Functional Magnetic Resonance Imaging during seven Motor Tasks: Variability of Primary and Secondary Motor Activation over 9 Subjects

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Purpose

We investigated neuronal activity during seven different motor tasks using functional magnetic resonance imaging (fMRI). The purpose of this study was to compare the variability of BOLD related activity in whole head volumes between subjects.

Introduction

The reconstruction of motor related activity has been investigated by several groups. Limited by a small number of slices (partial volume acquisition with high resolution [1]) or the type of motor tasks applied (finger tapping [2], leg and arm (PET) [3]), the results showed activation of the primary motor cortex and a variety of other secondary motor areas. In neurosurgical procedures information about these systems can help to plan the operation and monitor the outcome. In order to achieve a more detailed view on the interaction of different motor related activations in healthy subjects, we applied several motor tasks and tested the reliability and variability over subjects.

Methods

Nine healthy right handed subjects were scanned on a GE neuro-optimized system (1.5 T). Before the session, subjects signed an informed consent and were trained for the different motor tasks. After a set of structural images for offline transformation into Talairach space, the functional data (16 slices, 7 mm skip 1 mm, TR 2 sec) were acquired. During 8–10 runs with 125 consecutive whole head scans, each task was performed in four 30 sec off/on periods: finger tapping, toe movement, knee adduction, eye saccades, lip movement, tongue movement, contraction of the diaphragm pelvis and, in 6 subjects, index and middle finger button press. Detected activity was analyzed by cluster detection for peaks within Talairach space in each subject and for the grand average over subjects using methods described in [4]. For one subject we applied the method of cortex flattening described in [5].

Results

The grand average showed significant increase of the BOLD response for all motor tasks in various areas including bilateral primary motor cortex, supplementary motor area (SMA), bilateral basal ganglia and thalamus, secondary sensomotor area and bilateral cerebellum. Table 1 summarizes the results in Talairach space with the peak coordinates and the laterality in respect to the significance level. Analysis of the peaks for primary motor areas by ANOVA (task x peak x subjects) revealed a significant effect for task x peak (F=56).

While the primary motor cortex, SMA and bilateral cerebellar activation were reliably detected in each subject for each task, the distribution of activity within the basal ganglia and thalamus was different in terms of laterality and level of significance.

Task	M1	SMA	BGL/Thalamus	Cerebellum
Eye	-42 –11 46	-2 –9 60	R < L	R + L
Tongue	-54 –10 26	-6 1 53	R + L	R + L
Lips	-53 –15 43	3 –4 63	R > L	R + L
Pelvis	3 –12 65	-3 –9 53	R + L	R + L
Knee	0 –29 61	-3 –18 60	R + L	R + L
Finger	-35 –18 59	-5 –12 57	R + L	R > L
Toe	-3 –24 65	2 –7 58	R > L	R + L
Button	-37 –27 48	-3 –12 58	R + L	R > L

Table 1. Results based on average of 9 subjects. Peak coordinates for M1 (primary motor cortex) and SMA (supplementary motor area) in Talairach space for all motor tasks (rows). Laterality of significant activation for BGL (basal ganglia)/Thalamus and cerebellum (L = left, R = right)

Discussion

All applied motor tasks revealed significant BOLD responses in primary and secondary motor areas. The average of nine subjects showed a distribution of peak activity in the primary motor cortex related to the motor homunculus.

Within subjects, only the activation of the primary motor cortex, SMA and the cerebellum were reliable concerning laterality and significance level while the pattern of activation for basal ganglia / thalamus and secondary sensomotor area were different in each subject. As the different tasks were trained before the session but not monitored online, individual differences in force, frequency and range of the motor activity might have contributed to these results.

These results demonstrate the possible application of a broader variety of motor tasks in order to elicit activation in primary and secondary motor areas using functional magnetic resonance imaging.

References

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