somatosensory cortex (Areas 3a, 3b, 1,2).

Results:

Our finding for volunteers group confirm that there was greater volume of activation in the contralateral to the movement side lobe.[3] At fig 1 we present mean value and STD signal changes accordingly for right movement- left lobe ROI_L, left movement – right lobe ROI_R, both thumb movement – left and right lobe ROI_B.

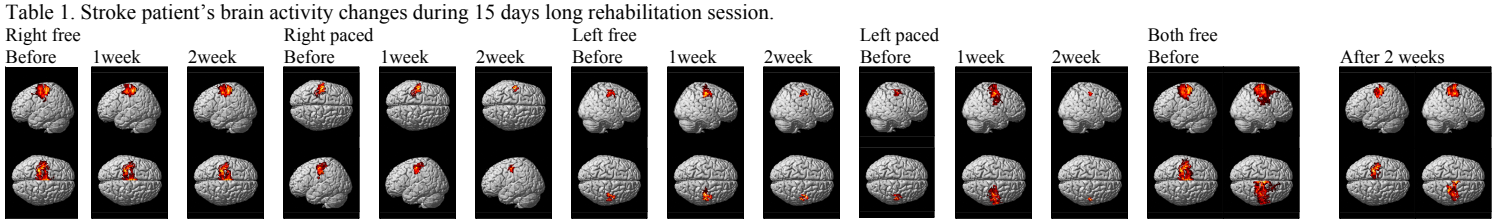


A) right handed B) left handed C) right free right paced

Fig. 1. Results for group of volunteers: A, B –. Mean value and STD for ROI. Condition:1- right free ROI_L; 2 – right paced ROI_L 3 -left-free ROI_R; 4 – left paced ROI_R; 5 - both free ROI_B; 6 – both paced ROI_B. C- example for right-handed group right free and right paced movement.

Table 1 presents results for stroke patient with severe right Upper extremity paresis (39 Y, four years after stroke, 3 /15 points of Upper Extremity section Rivermead Motor Assessment Scale). Data were collected during three weeks (15 days) long intensive physiotherapy (3 hours per day) targeted on improvement of functional use of the hand. Patient improved his score in RMA Scale and increased his active use of right upper extremity during every day activities.

Table 1. Stroke patient’s brain activity changes during 15 days long rehabilitation session.



Discussion/Conclusion

fMRI tests for both free and paced conditions showed high activations in brain motor areas. The proposed system can support diagnostics of motor disabled patients, who cannot perform motoric tests on their own. Moreover, it can reduce intersubject fMRI data variability due to better subject performance control. After performing clinical tests and completing the system, the device should prove useful in ascertaining the status of all patients with motoric disabilities. However, these observations should be replicated on a larger population of patients.

References:

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