

Simultaneous EMG-fMRI: methodological developments and application in tremor

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Summary

Simultaneous EMG-fMRI provides information on peripheral and central motor system components concurrently, but poses a technical challenge. Before this technique could be used to its full potential several methodological problems therefore had to be solved. In this project a method was developed to fully integrate information obtained from EMG and fMRI recordings in the analysis. Subsequently, this method was applied in patients with an action tremor, to show that EMG-fMRI is supplementary to conventional fMRI in the study of movement disorders.

Introduction

For a thorough understanding of the human motor system, in health and in disease, simultaneous measurements of peripheral and central motor system components would be a great advantage. Drawbacks of typical approaches, such as intracranial or combined EEG/MEG-EMG recordings are their invasivity and/or limited spatial resolution. A non-invasive technique that provides information on functional activity of the entire brain and muscle at the same time was not available for a long time. In an attempt to improve upon this situation, we started recording EMG and fMRI simultaneously at the BCN-NiC a few years ago.

Methodology

In the scope of this project, we have sequentially solved some of the important problems that EMG recordings during fMRI present. After the accuracy of EMG recordings of isometric muscle contractions during scanning had first been established, we aimed at incorporating the acquired information on muscle activity into the fMRI analysis. We integrated the additional information that the EMG provides on movement execution and intensity in the design, by application of a mathematical procedure (Gram-Schmidt orthogonalization). We hypothesized that this EMG-measure would help to reveal brain activity directly related to variability in task performance, which would be extremely helpful in patients with movement disorders. We first validated this approach in healthy controls who performed slow and fast wrist flexion-extension movements. Secondly, once the method of incorporating EMG information into the fMRI analysis was validated, our goal was to show that indeed new information on brain activity during pathological movement could be obtained by this technique. We investigated a group of patients with a familial action tremor; Familial Cortical Myoclonic Tremor with Epilepsy. We studied

the patients and a group of control subjects by simultaneous EMG-fMRI while they were executing wrist flexion-extension movements and during hand and arm posture.

Main results

Results of these studies showed that, just as a conventional fMRI recording and analysis, our approach can be used to identify neuronal circuitry associated with a specific motor task. The new approach can additionally help to identify brain activation directly related to variability in, or involuntary, movements, by employing the concurrently acquired EMG. Simultaneous EMG-fMRI is thereby supplementary to conventional fMRI and facilitates studies of the healthy motor system and of hyperkinetic movement disorders.

Future prospects

The technique of EMG-fMRI has matured and is now ready for application, which is proven by the fact that several studies in healthy subjects and patients with neurological disorders (multiple sclerosis, Parkinson's disease, Huntington's disease, essential tremor, periodic limb movements during sleep) are in preparation or ongoing, in Groningen, Amsterdam and elsewhere in the Netherlands.