

Reliability of Different Hand Motor Tasks Suitable for a Clinical Setting: A Comparative fMRI Study in Healthy Volunteers

C. Fellner¹, M. Schnizer², J. Trenkler¹

¹Institute of Radiology, Landesnervenklinik Wagner-Jauregg, Linz, Austria, ²Department of Neurology, Landesnervenklinik Wagner-Jauregg, Linz, Austria

Introduction

Many different hand motor tasks have been described in the literature for fMRI experiments. The aim of our study was to find a reliable motor task for clinical application which is able to unambiguously show the sensorimotor cortex (SMC) with a minimum of additional postprocessing time and with a minimum of effort for the patient. Therefore, we systematically compared 3 tasks with different complexity, each for the right and for the left hand, including 2 repetition experiments.

Materials and Methods

fMRI of 16 right-handed healthy volunteers (8 women, 8 men; mean age: 38 years) was performed on a 1.5 T system (Symphony, Siemens) using the standard head coil. 8 self-paced tasks were used in a fixed order: Opposition of thumb and index finger of the right (R I-II) and of the left (L I-II) hand, opening and closing of the fist of the right (R fist) and of the left (L fist) hand, finger tapping of all fingers of the right (R I-V) and of the left (L I-V) hand, repetition of R I-V (R I-V rep) and repetition of R I-II (R I-II rep).

An EPI technique with TR 2690 ms, TE 50 ms was applied with a pixel size of 3 mm x 3 mm (FOV: 192 mm, matrix size: 64 x 64). 30 transverse slices with a slice thickness of 3 mm and a slice gap of 25% were acquired for all tasks including 4 baseline (rest) and 4 activation periods (8 measurements per period). 3D motion correction (k-space interpolation) and 3D filtering was done on-the-fly. Further postprocessing was performed on a separate workstation (Leonardo, Siemens) using the BOLD card. A threshold of $t = 4.0$ for the t-test evaluation and a cluster size of 3 – excluding all activated areas below a cluster size of 3 pixels – was used for all subjects and all tasks. Color-coded t-maps were overlaid onto T1-weighted anatomical images with a pixel size of 1 mm x 1 mm and used for further evaluation which was done by 2 readers in consensus.

Number of slices with activation and maximum area of activation were described according to anatomical concepts (motor areas: SMC, supplementary motor area (SMA), cerebellum; prefrontal region, parietal region, basal ganglia; other infratentorial regions; extracerebral regions). Further evaluation was done for the SMC, SMA, and cerebellum. Identification of contralateral SMC was judged as excellent (1), good (2), moderate (3), still sufficient (4), poor (5), or impossible (6) according to unambiguous visibility of SMC in comparison to non-motor activated regions. Comparison of the results of different tasks was done using Wilcoxon's test. Furthermore, the threshold for t-test was judged as adequate, too high, or too low.

Results and Discussion

Identification of SMC was much easier using the thumb and index finger opposition (I-II) or the fist task than the finger tapping task of all fingers (I-V) (table 1). The differences were statistically significant for both hands; no significant differences were found for the repeated tasks versus the primary tasks (table 2). The fixed threshold for the t-test evaluation proved to be adequate in most of the I-II and fist tasks. In a few cases, it was judged to be too low so that huge areas of activation were seen, also outside the motor areas. In 5 of 128 experiments (8 tasks in 16 subjects) the SMC could not be identified using a fixed threshold; selecting a much lower threshold of 3.4 or even 2.8 it was seen in all cases.

	R I-II	R I-II rep	R fist	R I-V	R I-V rep	L I-II	L fist	L I-V
identification of SMC								
mean \pm standard deviation	2.1 \pm 0.9	2.8 \pm 1.6	1.8 \pm 0.9	3.2 \pm 1.3	2.9 \pm 1.4	2.0 \pm 1.4	2.3 \pm 0.9	2.9 \pm 1.0
excellent (1) or good (2)	11	7	12	5	7	13	11	5
impossible (6)	0	2	0	1	1	1	0	0
threshold for t-test								
adequate	14	12	14	10	10	13	13	11
too low	2	2	2	5	5	2	3	5
too high	0	2	0	1	1	1	0	0

Table 1: Identification of SMC: mean and standard deviation of grading on a scale from 1 to 6; number of cases with excellent (1) or good (2) results, number of cases with impossible identification (6). Appropriateness of a fixed threshold ($t = 4.0$) for the t-test evaluation: number of cases with adequate, too low or too high threshold

	R I-II versus R I-V	R I-II versus R fist	R I-V versus R fist	R I-II versus R I-II rep	R I-V versus R I-V rep	L I-II versus L I-V	L I-II versus L fist	L I-V versus L fist
identification of SMC	*	ns	*	ns	ns	*	ns	*
SMC contralateral	ns / ns	*/*	ns / ns	*/*	*/ ns	ns / *	ns / *	ns / ns
SMC ipsilateral	*/*	ns / ns	*/*	*/*	ns / ns	*/*	*/ ns	*/*
SMA	*/*	*/*	ns / ns	ns / ns	ns / ns	ns / *	ns / ns	ns / ns
cerebellum ipsilateral	*/*	*/ ns	ns / ns	ns / ns	ns / ns	ns / *	*/ ns	ns / ns
cerebellum contralateral	*/*	ns / ns	ns / *	ns / ns	ns / ns	ns / ns	ns / ns	ns / ns

Table 2: Comparison of different tasks (Wilcoxon's test): Identification of SMC; activation in different motor areas (results are given for the number of activated slices and for the maximum activated area). *: statistically significant differences ($p < 0.05$), ns: no statistically significant differences ($p \geq 0.05$)

The extension of contralateral SMC activation was smaller with the I-II than with the I-V and the fist task. This result is easily understood by involvement of additional brain areas by movement of additional fingers. Ipsilateral activation was significantly larger with the complex I-V finger tapping task compared with the much easier I-II or fist task. During the repeated tasks the amount of contralateral and ipsilateral activation was reduced (without statistically significant differences for the I-V task). This result can be interpreted as a learning effect. Statistically significant differences were found for SMA activation in the I-II task compared with the fist and I-V task. SMA activation increased from I-II to fist and was highest for the I-V task, which requires a lot of coordination. Activation in the cerebellum was once again most pronounced with the I-V task, reduced during fist movement and smallest for index finger – thumb opposition, but only the difference between I-II and I-V reached statistical significance on both sides.

Conclusion

A very simple motor task – opposition of thumb and index finger – can be recommended for application in patients to identify the SMC. This task worked reliably in both hands; furthermore, evaluation with a fixed threshold for the t-test evaluation was successful in most cases. If localisation of ipsilateral SMC and SMA is required additionally, a more complex task – like opening and closing the fist or even finger tapping of all fingers – is preferable. However, in simple as well as in more complex tasks learning effects were seen and might compromise clinical application.